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Rustification as a collateral process in clay-illuvial soils of northern Poland

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Abstract

The lessivage (clay-illuviation) and rustification are among the two most common soil-forming processes in soil cover of Poland. The horizons of illuvial accumulation of the clay fraction are observed in approx. 50% of Polish soils, while rusty soils constitute about 14% – that is almost half of all sandy soils in the country. Due to the different conditions of both processes – mainly lithological in nature – they are generally perceived as separable phenomena leading to the formation of two different types of soils – clay-illuvial soils (WRB – Luvisols) and rusty soils (Brunic Arenosols). However, in some soil profiles, especially those formed in sands covering glacial tills, the effects of both of these soil-forming processes are observed. The aim of the study was to characterize the soils with the features related to the illuviation (lessivage) of the clay fraction and the accumulation of iron sesquioxides in the form of iron coatings formed in-situ in the sandy material (rustification). In order to check how often these processes take place simultaneously, 29 soil profiles with a texture enabling the simultaneous acting of both processes in the young glacial areas of northern Poland were analyzed. In as many as 66% of cases, the presence of features related to both processes were found. The lack of the rustification was recorded predominantly in arable soils – often shallowed by erosion or with a clear stagnation of water in the eluvial horizons. Most of the studied soils were classified as texturally contrasted rusty clay-illuvial soils (WRB – Abruptic Luvisols (Brunic)) or lamellic rusty clay-illuvial soils (WRB – Lamellic Luvisols (Brunic)). Thus, both processes in soils developed from cover sands underlying by glacial tills are complementary to each other, and the profiles of A-Bv-Et-2Bt-2Ck morphology (designation of horizons according to Polish Soil Classification (PSC, 2019)) should be perceived as fully formed and undisturbed by human activity.

1. Introduction

Soil cover of Poland was formed under the influence of humid climate with a total precipitation higher than evaporability, determining leaching water regime in zonal soils. The climatically conditioned, zonal soils: clay-illuvial, podzol, brown and rusty soils, constitute 75% of the entire area of the country (Bednarek and Prusinkiewicz, 1997). Due to the above, common soil-forming processes include decalcification and acidification of the upper soil horizons and translocations of individual mineral components down the soil profile. It is therefore not surprising that there is a widespread presence of clay-illuvial soils (Luvisols or Retisols according to WRB) developed from glacial tills or of silt and loess deposits (about 50% of all soils – Sykuła et al., 2019) and podzolic soils (Podzols) evolved from sandy materials (about 12% of Poland). Both of these two units have morphology generally described as A-E-B-C with well-developed eluvial and illuvial horizons – pedogenic features common in subboreal humid climate. In some cases, these soils may not have eluvial horizons, due to lateral podzolization (Jankowski, 2014a) or agrotechnical treatments and slope processes often caused by human activities (Sinkiewicz, 1998; Kobierski, 2013; Podlasiński, 2013; Świtoniak et al., 2016). The other two types of zonal units – brown and rusty soils – include pedons with B horizons developed directly below humus A horizons. In the case of brown soils (Cambisols), which occur mainly on the slopes in the foothill regions of southern Poland, the A-B-C morphology may result from the lateral runoff of soil solutions or formation of slope covers (Kacprzak and Derkowski, 2007; Waroszewski et al., 2016; Kowalska et al. 2021. The most "inadequate" in the context of humid climate seems to be rusty soils (WRB – Brunic Arenosols) – sandy and highly permeable soils common in the Polish lowlands – covering about 14% of whole country. These soils, like mentioned above clay-illuvial pedons, were developed under deciduous forests in a humid climate (Jankowski et al. 2011). The diagnostic horizons of these soils, Bv – siderik, (names and designation of horizons are according to Polish Soil Classification – PSC 2019) have an orange-brown color due to the in-situ weathering accumulation of iron and aluminium compounds in coarse materials – sands, weak loamy sands or loamy sands, containing from 0 to 15% of the clay fraction. This process in Polish literature is called rustification (Konecka-Betley, 1968) as opposed to the process of brunification (e.g. Duchaufour, 1982; Schaetzl and Anderson, 2005) which taking place in finer-grained materials (mainly loams or silts) leading to the formation of kambik (WRB – cambic) horizons. Therefore, siderik horizons are close to the kambik except texture. Although the genesis of rusty soils has been the subject of research by many authors (e.g. Konecka-Betley, 1968; Kowalkowski et al., 1981, Prusinkiewicz and Bednarek, 1983; Bednarek, 1991; Konecka-Betley and Janowska, 1996; Kruczkowska et al., 2020), still some issues remain unclear. Their A-B-C morphology does not reflect leaching water regime. Because most of rusty soils occur in flat forest areas protected against erosion, lack of eluvial horizons cannot be explained by lateral movement of percolate or influence of slope processes. How is it possible that rusty soils, highly permeable for rain water, with in-situ accumulation of aluminum and iron sesquioxides in siderik Bv horizon are formed, next to clay-illuvial soils with thick and clearly marked eluvial horizons developed in the same climatic conditions and under similar vegetation? Some arguments in this discussion can provide the study of soils developed from sediments that allow simultaneous (or successive) development of both processes – rustification and clay-illuviation. Sandy mantles covering glacial tills or sands containing amounts of clay fraction high enough to develop argik (argic in WRB) horizons (loamy sands or sands with "inserts" of finer material) are best suited for this purpose. Some authors already describe soils with sandy deposits covering loamy materials where brunification or rustification and clay-illuviation processes overlap in one profile (eg. Kühn 2003; Kuhn et al. 2006; Yost et al. 2019).

The aim of this study is to determine how often and in what environmental conditions effects of clay-illuviation and rustification occur at the same time in the soil profiles in north part of Poland. An additional task was also to appraise the usefulness of the latest version of the Polish Soil Classification (2019) and WRB (IUSS Working Group WRB, 2015) in expressing the features of both processes in the name of soil taxon.

2. Study area and methods

The study was carried out in young morainic areas of North Poland within four mesoregions (Kondracki, 2009; Solon et al., 2018): Brodnica Lake District, Chełmno Lake District, Drwęca Valley, Świecie Plateau. The area is located in the zone of moist and cool temperate climate (IPCC, 2006). According to Köppen−Geiger Climate Classification, the region is located in the fully humid zone with temperate and warm summer (Kottek et al., 2006). Average annual air temperature (based on data from period 1951–1970) in the central part of studied area is 7.5°C (Wójcik and Marciniak, 1987a). The warmest month is July with average air temperature of 17.5°C, and the coldest month is February with average air temperature of -3.3°C. The average annual precipitation is 519 mm with the majority of precipitation occurring in summer and the maximum in July – 101 mm (Wójcik and Marciniak, 1987b). The humid period lasts for a whole year conditioning the leaching soil-water regime in pedons with good natural drainage.

The study area is located within the range of Pomeranian phase (16–17 kyr BP) of the Weichselian glaciation (Niewiarowski, 1959, 1986; Niewiarowski and Wysota, 1986; Marks, 2012), which left deposits of morainic glacial tills or fluvioglacial sands and gravels in the analyzed area.

In total 29 soil profiles were investigated. Almost all soils were located in moraine undulating and hilly plateaus. One profile was on the border between the plateau and slope of a marginal ice valley. In 27 cases texturally contrasted deposits occured – fluvioglacial or ablation cover sands (sands, weak loamy

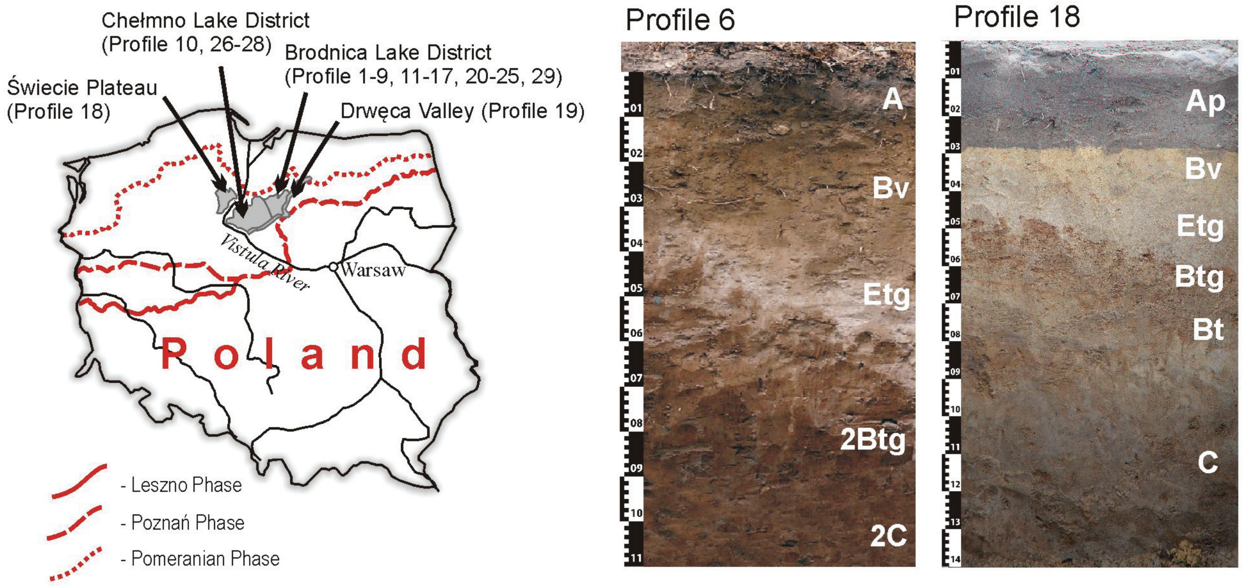

Fig. 1. Study area and examples of investigated pedons with clay illuviation and rustification: profile 6 – soil developed from sand cover on glacial till, profile 18 – soil developed from deep sands with inclusions and lamellaes of loamy sands

sands and loamy sand in texture) overlies glacial tills (mainly loamy texture – Table 1). Lithogenic discontinuities separating sandy deposits from glacial tills were at the ca. 70 cm depth. Two profiles were developed in deep (more than 2 m) sands contain lamination or inclusions of finer-grained material. Twenty soils were covered by managed forests – with canopy layer dominated by pines (*Pinus sylvestris*) and species typical for hornbeam forest (*Carpinus betulus, Tilia cordata, Quercus sp*) predominates in understory, herb layer and forest floor. Nine soil pits were located in agricultural areas – arable fields.

Disturbed soil samples were taken from every genetic soil horizons. Standard soil analyses were performed using the methods as follows: total organic carbon (TOC) content — by Tiurin's method; total nitrogen content by Kjeldahl method;

Table 1
Selected properties of the studied soils

No	use	Lithic discontinuity depth [cm]	Texture		A horizon		Bv		pH under A horizon	Horizon sequence
			Above lithic disc.	Below lithic discontinuity	Corg [%]	Thickness [cm]	Thickness [cm]	Lower boundary depth [cm]		
1	F	60	LS	SCL	1.42	10	35	45	4.8	O-A-Bv-Etg-2Bt-2Ck
2	F	45	LS	L	1.63	10	15	25	4.8	O-A-Bv-Et-2Bt-2Ck
3	F	55	LS	SL	1.47	15	10	25	4.7	O-A-Bv-Et-2Bt-2Ck
4	F	75	LS	L	1.44	12	43	55	4.9	O-A-Bv-Et-2Bt-2C
5	F	58	LS	SL	2.55	15	33	48	4.7	O-A-Bv-Etg-2Btg-2Cg
6	F	52	LS	L	1.25	10	32	42	5.2	O-A-Bv-Etg-2Btg-2C
7	F	40	LS	SCL	2.44	12	8	20	4.6	O-A-Bv-Et-2Bt-2Ck
8	F	82	LS	SL	3.03	9	39	45	4.6	O-A-Bv-Et-2Bt-2C
9	F	35	LS	SCL	1.38	10	10	20	5.6	O-A-Bv-Et-2Bt-2Ck
10	A	102	LS	L	0.90	35	35	70	5.9	Ap-Bv-Et-2Bt
11	A	80	LS	SL	0.49	35	20	55	6	Ap-Bv-Et-2Bt-2Ck
12	F	95	S	LS	1.48	20	25	45	5.2	O-A-Bv-Et-2Bt (lamellae)
13	F	100	LS	SL	0.69	20	35	55	4.8	O-A-Bv-Et-2Bt
14	F	74	LS	SCL	2.88	15	59	74	5.3	O-A-Bv-2Bt
15	F	77	LS	SL	1.44	10	45	55	4.9	O-A-Bv-Et-2Bt (lamellae)
16	F	110	LS	SL	1.77	12	58	70	4.7	O-A-Bv-Etg-2Bt (lamellae)
17	F	90	LS	SL	2.14	15	45	60	5	O-A-Bv-Etg-2Bt (lamellae)
18	A	50*	S	LS	0.66	30	10	40	5.1	Ap-Bv-Et-Btg (lamellae)-Bt-C
19	F	70*	S	SL	1.26	20	50	70	5.7	O-A-Bv-C with lamellae
20	F	70	LS	SL	2.37	25	20	45	4.8	O-A-Bv-Cgg-2Cgg
21	F	100	LS	SL	1.41	10	15	25	4.7	O-A-Bv-C-2Cg
22	F	100	LS	SL	1.87	12	43	55	4.6	O-A-Bv-C-2Cgg
23	A	45	LS	L	0.61	25	-	-	6.7	Ap-Etg-2Btg-2Ckg
24	A	65	LS	L	0.72	30	-	-	6.8	Ap-Et-2Btg-2Cg
25	A	40	LS	L	1.07	20	-	-	7.8	Ap-Et-2Bt-2Ck-2Cg
26	A	50	LS	L	0.72	35	-	-	7.1	Ap-Etg-2Btg-2Ckg
27	A	75	LS	L	0.54	35	-	-	6.9	Ap-Et-2Btg-2Ckg
28	A	75	LS	L	0.77	30	-	-	6.7	Ap-Etg-2Btg-2Cg
29	F	22	LS	L	1.43	15	-	-	4.9	Ap-Et-2Bt-2Ck

S – sands, LS – loamy sands, SL – sandy loams, L –loam, SCL – sandy clay loam; A – arable, F – forest

$CaCO_3$ content – volumetric Scheibler method; particle-size distribution – by sieve and sedimentary aerometric method; pH of soil-to-solution ratio of 1:2.5 using 1 M KCl and distilled H_2O as the suspension medium. Color has been described according to Munsell Soil Color Charts (2000).

The systematic position and symbols/names of diagnostic horizons were given after the sixth edition of the Polish Soil Classification (PSC, 2019) and WRB (IUSS Working Group WRB, 2015). English-language names of soil units (PSC, 2019) were given as proposed by Kabała et al. (2019).

Table 2
Systematic position of studied soils

No.	Process		Systematic position	
			PSC (2019)	WRB (IUSS Working Group WRB, 2015)
4	Clay illuviation and rustification	both processes well expressed	texturally contrasted rusty clay-illuvial soil	Albic Abruptic LUVISOL (Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic, Brunic)
8				
13				Albic LUVISOL (Arenic, Cutanic, Ochric, Endoraptic, Brunic)
14				Albic Abruptic LUVISOL (Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic, Brunic)
1			texturally contrasted rusty clay-illuvial soil (stagnogleyic)	Endocalcaric Albic Stagnic Abruptic LUVISOL (Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic, Brunic)
5				Albic Stagnic Abruptic LUVISOL (Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic, Brunic)
6				
12			lamellic rusty clay-illuvial soil	Lamellic Luvisol (Arenic, Cutanic, Ochric, Endoraptic, Brunic)
15				Lamellic Luvisol (Anoarenic, Cutanic, Endoloamic, Ochric, Endoraptic, Brunic)
17				
11			humic texturally contrasted clay-illuvial soil (rusty)	Endocalcaric Albic Abruptic LUVISOL (Aric, Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic, Brunic)
2			rusty clay-illuvial soil	Endocalcaric Albic Abruptic LUVISOL (Epiarenic, Cutanic, Ochric, Katoloamic, Epiraptic, Brunic)
19			typical rusty soil (proto-lamellar)	Eutric Lamellic, Brunic ARENOSOL (Ochric)
3		shallow Bv	texturally contrasted clay-illuvial soil	Endocalcaric Albic Abruptic LUVISOL (Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic)
7				Endocalcaric Albic Abruptic LUVISOL (Epiarenic, Cutanic, Ochric, Katoloamic, Epiraptic)
18			lamellic humic clay-illuvial soil (stagnogleyic)	Lamellic Stagnic LUVISOL (Arenic, Aric, Cutanic, Nechic, Ochric)
9			typical clay-illuvial soil	Endocalcaric Albic Abruptic LUVISOL (Epiarenic, Cutanic, Ochric, Katoloamic, Epiraptic)
10		deep Bt	humic rusty soil	Eutric Brunic ARENOSOL (Aric, Ochric, Bathyluvic, Bathyraptic)
16			brown-rusty soil	Dystric Brunic ARENOSOL (Ochric, Bathyluvic, Bathyraptic)
20	Rustification		brown-rusty humic soil (gleyic)	Gleyic UMBRISOL (Anoarenic, Geoabruptic, Endoloamic, Endoraptic, Brunic)
21			typical rusty soil	Dystric, Brunic ARENOSOL (Geoabruptic, Ochric, Endoraptic, Endostagnic)
22			gleyic rusty soil	Dystri, Brunic ARENOSOL (Geoabruptic, Ochric, Bathygleyic)
23	Clay-illuviation		texturally contrasted clay-illuvial soil (stagnogleyic)	Endocalcaric Albic Stagnic Abruptic LUVISOL (Aric, Epiarenic, Cutanic, Ochric, Katoloamic, Epiraptic)
24			humic texturally contrasted clay-illuvial soil (stagnogleyic)	Albic Stagnic Abruptic LUVISOL (Aric, Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic)
26				Endocalcaric Albic Stagnic Abruptic LUVISOL (Aric, Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic)
27				
28				Albic Stagnic Abruptic LUVISOL (Aric, Anoarenic, Cutanic, Ochric, Endoloamic, Endoraptic)
25			texturally contrasted clay-illuvial soil	Albic Abruptic LUVISOL (Aric, Epiarenic, Cutanic, Ochric, Katoloamic, Epiraptic)
29			typical clay-illuvial soil	Endocalcaric Abruptic LUVISOL (Aric, Epiarenic, Cutanic, Ochric, Katoloamic, Epiraptic)

3. Results

Out of all analyzed profiles, as many as 19 (66%) had distinct features of both processes – rustification and clay illuviation. In general, they are forest soils and have morphology: O-A-Bv-Et-2Bt-2C(k). Despite the fact that many of these soils occur in hilly areas – the soil cover, due to the protective role of the forest, does not show significant erosive transformations (Świtoniak 2014). The horizons Bv with sesquioxides accumulation occurred in these soils directly below the A horizons and had an average thickness of 31 cm. Illuvial cutans were clearly visible in the stage of field works in theses soils, but illuviation was also confirmed by micromorphological investigation described in previous papers (Świtoniak 2014, Świtoniak et al. 2016). The clay-illuvial forms generally started below lithic discontinuity and formed continuous zone (13 profiles) or lamellaes (6 profiles). In 18 soils, the thickness of the zone with clay illuviation (or sum of lamellae's thickness) was sufficient to distinguish the argik (WRB – argic) horizon. Only in one profile (number 19) the "expression" of illuviation was too weak – total thickness of lamellae was not enough for distinguish argik (WRB – argic) horizon. The overlapping of the clay illuviation process on the lithological heterogeneity resulted in a significant contrast in the texture of the most of described cases.

Only in three cases clay illuviation forms were not observed. The rustification process dominated in sandy covers of these soils, accompanied by gleyization in lower, loamy part of profiles – O-A-Bv-2Cgg.

The remaining soils (7 profiles) had well-developed argik (argic – WRB) horizons (Ap-Etg-2Btg-2Cg(k)), but there was no accumulation of sesquioxides under the humus horizons. In most cases, some stagnation of rainwater was noted here, associated with a lower permeability of the glacial tills laying below lithic discontinuities. Moreover, all of these soils were under agricultural cultivation and were exposed to human-induced erosion.

4. Discussion

In terms of lithology all the studied soils met the conditions enabling the development of both processes – clay movement and rustification. The top of the profiles was sandy and coarse-textured and met the criterion of distinguishing siderik but at the same time contained sufficient clay fraction for possible development of lessive process. Out of 29 tested profiles, as many as 19 (66%) showed the presence of features resulting from the both examined processes. Thus, the most common sequence of genetic horizons in the soils tested was: A-Bv-Et-2Bt-2C(k). Lack of the Bv horizons were noticed only in arable soils. The explanation for this state may be the destruction of these horizons as a result of human activity (plowing up to 30 cm) and partial, erosive shallowing of the soil profiles (Kobierski, 2013; Świtoniak, 2014). Taking into account that the average depth of the lower boundary of Bv horizons in the examined forest soils is only 48 cm, it can be assumed that in case of plowing up to 30 cm deep, only 18 cm of soil loss is enough to make these horizons completely disappear. The second reason for the lack of accumulation of sesquioxides may be periodic increased moisture over poorly permeable 2Bt horizons (visible in profiles as stagnic properties in Etg) – which increases the solubility and mobility of iron and aluminum compounds (Kowalkowski and Nowak, 1968; Jonczak 2013; Colombo et al., 2014) and enables more intensive leaching into deeper parts of profile. Taking into account that most of the clay-illuvial soils described in Poland belong to arable soils (exposed to erosion) or with finer texture in upper part of solum (e.g. Cieśla et al. 1978; Dąbkowska-Naskręt and Jaworska 1997; Stępniewski et al. 2000; Marcinek and Komisarek 2004; Paluszek, 2010; Podlasiński 2013; Loba et al. 2021) it is understandable why the A-E-B-C (without Bv) is described as a typical sequence for these soils. Only in three cases clay illuviation was not noted. In these soils, however, there was a strong gleyization in the lower part of the profile – which may have been the reason for the lack of illuvial features. The upper part of these soils was transformed by a rustification. The wide-spread coexistence of the features of clay illuviation and rustification in investigated forest pedons indicates that these processes are complementary under appropriate lithological conditions. The conducted research does not make it possible to determine whether they acted simultaneously in the same period or at different stages of soil formation. Taking into account the research of other authors the climatic conditions indicate that the lessivage process is, with certain periods of intensification – e.g. in the Atlantic, active since the beginning of the Holocene (e. g. Kühn, 2003; Budek, 2010). This is also confirmed by the studies of the illuvial bands in sandy soils – in some cases their age is determined at no more than 4800–4700 years (Prusinkiewicz et al., 1994).

In the case of rustification, some authors attributed this process to a periglacial or early Holocene genesis (Kowalkowski et al., 1981). Most recent studies of the origin of rusty soils, confirm that this process affected the sandy soils of Poland also in the later Holocene periods (Bednarek, 1991) and can be still active (Jankowski, 2014b; Papiernik et al., 2018). This would indicate that both described processes are taking place simultaneously – in the upper part of solum (Bv), the intensity of weathering and sesquioxides accumulation is higher than the rate of their leaching with the clay fraction into the deeper parts of profile (2Bt).

The polygenesis of the soils described is reflected in the names of taxons. According to the Polish Soils Classification (2019), all soils with a Bv thickness of more than 15 cm and an argik starting above 100 cm depth are classified as subtype rusty clay-illuvial soils. Due to lithological heterogeneity, they also generally met the criterion required for the texturally contrasted clay-illuvial subtype (texturally contrasted, rusty clay-illuvial soils). Pedons with Bt in form of lamellas could in turn be classified as lamellic rusty clay-illuvial soil. When the features of clay-illuviation began deeper (more than 100 cm – profiles 10 and 16), the soils were classified as rusty soils only. The introduction of these subtypes to PSC 6 (2019) allows a precise reflection of their properties in the name of the soil subtype.

When the thickness of the Bv level was less than 15 cm – rusty subtype can not be used. According to WRB (IUSS Working Group WRB, 2015) pedons with A-Bv-Et-2Bt-2C(k) were classified in WRB as Abruptic Luvisols. Brunic qualifier (cor-

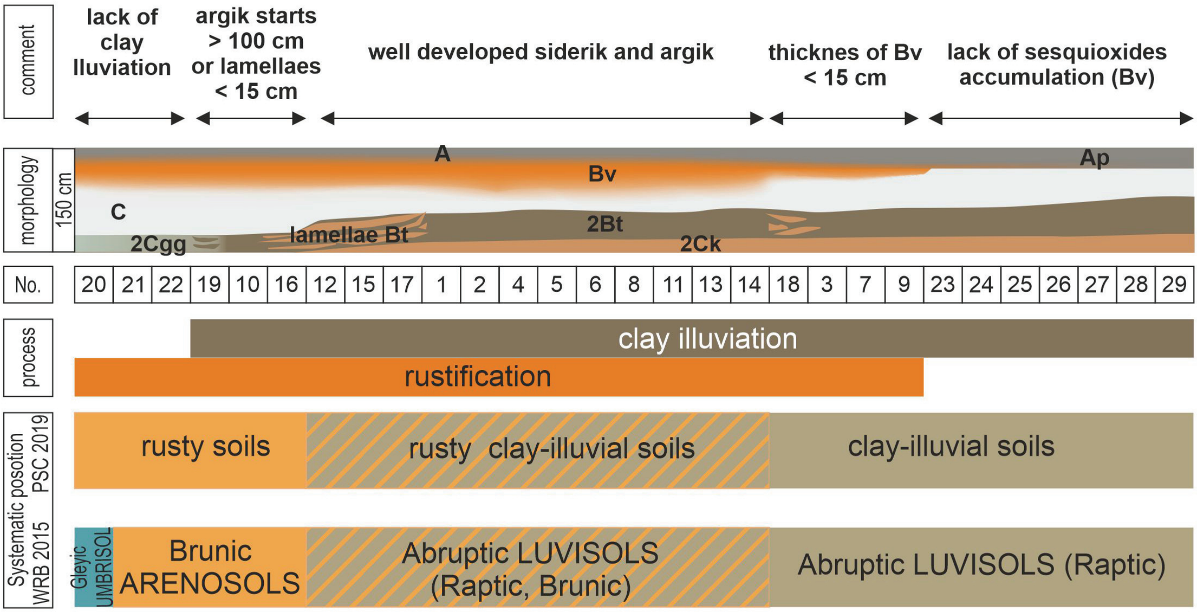

Fig. 2. Differentiation of properties and systematic position of the studied soils

responding to Siderik horizon in PSC 6) is not on the list of main or even supplementary qualifiers of this reference group. Despite its significant diagnostic importance, it can be added only at the end of the soil name. As well as the possibility of expressing the presence of cambic horizons (qualifier Neocambic) in Luvisols and Retisols – the Neobrunic qualifier should be added. Moreover, as in the case of PSC – Brunic cannot be applied with a Bv thickness of less than 15 cm. In the case of argik with upper boundary deeper than 100 cm, the soils passed to the Arenosols.

5. Conclusions

The conducted research allows for the redefinition of the "typical" set of soil-forming processes in textural contrasted lithologically heterogeneous sediments (sands on glacial tills) of young morainic areas. It should be noted that the process of clay translocation and the formation of lessive soils is often accompanied by the accumulation of sesquioxides in the upper part of the eluvial zone. Both processes could therefore be seen as complementary and characteristic of the humid subboreal climatic zone. Paleopedological and environmental studies by other authors indicate the possibility of simultaneous activity of both processes during the soil evolution. The results allow for the formulation of the following detailed conclusions:

- The coexistence of the clay-illuvation and rustification is not unique feature of texturally contrasted soils. The sequence A-Bv-Et-2Bt-2C(k) should be understood as an expression of the regular and common polygenesis of soils developed from sands covering glacial tills;
- Lack of Bv horizon in texturally contrasted clay-illuvial soils is often the result of 1) deepening the humus horizon during plowing, 2) erosive soil shallowing (truncation), 3) stagnation of water on 2Bt horizons
- The wide range of subtypes in clay-illuvial soils in PSC (2019) enables precise manifestation of the features of both processes. The studied soils belonged mainly to texturally contrasted or lamellic rusty clay-illuvial soils. The subtype expressing rustification in clay-illuviated soils was missing in earlier versions of the PSC.
- For the correct classification of the discussed soils, an additional qualifier – Neobrunic should be introduced in the WRB. It would be the equivalent of the Neocmbic qualifier already used in soils with argik horizons (Luvisols, Retisols) having finer texture and cambic horizon in the upper part of the soil profile.

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Rdzawienie jako proces towarzyszący iluwiacji iłu w glebach północnej Polski

Słowa kluczowe

Gleby strefowe
Siderik
Gleby płowe
Gleby rdzawe
Lessiważ

Streszczenie

Proces lessiważu i rdzawienia należą do dwóch najbardziej powszechnych procesów glebotwórczych na terenie naszego kraju. Poziomy iluwialnego nagromadzenia frakcji iłowej obserwowane są w ok. 50% gleb Polski podczas gdy gleby rdzawe stanowią około 14% – czyli prawie połowę wszystkich gleb piaszczystych. Ze względu na odmienne uwarunkowania obu procesów – głównie o charakterze litologicznym – są one generalne postrzegane jako zjawiska występujące rozłącznie i prowadzące do powstania dwóch różnych typów gleb – gleb płowych i gleb rdzawych. W niektórych profilach glebowych – szczególnie wytworzonych z piasków naglinowych, obserwowane są jednak efekty obu tych procesów glebotwórczych. Celem prezentacji jest charakterystyka gleb, w których jedocześnie można zaobserwować cechy związane z iluwialnym nagromadzeniem frakcji ilastej (lessiważ) oraz nagromadzenia półtoratlenków żelaza w formie otoczek żelazistych wytworzonych in-situ w materiale piaszczystym (proces rdzawienia). W celu sprawdzenia jak często procesy te zachodzą symultanicznie przeanalizowano 29 profili glebowych o uziarnieniu umożliwiającym jednoczesny przebieg obu procesów w obszarach młodoglacjalnych Polski północnej. Aż w 66% przypadków stwierdzono obecność cech związanych z obydwoma procesami. Brak procesu rdzawienia odnotowano jedynie w glebach ornych – często spłyconych erozyjnie lub mających wyraźne oglejenie opadowo-wodne w poziomie eluwialnym. Większość z badanych gleb zaklasyfikowana została jako gleby płowe dwudzielne rdzawe (WRB – Abruptic Luvisols (Brunic)) lub gleby płowe lamellowe rdzawe (WRB – Lamellic Luvisols (Brunic)). Oba procesy w glebach wytworzonych z piasków naglinowych są więc względem siebie komplementarne, a profile o budowie A-Bv-Et-2Bt-2Ck powinny być postrzegane jako w pełni ukształtowane i niezaburzone działalnością człowieka.