ŽEMĖS ŪKIO MOKSLAI. 2008. T. 15. Nr. 3. P. 80–86

Specificity of pedogenesis in shallow soils on massive rocks of East Fennoscandia

Sofia Lessovaia[1],

Oleg Chertov[2],

Sergey Goryachkin[3]

[1] *Department of Physical and Evolution Geography, Faculty of Geography and Geoecology, St.-Petersburg State University, V. O. 10th line, 33, 199036 St. Petersburg, Russia*
E-mail: lessovaia@yahoo.com

[2] *University of Appl. Science, Bingen. Berlinstr, 109, 55411 Bingen, Germany*
E-mail: oleg_chertov@hotmail.com

[3] *Institute of Geography, Russian Academy of Sciences, Staromonetny, 29, 119017 Moscow, Russia*
E-mail: sergey.gor@mail.ru

The shallow soils of East Fennoscandia on massive rocks under lichen and lichen-moss vegetation were studied. The rocks were represented by (i) nepheline syenites, (ii) amphibolites, (iii) metamorphized gabbro-diabase and (iv) their derivates. Besides "soils" as litters on rocks and Podzols on sandy moraines, there was found a unique variant of soil formation as shallow (<5–10 cm) stony soils that were formed on the fine earth derived from hard rocks without any admixture. These soils are classified as *Leptosol* (WRB, 2006) and as "lepto-podburs" in the Russian classification system (2004). Their recent pedogenic processes are: (i) transformation of soil organic matter *in situ,* (ii) formation and migration of R_2O_3-organic complexes, (iii) mineral disintegration. They are combined in one soil horizon as depth and fine earth are not enough to form a proper soil profile. Phyllosilicates are present in the sola due to epigenetic ("pre-pedogenic") alteration of rock.

Key words: pedogenesis, soil organic matter, mineral composition

INTRODUCTION

Shallow stony soils underlain by hard bedrocks – *Leptosols* – are the most widespread soil group in the world: their area is 1655 million hectares (World…, 2006). The study of these soil formation has a long history. This problem includes some aspects:

– the direction of soil formation processes on shallow and stony substrates is determined by rock composition and its susceptibility to weathering processes and the degree of phyllosilicate enrichment (Седов, 1992; Таргульян, 1971). The above mentioned enrichment is in accordance with regulations of primary rocks weathering (Wilson, 2004);

– lichens among different types of plants have the strongest influence on hard substrate (phyllosilicate transformation and taking out of iron by organic acids in the silicate matrix) (Augusto et al., 2000; Chen et al., 2000; Prieto et al., 1994; Wilson, Jones, 1983; Еленкин, 1901; Полынов, 1945; Ярилова, 1947);

– regularities of the initial soil formation and the development of fragmentary soils (Богатырев, 1959).

Nevertheless, the regularities of profile genesis, transformation of the mineral matrix and soil organic matter in the shallow sola underlain by hard bedrocks remain unsolved. The nature of the loose layer – whether it is allochthonous or autochthonous – is not always clear, though this is the key question for soil genesis interpretation.

The aim of our research was to study shallow soils on the basic and alkaline hard rocks: nepheline syenites, amphibolites and metamorphosed gabbro-diabases in the mountainous tundra and taiga of East Fennoscandia (Kola Peninsula and the Republic of Karelia). The study was focused on the rocks that occupy relatively small areas in north-west Russia in order to diagnose a possible admixture of allochthonous moraine material with a distinct predominance of granite derivates.

OBJECTS AND METHODS

The objects of the present research are soils on hard basic and alkaline rocks represented by (i) nepheline syenites and (ii) amphibolites in the mountainous tundra and northern taiga of Kola Peninsula, respectively, and (iii) metamorphosed gabbro-diabases in middle taiga of the Kivach Nature Reserve in the Republic of Karelia (Figs. 1–4). Soils developed directly from

Fig. 1. Scheme of study site location: *1* – Kola Peninsula, *2* – Kivach Nature Reserve in the Republic of Karelia

Fig. 2. Landscape of mountainous tundra of Kola Peninsula

Fig. 3. Blocks of amphibolites in the northern taiga of Kola Peninsula

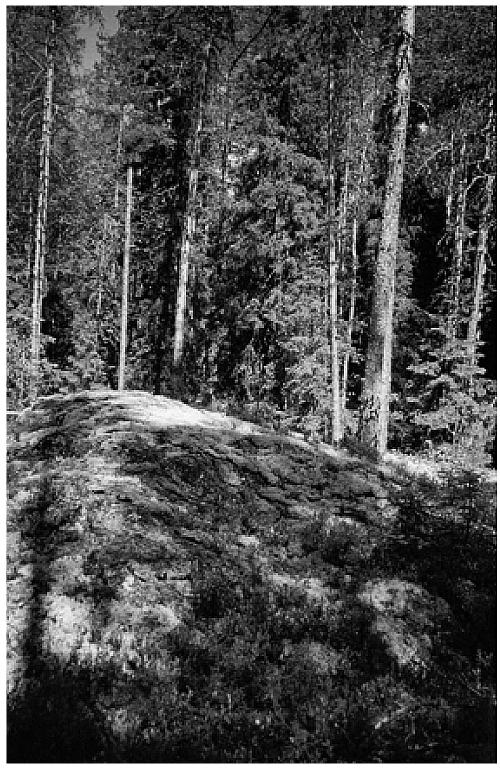

Fig. 4. Blocks of metamorphosed gabbro-diabases in middle taiga of Kivach Nature Reserve in the Republic of Karelia

the fine earth fraction of hard rocks as well as those in which fine earth contained an admixture of allochthonous moraine material were studied.

The indexation of soil horizons was given according to "Classification and Diagnostics of Russian Soils" (Классификация…, 2004). The physical-chemical properties were determined according to (Аринушкина, 1970); the "amorphous" and poorly crystallized iron was determined with oxalate extract (according to Tamm), and iron bound with organic matter was determined with pyrophosphate extract (according to Bascomb) (Воробьева, 1998). The bulk contents of elements were determined by the X-ray fluorescence method on Tefa-611.

The group and fraction composition of humus was determined by the Ponomareva–Plotnikova method. The soil organic matter in the extracts was determined by the wet (dichromate) combustion method (according to Tyurin), and the total content of organic carbon was determined using a Vario III.

The mineral composition of the rocks was studied in petrography thin sections on a Polam P-312. The mineral composition of the fine fractions was studied by the X-ray diffraction method on a DRON-2 diffractometer, with a cobalt anode, monochromator. Fine fractions were separated by the Gorbunov method after the preliminary treatment of fine earth with the Mehra–Jackson reagent.

RESULTS AND DISCUSSION

Geographical and morphological description of the soils

The study plots in the mountainous dwarf shrub-lichen tundra of Kola Peninsula are located in the Vud'yavriok creek valley (67°40,532' N, 33°39,316' E, at 430 m a.s.l). Huge blocks of nepheline syenites (diameter 1–2 m) on the surface undergo an intensive weathering. As a result of the redistribution of weathering products around the blocks, the old strongly weathered material of loamy texture is buried under the freshly accumulated gravely sandy material. The weathering products have also accumulated in small cavities on the upper surface of the rock blocks. So, in this case the most strongly weathered material is located on the top of the blocks. The side walls of the blocks are overgrown with bear-berry *Arctostaphyllos uva-ursi*, crowberry *Empetrum hermaphroditum*, and lichens *Cladonia* spp. and *Cetraria nivalis*, which gravely material accumulates. Pit. X-05-1b is located in the southern side of the block at a distance of 40 cm.

Oaomr 0–6 cm. Material is represented by a mixture of nepheline syenite derivates and fragments of the litter and raw-humus horizons of a dark gray with brownish tint (10YR3/2), slightly dry; slightly decomposed plant remains are abundant; the boundary is smooth.

BHFao 6–12 cm. Dark brown (coffee-like) 5YR3/2, slightly wet, loamy, structureless, abundant of living roots and their debris of different degree of decomposition; absence of the gravely material. The horizon is underlain by a solid surface of nepheline syenites.

M. Smooth massive nepheline syenites with no fissures and cavities on the surface.

This solum is characterized by the presence of a thin peaty litter horizon (O) with fragments of a raw-humus horizon (ao) and horizon with properties of both raw-humus and the illuvial Al-Fe-humus (BHF) horizon. According to the classification system (Классификация…, 2004) it should be classified as the BHFao one. The classification problem of shallow soils with Oao-BHFao-M profile has been elucidated earlier (Лесовая и др., 2008). We suggested to classify them as the type of *Lepto-podburs* (from Gr. *Leptos* – shallow), subtype of Raw-humus Lepto-podburs. They differ from typical podburs by superimposed O(AO) and BHF horizons. Pit X-05-1b should be classified as a gravely laterally accumulative Lepto-podbur because of the periodic input of fresh gravely and fine earth material onto the surface from the hard rock blocks. The main features of its solum are formed by the normal pedogenesis – *in-situ* transformation of soil organic matter and mineral matrix and the vertical migration of Al-Fe-humus compounds.

The accumulation of nepheline syenite derivates is present only in the nearest zone around the blocks. At some distance from the blocks, the surface layer is composed by the allochthonous moraine substrate. The vegetation community differs from that on the nepheline syenite side walls and is represented by dwarf birch *Betula nana*, crowberry *Empetrum hermaphroditum,* cranberry *Vaccinium vitis-idaea*. Their covering is about 50% of the surface. Among the lichens *Cladonia stellaris* and *Cetraria islandica* dominate, very rare are *Cetraria nivalis* and *Cladonia arbuscula*. Not far from the blocks of nepheline syenites (~1 m), on moraine substrates with an admixture of nepheline syenite material, Podzols are formed. Pit X-05-2 of humus-illuvial podzol is located 7 m to the south of Pit X-05-1b in a closed microlow. It is characterised by the following sequence of horizons: litter (+7–0) – Oao (0–3) – E (3–5) – BF (5–7) – BHF (7–15) – BC (f)(15–35) – 2BC (35–43).

Blocky outcrops of amphibolites are located in the northern taiga, to the south of Khibiny Mountains (67°32,65'N, 33°46,08'E). Their height reaches 5 m and width 10 m. The surface of the blocks is covered with lichens; cushions of *Cladonia: C. arbuscula, C. uncialis, C. stellaris.* Mosses (*Polytrichum commune*) are in the depressed stage. There are trees among the lichen cushions: sparse birch *Betula pubescens*, ash *Sorbus aucuparia,* spruce *Picea obovata.* Fine earth is accumulated in the microlows and small cavities in the block surface. The thickness of the fine earth layer in the blocks is up to 10 cm. Pit X-05-3a of raw-humus lepto-podbur is situated on the surface of a large amphibolite block.

Oao 0–2 cm. Dark gray 5YR2.5/1, moist, a lot of roots and pebbles of amphibolites, the latter are covered by dark-brown films, the boundary is smooth.

BHFao 2–6 cm. Brown 5YR2.5/2, evenly coloured, slightly dry, abundant pebbles, the light loamy fine earth material, loose crumby structure, a lot of living roots and their remains of different degree of decomposition. This horizon is underlain by a massive amphibolite bedrock. The rock fragments in the solum are covered with brown films.

M. The rock surface is dissected by small fissures; gravely and fine earth material is accumulated in the cavities.

Like in the case of nepheline syenites, the areas of soils that formed directly from the fine earth fraction of amphibolites are small. Soils on the moraine deposits dominate in soil cover. Along the periphery of the blocks, the depth of fine earth with an admixture of moraine substrate is 30–40 cm. The vegetation community differs from the one on the amphibolite blocks by a greater number of trees (birch, spruce and aspen) and a better development of mosses, herbs and dwarf shrubs. Pit X-05-3 c of iron-illuvial podzol with the following consequence of soil horizons: litter (+4–0 cm) – E (0–4) – BF (4–22) – M (brittle surface of the massive amphibolite bedrock) is located on a local elevation near a large block of amphibolites. The fine earth of this solum is characterised by an admixture of moraine material.

Metamorphosed gabbro-diabases of the middle taiga zone in Karelia occupy a lager area. They compose local residual ridges (selgas). Pit K-04-04 of raw-humus Lepto-podbur is located on the top of a small ridge in the south-east part of the Kivach Reserve (62°15,195' N; 33°57,278' E). The ridge is covered with lichens *Cladonia uncialis,* with an admixture of *C. arbuscula* (3–5%). Some spots on the surface have no vegetation. Accumulation of the local fine earth takes place in the rock fissures and cavities as well as in the case of amphibolites.

Litter +1–0 cm. Thalli of lichens with a well-preserved morphological composition.

Oaoe 0–3 cm. Brownish gray 7.5YR2.5/2, slightly dry, slightly compacted, loose crumb structure, texture difficult to determine due to the presence of organic matter from loamy sand to light loam; bleached light-coloured grains are present in the mass of horizon, their amount increases near the lower boundary with a thin (1–3 mm) bleached interlayer, fragments of darker spots with a lot of roots are on the boundary; the boundary is abrupt.

BHFao 3–6 cm. Brown to dark reddish-brown 5YR3/3, slightly dry, loam, fine crumby structure, penetrated by roots, the upper part of the underlying bedrock is brittle and may be crushed with a knife, below there is a massive bedrock.

M. Massive bedrock, the surface is covered by a network of fissures.

The depth of the fine earth near the ridges is 20–40 cm. The admixture of moraine material in the fine earth is very low. The vegetation community is represented by pine trees (70 years, some of them up to 100 years old). There are lingberry, bilberry and green mosses (*Pleurozium schreberi, Hylocomium splendens*) in the ground cover. Pit K-04-09 of typical podbur is located 1.5 km to the north-east of pit K-04-04 in the upper part of a low ridge. This ridge is covered with derivates of metamorphosed gabbro-diabases. The soil profile consists of the following horizons: litter (+4–0 cm) – Oao (0–4) – BHF(4–10) – BC(hf) (10–28) – M.

So, the described sola characterize the twin objects that are developed in the same bio-climate conditions and differ by the character of fine earth fraction: those only from the local hard rock (nepheline syenites, amphibolites, metamorphosed gabbro-diabases) and those with an admixture of acid moraine materials (podzols of mountainous tundra and northern taiga of Kola Peninsula) or with a local redistribution of fine earth from hard rocks with a small admixture of acid material (podbur of middle taiga in Karelia).

Mineralogical composition

Homogeneous / non-homogeneous soil parent substrate was determined on the base of the mineral composition of rocks and fine earth. In the mountainous tundra, in case of nepheline syenites, fine earth formation is a result of the physical disintegration and dissolution of weatherable minerals (pit X-05-1b). This leads to appearance of the amorphous phase on fine fractions. The fine earth of podzol (pit X-05-2) is non-homogeneous according to mineral composition. Cobble material from horizons E-BF mostly belongs to the epidote–amphibole–biotite gneiss. The influence of gneiss as a source of fine earth fractions is most pronounced in the E horizon. In the silty fractions of the E horizon mica prevails among clay minerals, and in the clay-size fraction the content of poorly ordered mixed layered chlorite–vermiculite (smectite) increases as a result of chlorite degradation. X-ray diffraction patterns from the clay size fraction in the lower horizons are similar to those from BHFao in the pit X-05-1b. The peaks of clay minerals are relatively weak and indistinct.

In the Lepto-podbur on the amphibolites in the northern taiga zone (pit X-05-3a), in the clay and silty fractions, clay minerals are absent because the "pre-pedogenic" alteration of these rocks did not result in phyllosilicate formation or pedogenesis. Fine earth is formed mostly by physical disintegration. The pebbly material from podzol (pit X-05-3c) is mostly derived from the leucocratic binary plagioclase-microcline granite but not from the amphibolites. In this solum, phyllosilicates are much better determined in silt fractions in comparison with clay-size ones due to disintegration of coarser fractions. This distribution is opposite to the usual regularity of phyllosilicate distribution in the fine fractions of podzols. Micas dominate among phyllosilicates in the BF horizon, and vermiculite as a product of mica degradation appears in the E horizon in silt fractions. In the clay-size fraction of the BF horizon, only poorly ordered mica is diagnosed among clay minerals. In the clay size fraction of the E horizon, the smectitic phase appears as a result of a more pronounced level of mica degradation in comparison with silt fractions. The accumulation of the smectite phase in the E horizon of podzols is normal, i. e. the ratio of its formation exceeds the rate of its eluviation from this horizon.

In the middle taiga zone, the initially basic rocks according to SiO_2 content (~60%) belong to the intermediate rocks (metamorphosed gabbro-diabases) that resulted from metamorphism and epigenetic transformation (Table 1).

In fine fractions of Lepto-podbur (pit K-04-04), phyllosilicates inherited from metamorphosed gabbro-diabases (chlorite, micas, kaolinite, mixed layered chlorite-vermiculite (smectite)) are detected in the solum. Chlorite degradation takes place in the medium silt fraction. Talc is detected in the clay-size

T a b l e 1. **Bulk content of some elements and extractable forms of iron and aluminium**

Horizon, depth, cm	SiO_2	Fe_2O_3	Al_2O_3	K_2O	CaO	MgO	TiO_2	Fe_2O_3o	Fe_2O_3p	Al_2O_3o
	% of calcined sample							%		
Gravelly laterally accumulative lepto-podbur on nepheline syenites, pit X-05-1b										
Oaomr, 0–6	49.21	4.42	29.39	2.28	4.34	1.47	1.16	0.29	0.23	2.55
BHFao, 6–12	37.74	4.80	46.14	1.50	1.33	2.27	0.91	0.72	0.67	11.24
Humus-illuvial podzol on nepheline syenites, pit X-05-2										
Oao, 0–3	61.49	5.22	17.46	3.47	4.84	1.16	2.22	0.31	0.41	0.47
E, 3–5	71.24	4.53	13.06	3.85	2.06	1.19	1.88	0.28	0.32	0.20
BF, 5–7	61.39	11.85	15.37	2.93	2.73	1.85	1.59	–	–	–
BHF, 7–15	51.29	8.65	29.23	2.36	2.72	1.72	1.20	1.56	0.75	7.55
BC(f), 15–35	56.52	6.04	25.97	2.63	3.01	2.36	0.98	0.50	0.22	7.61
2BC, 35–43	58.84	6.48	22.45	2.59	3.15	2.72	0.99	0.22	0.12	5.63
Raw-humus lepto-podbur on amphybolites, pit X-05-3a										
Oao, 0–2	61.44	10.32	11.30	0.67	8.43	1.62	2.93	0.74	0.70	0.41
BHFao, 2–6	61.44	11.39	11.96	0.30	8.01	2.17	2.75	0.48	0.50	0.26
M, 6–↓	54.76	17.23	12.04	0.12	10.57	2.87	1.26	–	–	–
Iron-illuvial podzol on amphybolites, pit X-05-3c										
E, 0–4	73.94	3.62	12.76	1.48	3.10	1.50	0.96	0.19	0.16	0.06
BF, 4–22	55.46	12.64	20.80	1.14	3.39	1.70	1.25	2.56	0.66	3.47

Table 1 (continued)

Horizon, depth, cm	SiO_2	Fe_2O_3	Al_2O_3	K_2O	CaO	MgO	TiO_2	Fe_2O_3o	Fe_2O_3p	Al_2O_3o
	% of calcined sample							%		
Raw-humus lepto-podbur on metamorphosed gabbro-diabases, pit K-04-04										
Oaoe, 0–3	67.95	7.57	14.44	0.50	4.85	1.77	1.69	0.94	0.68	0.62
BHFao, 3–6	67.87	8.36	12.36	0.45	5.14	2.29	1.66	0.88	0.66	0.72
M, 6–↓	60.65	9.92	11.43	0.27	8.80	5.40	1.10	–	–	–
Typical podbur on metamorphosed gabbro-diabases, pit K-04-09										
BHF, 4–10	67.98	8.13	15.31	1.07	2.77	2.07	1.25	1.07	0.44	0.74
BC(hf), 10–28	64.06	7.57	17.32	1.23	2.75	3.24	1.33	0.76	0.30	1.07

Note. o – extracted by oxalate, p – extracted by pyrophosphate, dashes – absence of determination.

fraction. The portion of vermiculitic (smectitic) layers in the mixed layered minerals increases in the fine earth fractions from the upper horizon (Oao). In the podbur (pit K-04-09) the mineral composition of fine fractions is identical to that in the pit K-04-04. Contrary to usual smectitic phase increasing in the sublitter horizon, there is no considerable redistribution of clay minerals in this profile.

In comparison to the nepheline syenites and amphibolites, the pre-pedogenic alteration of metamorphosed gabbro-diabases resulted in a considerable accumulation of phyllosilicates in it. A significant reserve of phyllosilicates in the coarse fractions determines their constant input to the clay-size one. This leads to the absence of a strong phyllosilicate redistribution in the solum. The profile of the studied podzols differentiated according to mineral composition was formed a result of an acid moraine substrate admixture, i. e. the initial lithological non-homogeneity of fine earth.

Physico-chemical properties and organic matter

The bulk content of elements in fine earth correlates with the homogeneity / non-homogeneity of sola according to mineral composition (Table 1). Lepto-podbur on nepheline syenites (pit X-05-1b), in comparison with podzol (X-05-2) developed on a mixture of allochthonous moraine material, is characterized by a low content of SiO_2 and a high level of Al_2O_3.

The content of oxalate-extractable aluminium in soils on nepheline-syenites is higher than the content of oxalate-extractable iron. Humic substances form complexes with iron compounds which are seen from the high content (up to 100%) of pyrophosphate-extractable iron in the oxalate-extractable one. Podzol is strongly differentiated by the bulk chemical composition. The presence of substrates allochthonous for nepheline syenites that is enriched by quarts and feldspars is the reason for the mentioned differentiation and oxalate-extractable aluminium.

Amphibolites belong to the group of basic rocks due to the bulk content of SiO_2 (Table 1). But the fine earth of solum (pit X-05-3a), even in the case of absence of allochthonous admixtures, differs from the initial rock by a higher content of silica and a lower one of iron and calcium. According to SiO_2 content, the fine earth corresponds to the intermediate rocks. In case of acid moraine substrate admixture, profile differentiation takes place like in the case of podzol (pit X-05-3c). The redistribution of soil organic matter transformation processes and non-silicate iron compounds is well pronounced in it. In the pit X-05-3a, oxalate-extractable ("amorphous") iron is mostly represented by iron-organic compounds, but in the pit X-05-3c, in the BF horizon, a considerable part of "amorphous" iron compounds is not bound with organic matter.

Soils of the middle taiga zone according to SiO_2 content belong to the group of intermediate rocks. The fine earth is homogeneous due to the bulk content of elements. The soils are characterized by a high content of iron, magnesium and titanium. In a thicker profile of podbur (pit K-04-09), the presence of moraine admixture is shown by the lower content of calcium, which may be due to admixture of more stable K-Na feldspars. Almost all "amorphous" iron is bound with organic matter in the Lepto-podbur (pit K-04-04). In case of podbur (pit K-04-09) in which the profile depth increases, the decomposition of organic matter transformation processes and nonsilicate iron content minerals take place as shown for podzol on amphibolites.

All the soils studied are acid (Table 2). The general regularity is that Leptic podburs have a higher content of the fine fraction in comparison with podzols and podbur. Organic horizons of these soils are of raw humus type with a high loss of ignition, low ash content and a substantial concentration of non-soluble C in plant residues (Table 2).

A significant portion of organic matter in mineral horizons was extracted with a standard pyrophosphate solution. A high concentration of the 1st and 2nd fractions of fulvic and humic acids is also typical of these soils. It reflects a high content of easily soluble humified matter. On the contrary, there is a rather low content of the 3rd fractions of fulvic acids and humic acids that are strongly bonded with sesquioxides and perhaps with clay minerals in the soil profile. It shows that the content of sesquioxides and clay minerals in the shallow profile of these soils is not enough to bond most of humified organic matter. In comparison with a pool of organic debris and humified material, a bulk mass of sesquioxides and clay minerals is too small for organic matter stabilization in these soils. The high ratio of organic carbon and nitrogen reflects a low content of nitrogen in soil organic matter.

The value of non-hydrolyzed remnants is high and results from non-decomposed plant remains. This characteristic decreases in BHFao horizons where it characterises the more stable organic matter. Another specificity of these horizons is that almost all oxalate-extractable iron is related with organic matter. In spite of the bioclimatic conditions (mountainous tundra – middle taiga), in all profiles in BHFao horizons the Cha / Cfa ratio and the value of the 1st fractions of fulvic and humic acids related with non-stable sesquioxides are high. A potential source of these sesquioxides, especially iron, could be amphiboles and pyroxenes of soils on nepheline syenites, amphibolites of Kola Peninsula and pyroxenes of metamorphosed

Table 2. **Some physical-chemical and organic matter properties of soils**

Horizon	pHH$_2$O	< 0.01 mm, %	Cp	LI	C%	Cha/Cfa	1	2	3	1a	1	2	3	C : N
			%				Humic acids			Fulvic acids				
							Carbon of fractions, % of C in soil							
Gravelly laterally accumulative lepto-podbur on nepheline syenites, pit X-05-1b														
Oaomr	4.6	–	4.6	49.8	34.1	0.85	10.0	6.7	7.0	10.7	0.4	13.1	3.9	27
BHFao	5.4	27.4	14.4	–	21.8	0.96	12.5	8.0	8.8	13.7	1.0	12.3	3.5	23
Humus-illuvial podzol on nepheline syenites, pit. X-05-2														
Oao	4.4	–	4.2	62.5	36.5	1.68	12.2	3.8	9.2	1.2	4.2	5.4	4.2	26
E	4.6	16.7	0.4	–	2.9	–	–	–	–	–	–	–	–	23
BHF	5.3	12.6	7.5	–	9.9	0.27	5.5	4.8	3.6	14.4	3.9	28.2	4.6	26
BC(f)	5.4	15.3	2.1	–	–	–	–	–	–	–	–	–	–	18
2BC	5.6	21.1	1.0	–	1.7	–	–	–	–	–	–	–	–	17
Raw-humus lepto-podbur on amphybolites, pit. X-05-3a														
Oao	4.4	–	4.5	44.8	32.0	1.51	4.7	15.3	5.7	1.5	4.9	7.0	3.4	23
BHFao	4.5	29.1	2.3	–	7.6	0.76	12.8	6.6	4.7	1.0	17.7	0.0	12.8	24
Iron-illuvial podzol on amphybolites, pit. X-05-3c														
E	4.6	11.4	0.2	–	2.1	–	–	–	–	–	–	–	–	34
BF	4.8	11.3	1.9	–	3.7	0.19	6.9	1.4	4.3	22.0	1.8	37.9	4.3	25
Raw-humus lepto-podbur on metamorphosed gabbro-diabases, pit. K-04-04														
Oaoe	4.2	–	3.5	28.9	10.0	–	–	–	–	–	–	–	–	20
BHFao	4.4	34.8	2.2	17.2	5.4	0.92	13.0	9.2	4.6	12.1	3.9	9.2	3.9	19
Typical podbur on metamorphosed gabbro-diabases, pit. K-04-09														
BHF	4.6	12.7	1.5	–	–	–	–	–	–	–	–	–	–	–
BC(hf),	4.8	10.0	0.8	–	–	–	–	–	–	–	–	–	–	–

Note. C – total organic carbon, Cp – carbon, extracted by pyrophosphate, LI – loss on ignition, Cha – carbon of humic acids; Cfa – carbon of fulvic acids; C : N – carbon and nitrogen ratio.

gabbro-diabases of Karelia. This rather labile system of soil organic matter in shallow soils should have a significant reaction capacity for soil minerals' weathering (Sverdrup, 1990) and quite a high rate of soil organic matter mineralization (Чертов и др., 2007).

There is a high concentration of fulvic acid fractions 1 and 2 in the Al-Fe-humus horizons of podzols. It reflects a rather high solubility of soil organic matter, as pointed out above, and the participation of this organic matter in the processes of soil minerals' weathering (marked by fulvic acid fraction 2). The admixture of an acid moraine substrate which potentially contains a low level of silicate iron and the increase of solum depth as a result of local fine earth redistribution lead to a decrease of iron in complex with organic matter content.

CONCLUSIONS

1. The small depth of soils on a massive substrate – "Lepto-podburs" – is a pedogenetic factor. Their recent pedogenic processes are restricted to one soil horizon as it is not enough depth and fine earth to form a proper soil profile. These processes are: (i) transformation of soil organic matter *in situ*, (ii) formation and migration of R_2O_3– organic complexes, (iii) mineral disintegration.

2. The proper soil profile with a set of soil horizons formed by recent pedogenic processes occurs in case of admixture of acid moraine substrate and fine earth depth increase (mountainous tundra and northern taiga of Kola Peninsula) and depth increase due to local fine earth redistribution (middle taiga, Karelia).

Received 14 June 2008
Accepted 17 July 2008

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Sofia Lessovaia, Oleg Chertov, Sergey Goryachkin

DIRVODAROS YPATYBĖS SEKLIUOSE DIRVOŽEMIUOSE ANT RYTŲ FENOSKANDIJOS MASYVIŲJŲ UOLIENŲ

S a n t r a u k a

Buvo tyrinėjami seklūs dirvožemiai, susiformavę po kerpių ir samanų su kerpėm danga ant masyvių kristalinių uolienų Rytų Fenoskandijoje. Dirvodarinės uolienos skyrėsi pagal kilmę ir sudėtį: (i) nefelino sienitai, (ii) amfibolitai, (iii) metamorfiniai gabro diabazai bei (iv) jų derivatai (t. y. jų antriniai produktai). Be įprastų, ant moreninio substrato susiformavusių *podzol* (tipingųjų jauražemių) ir *podbur* (t. y. jauražemių be eliuvinio horizonto, panašių į rudžemiškuosius jauražemius) bei *pertozem* (paklotė ant uolos) ant masyvių uolienų buvo ištyrinėtas gana retas atvejis – žvyringi seklūs (<5–10 cm) dirvožemiai, susidarę iš masyviųjų uolienų smulkžemio be kitos kilmės nuogulų priemaišos. Šie dirvožemiai vadinami *Leptosols* (WRB, 2006), arba *Leptopodbur* (pagal Rusijos dirvožemių klasifikavimą ir diagnostiką, 2004). Šiuolaikiniai dirvodaros procesai juose (organinės medžiagos transformacija *in situ*; silikatų geležies imobilizacija geležies ir organinių medžiagų kompleksuose, skaidymasis) dėl dirvožemio plonumo praktiškai neišsiskirstę į horizontus. Pedogeniškai kintant mineralinei matricai smulkiosiose frakcijose neatsiranda sluoksniuotųjų silikatų, jei jų nebuvo gimtosiose uolienose.

Raktažodžiai: dirvodara, organinės dirvožemio medžiagos, mineralinė sudėtis