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Surface Gleying in Forest Soils

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Depending on the duration of a perched water table as well as on textural discontinuity of pedogenetic or stratified origin within the soil, we have identified three types of forest-soil systems relevant soil genesis. The first with a perched water table of short duration and *Oxalis* vegetation carries Stagnic Luvisols with a profile characterized by synchronous ferrolysis, lessivage, accumulation of scattered ferrous-ferric neoformations, mottlings and marbling. The second has Gleyic Podzoluvisols with a bisequal eluvial profile formed during prolonged stagnation of perched water under the *Oxalis-Myrtillus* vegetation. Percolation and podzolization are characteristic of the upper solum where gleyic properties are absent and stagnic properties are weakly developed. The lower profile has stagnogleyic properties with a bluish tinge, enriched with ferrous compounds and numerous secondary ferric mottlings. The third type of site is waterlogged for long periods and has *Aegopodium* vegetation. Calcari-Gleyic Luvisols and Eutric Planosols with marked stagnic and gleyic properties are formed as a result of ferrolysis, surface gleying shown as by bluish neoferrans and marbling as well as by ferric mottles, lessivage and accumulation of ferrous iron *in situ*. We suggest ratios of the humus to chemical indices of the various horizons to identify pedogenetic phenomena.

Key words: Estonia, surface gleying, ferrolysis, Stagnic Luvisol, Gleyic Podzoluvisol, Eutric Planosol.

Introduction

Special attention has always been paid to the diagnostic features of waterlogged soils to identify their ecological and genetic characteristics in the progress and evolution of any soil continuum depending upon the ground and/or surface aquic situation (Schlichting & Schwertmann, 1973; Zaidelman, 1974; Vaičys, 1975; Baize, 1989; Blume, 1990; Zvereva et al., 1997; Park & Burt, 1999; Matinian, 1999). In accordance with the US Soil Taxonomy, aquic moisture relationships are characterized by saturation with water for periods long enough to give reducing conditions throughout the soil or in its lower horizons (Bouma, 1983). Under the influence of stagnant perched water in the upper horizons of heavy-textured soils and/or at the junction of layers of contrasting texture, reduction alternates with oxidation. This results in formation of stagnic and gleyic properties (Blume, 1990; Driessen & Dudal, 1991) involving ferrolysis, changes in ferrous-ferric relationships and appearance of ferrous neoformations (Brinkman, 1979;). Stagnic and Gleyic soils are widespread (Dudal, 1990), so their genesis has always attracted attention also because of the similar morphology of some eluvial soils, the genetic nature of, and distinction between surface gleying, lessivage, ferrolysis, podzolization, etc. and the respective soils have been much studied (Schlichting & Schwertmann, 1973, Zaidelman, 1974; Vaičys, 1975; Brinkman, 1979; Zonn, 1986, 1996; Baize, 1989; Zvereva et al., 1997).

Aquic conditions are widespread on flat land in Estonia. Different Gleyic and Gleysols form about 50% of total and 48% of the forest territory, respectively (Kokk, 1995). The effects of pseudopodzolization (seasonal gleying in the upper profile accompanied by lessivage and deferritization) rather than podzolization, recognized in the past, was studied (Reintam, 1971). Later, further information about surface gleying and ferrolysis as well as stagnic and gleyic properties was assembled by various authors (Dudal, 1990; Brinkman, 1979; Blume, 1990), while in Estonia a comparative study of the diagnostic features and genesis of some surface gleyed soils was conducted and discussed at several conferences (Reintam, 1986, 1990, 1995; Reyntam & Tsobel, 1991). In Estonia, about 19% of total territory and 8% of the forest areas are covered with soils of seasonal surface waterlogging (Kokk, 1995). They occur mainly within the watershed uplands of Southern

Estonia and in transitional areas both to Peipsi and West-Estonian Lowlands. The present paper focuses the genetic origin of forest soils developed in temporary aquic conditions that induce surface gleying.

Material and methods

In spite of the presence of database on the whole territory, the soils for this study were selected on the site of Forestry Training and Experimental Centre "Järvselja" of the Estonian Agricultural University (Kasesalu, 1993), South-Eastern Estonia (58°16'N, 27°23'E) where the variability of surface-gleyed soils appeared in a short distance within only some forest compartments. Here reddish-brown loamy till is deeply leached during the Holocene and only rarely contains carbonates within 1–1.5 metres depth. Flat glacial plains and ridges rise from the shallow shoreside basin of Lake Peipsi resembling "islands". In this way reddish-brown till is patchely covered with lacustrine and/or colluvial sandy deposits which form the upper layer of bisequal profiles. Most of the soils have a perched aquic regime. The vegetation is mixed Norway spruce and deciduous (silver birch, aspen, black alder, maple, lime-tree) forest of varied types and is largely undisturbed. The classification of forest site types described by Lõhmus (1984) is used.

Stagnic (Albi-Gleyic) Luvisols (A–Ewg–Bt or Btg–C profile) with a perched water table of short duration in the Ewg-horizon were investigated on re-afforested arable land (Figure 1). The data on the influence of afforestation on the characteristics of Luvisols were published in the *Proceedings of the First International Symposium on Forest Soils* (Reintam, 1990) and partly provide basic information for the discussion in this paper. Podzoluvisols (A–E–Eg–Bg–C), Planosols and Luvisols (A–EwG–Btg–C) with a perched water table of prolonged duration and different stagnic and gleyic properties occur in the environs of the Järvselja Virgin Forest Reserve. The first results of comparative plant community, forestry and pedogenetic investigations were discussed and published (Reintam et al., 1987, 1991; Reintam, 1995), while the main topics of surface gleying have not been previously considered. The morphological description and sampling of soil profiles were carried out by the traditional and well-known way used in soil science everywhere. The soils are classified in accordance with the concepts of FAO (1994) and by Driessen & Dudal (1991).

Figure 1. Young Norway spruce stand of 37 years planted on arable land in 1954.

The soils were analysed at the laboratories of the Institute of Soil Science and Agrochemistry, Estonian Agricultural University. Fine earth with particle size less than 1 mm was used. The group and fractional composition of humus was determined by alternate acid-alkaline treatment after the Tyurin-Ponomareva volumetric method (Ponomareva, 1957) with the obtained results expressed in percentages of organic carbon. The total percentage of the latter and nitrogen were ascertained by Tyurin (analogy is the Anne method) and Kjeldahl methods, respectively (Arinushkina, 1970; Ranst et al., 1999). Nonsiliceous (dithionite-extractable) iron was determined after Coffin, amorphous (oxalate-extractable) sesquioxides and silica, after Tamm and iron activity (Feo : Fed), after Schwertmann (Ranst et al., 1999). Exchangeable aluminium was determined after Daikuhara-Sokolov in 0.1M KCl, base saturation, after Kappen and particle-size composition, after Katchinsky (Arinushkina, 1970). Total chemical analysis following alkaline fusion treatment was conducted, iron and aluminium were ascertained with sulphosalicylic acid and aluminone, respectively (Arinushkina, 1970). Molecular ratios were calculated using the chemical data obtained.

Results and discussion

Surface gleying of short duration

The perched water table of short duration near the top of any forest loamy Luvisol profile has led to formation of a bleached horizon with small ferric concretions and rusty mottlings directly below the humus horizon. An increase in textural discontinuity due to progress of lessivage tends to be accompanied with the gleyic pattern, blue in colour, not only in root channels, but also on the ped matrix of the Bt-horizon. This phenomenon was also described in Lithuania (Vaičys, 1975) and in the United Kingdom in the upper position of soil catena (Park & Burt, 1999). After Blume (1990), such features in our soils are stagnic in their origin but resemble strongly gleyic formations against the background of the reddish-brown surface of the tilly profile. As stability is characteristic of blue neoformations in the Ewg–Btg subsection, it can be suggested that ferrous iron is located within the structure of secondary alumosilicates rather than in interlayers (Brinkman, 1979) (Figure 2).

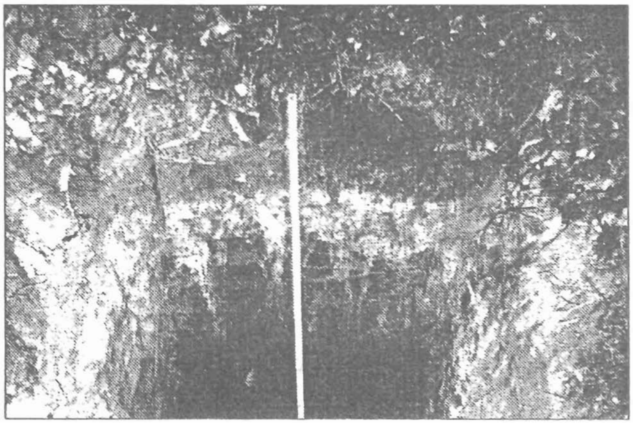

Figure 2. Stagnic Luvisol with surface gleying of short duration under the young Norway spruce stand.

Stagni-gleyic properties are characterized by some iron relationships under different vegetation (Table 1). Prevalence of amorphous compounds over crystalline ones is shown by the marked Fe-activity in all sola. At the same time, Stagnic Luvisol profiles are characterized by relatively uniform distribution of total nonsiliceous iron oxides. Rapid recrystallization of amorphous pedogenetic products, characteristic of brown forest soils in the conditions of oxidation (Zonn, 1982, 1996; Park & Burt, 1999), seems to be excluded under temporary waterlogging. That is why reduction of amorphous ferric oxides is feasible, and consequent insertion of ferrous iron into the structure of clay minerals is favoured (Brinkman, 1979). There is no doubt that amorphous coatings of ferrous iron have been formed both on the grains of primary minerals and on pore walls, while a tendency of the equilibrium between the processes of iron mobilization, reduction, formation of coatings, and secondary ferrous silicates becomes evident (Figure 3).

Table 1. Chemical characteristics of Stagnic (Albi-Gleyic) Luvisols

Vegetation	Horizon and depth, cm	Fe-activity, %	Non-siliceous Fe_2O_3, % of total	Molecular ratios of oxides in				Ratios of nonsiliceous Fe_2O_3 to	
				fine earth		clay			
				Si:Fe	Si:Al	Si:Fe	Si:Al	clay	silt + clay
Scots pine stand of (*Hepatica*-) *Oxalis* site type (>100 yrs)	A 0-10	88	22	93	24	6.2	4.8	0.08	0.01
	A 10-20	97	27	94	22	6.2	4.3	0.08	0.02
	Ewg 22-32	89	22	68	17	5.6	4.2	0.07	0.02
	Btg 35-45	93	14	43	16	4.4	4.4	0.03	0.01
	Btg 55-65	77	15	48	16	4.4	4.4	0.03	0.01
	C 90-100	55	23	50	19	4.1	4.3	0.05	0.02
Young Norway spruce stand of *Oxalis* site type (37 yrs)	A 0-10	81	31	132	21	5.4	4.2	0.09	0.03
	A 10-20	66	31	133	18	6.0	4.2	0.08	0.02
	Ewg 21-30	56	31	80	16	4.9	3.8	0.09	0.03
	Btg 30-40	47	41	68	18	4.3	4.1	0.06	0.03
	Btg 45-55	34	37	54	14	4.2	3.9	0.08	0.03
	Bt 60-70	62	21	54	18	4.1	4.1	0.05	0.02
	C 90-100	40	23	52	17	3.4	4.1	0.07	0.03
Field fallow, *Deschampsia–Agrostis* ass. with *Juncus sp.* and *Carex leporina*	A 0-10	38	46	140	20	3.1	4.3	0.11	0.03
	A 10-20	88	18	125	19	4.0	5.1	0.09	0.02
	A 20-28	83	25	134	23	4.8	5.3	0.07	0.02
	Ewg 28-40	89	26	95	21	4.8	4.5	0.08	0.02
	Btg 40-50	44	34	58	16	4.1	4.7	0.08	0.03
	Btg 50-60	82	16	61	16	4.9	5.5	0.04	0.02
	Btg 65-75	87	18	71	15	4.0	3.9	0.05	0.02
	BC 85-95	52	29	71	18	5.0	4.3	0.08	0.03

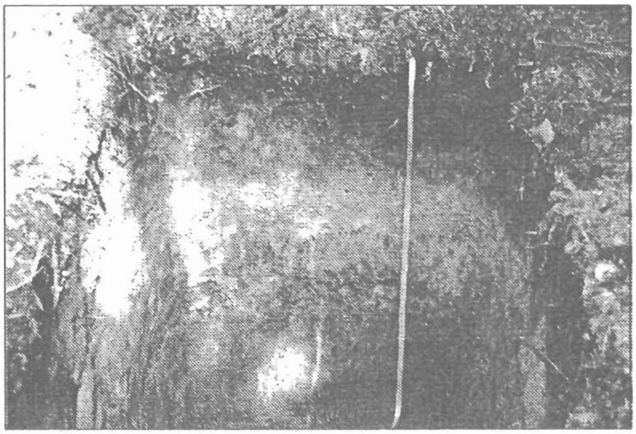

Figure 3. Gleyic Podzoluvisol with bisequal eluvial horizon – Gleyic Podzoluvisol subsection on the subsection of Eutric Planosol.

Translocation of iron can be assumed on the basis of $SiO_2 : Fe_2O_3$ ratio for fine earth. However, after suggestions of Baize (1989) and Matinian (1999), it is impossible to interpret this phenomenon as podzolization, because aluminium is homogeneously distributed in fine earth with depth and is stable in the clay fraction. Changes in silica : ferroxides ratios are obviously due to lessivage, as far as nonsiliceous ferric-ferrous compounds reveal even accumulation in top and mid of soil profiles. Textural discontinuity resulting from lessivage is marked by redistribution of ferrous silicates. However, the movement of mobile amorphous oxides is impeded by neoargillans as described by Washer & Collins (1988) in Florida. The depletion of clay from iron in the humus horizon of forest soils is probably due to increased reduction and chelation in the presence of free fulvic acids, which results in rapid regeneration of nonsiliceous forms of ferrous iron without interaction with clay. In spite of this, the ratio of nonsiliceous dithionite-extractable iron oxide to both clay and silt + clay remain constant throughout the profiles.

Surface gleying of prolonged duration

Soil formation under prolonged perched water stagnation depends on the depth of the textural discontinuity. The deeper it is, the thicker the solum leached by downward movement of water. After Zaidelman (1974), percolative-stagnic and stagnic moisture relationships are characteristic of these situations. Depending upon moisture status, different forest ecosystems are formed, while the calcareousness and texture of the parent till play a great role (Reintam et al., 1987). Disappearance of *Myrtillus* and occurrence of *Galeobdolon* are typical of the enrichment of forest site types on the soils with surface gleying.

The *Oxalis-Myrtillus* vegetation is typical of the soils of percolative regime both in automorphic and surface-hydromorphic conditions. Prolonged duration of a perched water table in the loamy topsoil can be diagnosed by the presence of hygromezophytic herbs exigent of mineral nutrients. Such vegetation is characteristic of the *Aegopodium* forest site type which occupies first of all large territories on Gleyic Cambisols and Gleyic Luvisols of ground gleying in other regions of Estonia. However, their occurrence in the conditions of surface gleying could be diagnostic for ascribing gleyic attributes to Planosolic formations and for distinguishing the latter from Gleyic Luvisols. Ground litter is practically absent from the areas of the *Aegopodium* vegetation, which demonstrates very rapid transformation of falling litter and turnover of substances. Bisequal ground litter of *Moder*-type with thickness of 3–7 cm and supply of 3–5 kg m^{-2} characterizes the *Oxalis-Myrtillus* forest site type (Reintam et al., 1987, 1990).

Irrespective of the depth, continuity and character of surface overmoistening as well as of plant community and ground litter status, humus-accumulative process has resulted in formation of fulvic-humic humus which is rich in nitrogen and predominantly complexed with active sesquioxides (Table 2). Taking the C : N ratio into consideration, maturity of humus shows evident progress through the decrease in water percolation. As Schoneau & Bettany (1987) suggested, influx of labile N-rich fulvic compounds into the bleached stagni-gleyic horizon is probable. As a result of fixation of fulvic-humic complexes with active sesquioxides, amongst which ferrous complexes must be present, the humus of the eluvial section of both Gleyic Luvisols and Planosols in the humus-accumulative horizon has become Ca-fulvic against the background of a high degree of humification. Such humus relationship tends to be favourable for ferrolysis (Brinkman, 1979; Bouma, 1983) and for prevention of podzolization.

Table 2. Humus characteristics of soils with prolonged surface overmoistening

Soils,[a] compart-ment	Horizon and depth, cm	C	N	C : N	C, % of total organic C			H.a.[b] / F.a.	1st fr.[c] / 2nd fr.
		%			soluble fract-ion	humic acids	free fulvic acids		
PDg	A 10-20	2.88	0.13	22	55	30	5	1.4	4.8
242	E 25-35	0.51	0.04	13	29	8	14	0.4	9.0
	Eg 38-47	0.39	0.05	8	29	6	11	0.4	2.5
PLe	A 0-10	3.00	0.25	12	53	24	13	0.9	8.2
242	A 10-20	2.10	0.13	16	63	29	19	0.9	5.2
	Ewg 22-32	0.80	0.07	11	59	29	16	1.0	11.1
LVcg	A 0-10	3.80	0.46	8	66	32	15	1.1	26.5
228	A 10-20	2.80	0.29	10	79	43	22	1.3	4.8
	EwG 25-35	0.34	0.03	11	86	23	23	0.4	0.4
LVcg	A 0-10	6.72	0.54	12	53	25	2	1.0	1.7
243	A 10-20	4.68	0.39	12	65	27	2	0.8	1.7
	EwG 20-30	0.28	0.05	6	79	18	11	0.3	0.6

[a] PDg — *Gleyic Podzoluvisol*, PLe —*Eutric Planosol*, LVcg — *Calcari-Gleyic Luvisol*

[b] Humic acids : Fulvic acids (here and further)

1st fr. (humic and fulvic acids bound with mobile sesquioxides) : 2nd fr. (humic and fulvic acids bound with alkaline earths) ratio

At the same time, complexity of humus with active sesquioxides and its change into fulvic humus are characteristic of percolative water regime. Compared with surface aquic Luvisols and Planosols, a bisequal eluvial profile described already by Brinkman (1979) can be observed in Gleyic Podzoluvisol. The upper horizon (E) is impoverished with respect to iron (Table 3) and clay, whereas Al-fulvic complexes are predominant here (Reintam et al., 1991). The lower horizon is stagni-gleyic (Eg), formed particularly as a result of influx of saturated ferrous fulvates and fixed with alkaline-earths delivered as a result of silicate weathering. Such a sequence of humus status allows us to interpret this soil as Gleyic Podzoluvisol, although podzolic attributes tend to prevail over luvic (lessivage) in the upper part of the eluvial profile. Except for the upper eluvial horizon of Gleyic Podzoluvisol, soils of prolonged surface gleying are characterized by the profile uniformity in the aluminium content, although impoverishment with respect to iron and its redistribution are evident. After Brinkman (1979) and Baize (1989), this represents typical ferrolysis which occurs in the reduction of ferric pedogenetic products during the continual waterlogged season and redistribution of ferrous iron within the section of Ewg(EwG)–Btg. Reoxidation as well as recrystallization of mobile ferrous iron can occur in the dry season. These processes have been described both in "lithomorphic" and "pedomorphic" Planosols in Champagne Humide, France (Baize, 1989) as well as in the North-West of Russia (Matinian, 1999) and in the Far East (Zonn & Zapozhnikov, 1998).

Table 3. Chemical characterization of soils with surface overmoistening of prolonged duration

Soils *	Horizon and depth, cm	Nonsiliceous Fe_2O_3, %		Fe-activity, %	Ratio of SiO_2 to		Ratio of nonsiliceous Fe_2O_3 to	
		of soil	of total Fe_2O_3		Fe_2O_3	Al_2O_3	clay	silt + clay
PDg	A 10-20	0.10	3	60	79	33	0.03	0.01
	E 25-35	0.15	6	40	93	24	0.02	0.01
	Ewg 38-47	0.40	18	60	103	17	0.06	0.02
	Bg 50-60	1.38	35	52	55	16	0.09	0.02
	BC 105-115	0.94	36	32	81	14	0.08	0.03
PLe	A 0-10	0.29	8	72	65	15	0.05	0.01
	A 10-20	0.38	17	55	102	19	0.06	0.02
	Ewg 22-32	0.37	27	57	159	20	0.05	0.02
	Btg 35-45	0.74	12	73	35	17	0.05	0.02
	BC 110-120	1.28	39	12	66	17	0.12	0.04
LVcg	A 0-10	0.50	34	54	159	22	0.11	0.03
	A 10-20	0.44	31	68	165	23	0.11	0.02
	EwG 25-35	1.04	35	43	74	21	0.08	0.04
	Btg 40-50	0.92	36	20	89	21	0.09	0.03
	C 110-120	0.98	36	21	76	21	0.08	0.03
LVcg	A 0-10	0.48	20	65	94	25	0.12	0.03
	A 10-20	0.69	35	80	117	20	0.19	0.03
	EwG 20-30	0.65	33	37	111	25	0.11	0.03
	Btg 30-45	0.81	28	42	75	16	0.08	0.03
	C 85-95	0.87	32	33	78	16	0.11	0.02

* Abbreviations See Table 2.

The mottled colour of the profile is due to the distribution of ferric-ferrous compounds on minerals and in their crystalline structure (Mokma, 1993). Eluvial horizons with stagni-gleyic properties contain sufficient quantities of amorphous ferrous materials to cause their light colour with a bluish tinge. A well-developed tonguing as well as stagni-albi-gleyic neocutans, described by Vepraskas & Wilding (1983) from the forested toposequence of Alfisols, are also typical of the agrillic section of surface gleying and allow us to identify and confirm seasonal saturation and iron reduction. Amorphous ferrous complexes have obviously accumulated in the Bg-horizons as coatings on mineral grains (Table 3). However, accumulation of recrystallized ferrous formations on the walls of pores and root channels cannot be excluded. In spite of high iron activity, the top of some humus horizons and the eluvial horizon of podzolic origin contain extremely small amounts of amorphous compounds in the conditions of percolative water regime, and their colour is caused by humus and by nearly colourless quartz, respectively. Ratios of nonsiliceous iron oxides to fine-dispersed fractions (Table 3) demonstrate podzolic-stagni-gleyic differentiation in Gleyic Podsoluvisols and stagni-gleyic differentiation in both Planosols and Gleyic Luvisols. Their possible podzolization is completely excluded and ferrolysis appears the main pedogenetic process (Figures 4, 5).

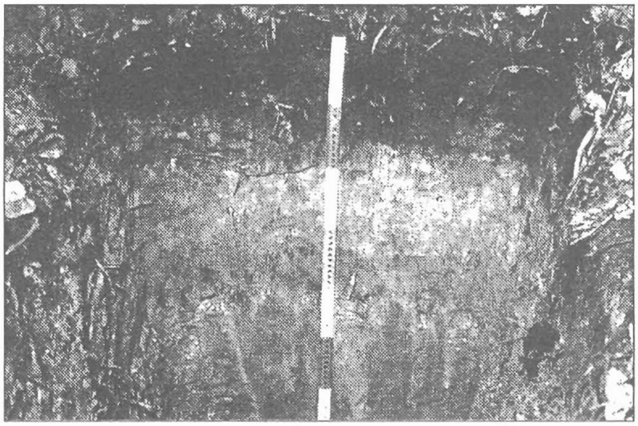

Figure 4. Stagnic Luvisol with surface gleying of prolonged duration in the Järvselja Virgin Forest Reserve.

Figure 5. Eutric Planosol with surface gleying of prolonged duration.

Besides the criteria of the discussed genetic diagnostics, several ratios between the indices of different diagnostic horizons were calculated (Table 4). Differences between the indices of humus relationship of the upper (A') and deeper (A") parts of the humus horizon could be used as ratios for distinguishing organic agents for pedogenetic activity. By means of the relationship between the status of sesquioxides, base saturation, etc. it is possible to characterize the output of pedogenesis itself.

Table 4. Ratios of indices in different horizons

Characteristics		Soils			
		PDg	PLe	LVcg	LVcg
Organic C	(A' : A")	3.6	1.4	1.4	1.4
Degree of humification	(A' : A")	3.8	0.8	0.7	0.9
Nonsiliceous Fe_2O_3	Bg : A	10.1	3.1	2.1	1.7
	Bg : Ewg(E)	6.7	2.8	0.9	1.2
	ELg(E) : A	1.5	1.1	2.2	1.4
Base saturation :	Bg : A	3.0	2.8	1.6	1.2
	Bg : Ewg(E)	1.7	3.1	1.1	1.1
	Ewg(E) : A	1.7	0.9	1.5	1.1

Temporarily surface-waterlogged Stagnic Luvisols (Dystric Planosols) with eluvial horizons directly under the humus-accumulative horizon and at the junction of layers of contrasting texture with stagnic and stagnigleyic properties, respectively, were studied on reddish-brown noncalcareous till under the spruce stands of the *Oxalis* forest site type in South-Eastern Estonia (Reintam, 1986). An illuvial horizon with ferric properties occurs between two eluvial ones, the argillic horizon below the contact stagni-gleyic horizon containing blue-coloured marbling and ferrous-ferric mottlings on its peds and root channels. In contrast to the suggestion by Kashansky (1974), the interpretation of the chemical and mineralogical data shows that synchronous progress of ferrolysis, lessivage, surface gleying and argillization is characteristic of the genesis of these bisequal soils (Reintam, 1986). Ratios of the percentage of nonsiliceous iron to that of clay (silt + clay), calculated on the basis of earlier published data, reveal profile uniformity except in the thin subsequence of A–Ewg horizons at the top. Like the "minipodzol" after Brinkman (1979), the sequum shows a smaller ratio against the background of iron activity higher than 90%. It means that modern ferrolysis develops on the basis of previous podzolization, while recrystallization of amorphous iron is accompanied by formation of ferric mottlings in the following horizon. After Wang et al. (1989), crystalline iron oxides impede podzolization.

Conclusions

The diagnostics and pedogenetic characterization of forest soils with seasonal surface aquic regime and gleying can be concluded as follows.

(1) A perched water table of short duration results in formation of Stagnic Luvisols under stands of the *Oxalis* forest site type. Surface gleying is expressed by the presence of ferric mottlings and micronodules in the albi-stagnic horizon, which shows rapid alternation of oxidation-reduction conditions. Bluish marbling on ped surfaces and root channels is typical of the argillic horizon. Intensive ferrolysis is revealed by high iron activity in the entire profile, while consequent insertion of ferrous iron into the structure of clay minerals is favoured. Only a slight translocation of iron indicates synchronous ferrolysis and lessivage (pseudopodzolization) without breakdown of alumosilicates. The uniformity of dithionite-extractable iron to the clay size fraction ratio is a good criterion to diagnose ferrolysis and short periods of surface gleying. Against the background of clay/silt lessivage, the accumulation of nonsiliceous (probably ferrous) iron is noteworthy.

(2) Prolonged stagnation of a perched water table is due to pedogenic textural discontinuity formed during previous soil development under the conditions of subsequent automorphism and/or short-time hydromorphism. This leads to differentiation of organic agents, disappearance of *Myrtillus* and occurrence of *Galeobdolon-Asperula-Mercurialis* typical of alternation of the *Oxalis-Myrtillus* forests on Gleyic Podzoluvisol with the *Aegopodium* forests on Eutric Planosol and/or Calcari-Gleyic Luvisol. Favoured ferrolysis is due to an influx of labile N-rich fulvic compounds into the stagni-gleyic horizon where their transformation into Ca-fulvates takes place.

(3) The bisequal eluvial profile is diagnostic of Gleyic Podzoluvisol: the upper horizon (E) is impoverished with respect to iron and clay, the lower one (ELg) is stagni-gleyic in its origin and similar with respect to aluminium with the underlying gleyed argillic horizon. Redistribution of ferrous iron within the Ewg(G)–Btg horizons can take place, while partial reoxidation and recrystallization of ferrous iron into ferric iron produce mottlings on the whitish and/or bluish horizon and on bluish-marbled reddish-brown argillic peds and pore walls. In spite of high iron activity, the ratio of nonsiliceous iron oxides to fine-dispersed fractions demonstrates bisequal differentation in the Gleyic Podzoluvisol profile.

(4) In addition to well diagnosable stagnic properties in the albic horizon of the Planosol profile, the attributes of surface gleying became evident. Bluish tinge and ferric mottlings are characteristic of the albic horizon underlain by the argillic solum marbled as a result of surface gleying. Eutric Planosols can genetically be compared with Calcari-Gleyic Luvisols, the *Aegopodium* forest site type being a diagnostic for both formations.

(5) Depending upon the situation in forest vegetation, differences between the indices of humus relationship of the upper and deeper parts of the humus horizon are suggested for diagnosing pedogenetic agents. Ratios larger than three can characterize contrasting differences between the subsequums of organoprofile and topsoil eluviation there. Ratios of the status of sesquioxides, iron activity, base saturation, etc. of various horizons allow us to identify podzic, stagnic and luvic phenomena. Profile homogeneity according to these ratios can be used for distinguishing stagni-gleyic properties from the properties of podzolic and podzoluvic origin.

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ПОВЕРХНОСТНОЕ ОГЛЕЕНИЕ ЛЕСНЫХ ПОЧВ

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Резюме

В зависимости от длительности застоя верховодки и двучленности либо почвенного, либо геологического происхождения, три типа систем лес-почва, связанных с особенностями генезиса почв были идентифицированы. Первый из них развивается в условиях кратковременной верховодки под лесами кисличного типа местопроизростания. Развиваемые буро-псевдооподзоленные почвы характеризуются синхронным ферролизом, лессивированием и аккумуляцией разбросанных новообразований, пятен и налетов окисных и закисных соединений железа. Второй тип встречается в условиях длительного застоя верховодки под лесами кислично-черничного типа местопроизростания. Профиль дерново-подзолистых глееватых почв отличается элювиальной двучленностью, притом промывание и оподзоливание развиваются в ее верхней части, где признаки застойной верховодки и оглеения являются весьма скромными. Нижняя часть их элювиального профиля образована в результате стагноглеевых процессов и отличается сизоватой окраской, обогащенностью закисным железом и обильным наличием вторичных пятен окисного железа. Третий тип, характеризуется длительным застоем верховодки под лесами снытьевого типа местопроизростания. Образованным бурым глееватым лессивированным и псевдоглеевым почвам характерны явные стагноглеевые признаки, ферролиз, поверхностное оглеение, сизые новообразования и налеты, а также ржавые пятна, лессивирование и аккумуляция окисного железа на месте. Нами представляются соотношения между гумусовыми и химическими показателями в разных горизонтах в целях их использования в диагностике лесных почв.

Ключевые слова: поверхностное оглеение, ферролиз, псевдооподзоленная почва, дерново-подзолистая глееватая почва, псевдоглеевая почва.