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Soil Genesis

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CONTEMPORARY STATE AND THE ATTEMPT AT THE RECONSTRUCTION OF THE SOIL COVER IN THE HIGHLY DIVERSIFIED LOESS AREA ON THE BASIS OF THE SANDOMIERZ UPLAND IN OSTROWIEC ŚWIĘTOKRZYSKI AND ĆMIELÓW SURROUNDINGS

Abstract: This study is an attempt at reconstructing the soil cover of the northern slope of the Opatów loess patch based on the morphology analysis of 23 investigated soil profiles and their chemical properties. It was stated that at present the investigated area is mainly occupied by secondary, typical brown soils, acid and leached, on slopes weakly developed, strongly eroded. The Holocene model profiles of grey-brown podzolic soils occur only in forest areas, e.g. in the Las Górny forest. The bottom of the loess valleys is mainly occupied by deluvial-aluvial soils, as an effect of long lasting human activity started in neolith.

The early neolithic settlement of the Opatowska Upland was caused by the following factors: fertile soils derived from loess, landform features of the loess upland areas, the pattern of the river network, as well as the occurrence of the flint outcrops: Świeciechów, chocolate and striped.

Successive transformations of the soil cover coincided with ancient mining and metallurgy occurring on the north foreland of the Holy Cross Mountains, then with the historical period. Spatial variability of the soil cover expressed in the mosaic of the slope and valley soils is an effect of the above transformations.

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The most investigated fragment of the Opatów-Sandomierz soil cover of the loess patch is the catchment area of the Opatówka river. The results of the research carried out on this fragment of the loess patch were published in several works [1–3, 19, 24, 29]. It was stated that at present chernozems occupy about 5% of that surface [19], and the highly eroded soils lying on loess, which used to be grey-brown podzolic soils (according to WRB – Haplic Lvisols), are under strong erosional processes. Less attention was paid to the northern margin of the Opatów loess patch. Within this area, paleogeographic investigations were carried out, connected with stratigraphy and genesis of the loess of the northeastern margin of the Holy Cross Mountains, which constitute the parent material for the investigated soils [5–7, 10, 11, 16].

Thus, the main aim of this study is an assessment of the contemporary state, as well as an attempt at reconstruction of the soil cover of the northern margin of the Opatów loess patch.

STUDY AREA

The investigated area of the northern slope of the Opatów loess patch situated to the south of the Kamienna river (from Ostrowiec Świętokrzyski to Ćmielów, between the Kamionka river and Obręczna) is an area of great scenic beauty, considered representative for the whole Sandomierz Upland on account of the geomorphology of the area, including a dense net of gullies connected with the proximity of the Kamienna river [3] (Fig. 1).

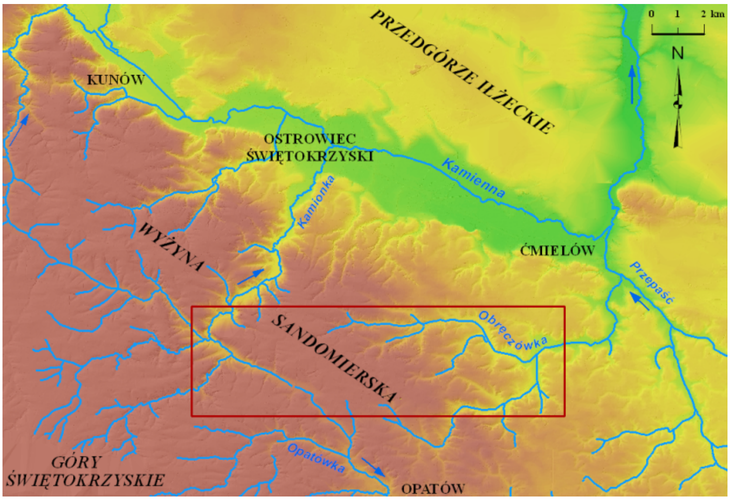

Fig. 1. Extent of the study area on a background of the numerical map of the relief of the north-eastern margin of the Holy Cross Mountains
Source: Digital Terrain Model (TIN).

The investigated area is a part of the Opatów anticlinorium as well as northern syncline. Both are the tectonic units of the eastern part of the Paleozoic massif of the Holy Cross Mountains [25]. This area is situated within the border line, distinctly visible in the morphology, among the Devonian, Permian, Triassic and Jurassic deposits, which constitute a part of the Paleozoic-Mezozoic margin of the Holy Cross Mountains [15, 22].

The prevailing deposits are sandstones, mudstones, claystones, clays and limestones originated in the above-mentioned geological periods, then covered with glacial and fluvioglacial deposits of the Middle Polish Glaciation and, varying in age, loess, divided by interglacial and interstadial fossil soils [6, 16].

The Holocene deposits with thickness of about 1.5 m, being an effect of the long lasting denudation of the loess high plains, lasting with breaks from the neolithic period, overlap with alluvial deposits commonly occurring within dry loess valleys, as well as river valleys and watercourses, building floodplain.

The slopes of the Kamionka, Przepaść and Obręczówka river valleys, which dissect, within the investigated area, the north margin of the Kamienna river valley, are distinguished by considerable inclinations and denivelations reaching 45–60 m, and in the case of the Kamionka river – 90 m. Such configuration of the land favours intensified erosional processes. The soil cover of this area is modified mainly by ploughing, as well as surface and linear erosion reaching the highest intensity during heavy rainstorms. Erosional processes are also caused by a dense net of road gullies (area with road gullies occupies 93% of the mesoregion, 51% area has the road gullies density of 0.5–1 km/km2) dissecting the Sandomierz Upland [20]. This area is intensively cultivated, has a low afforestation rate and lacks any larger industrial centres.

METHODOLOGY

In the field, the description of soil morphology was made and soil samples were taken for laboratory analysis from the main and transitory soil horizons. Altogether, 23 profiles were investigated. These 23 profiles were made along transects, which cut different forms of land use: ploughland, fallow, forest and meadow. Most of the profiles, i.e. 20, were made in the Obręczówka river valley and its side tributaries. This river, after connecting with the Przepaść river, ends its course in the Kamienna river in Ćmielów surroundings. The remaining 3 profiles were made in the Las Górny forest situated on the Kamionka river next to Ruszków and Czerwona Góra villages (Fig. 2). The types and subtypes of the soils were determined according to the soil systematics of the Polish Soil Science Society [1989] and [WRB 2006/2007]: i.e. 7 profiles are weakly developed soils (Calcaric Regosols), 6 deluvial soils (Eutric Fluvisols), 3 gley soils (Haplic Gleysols), 3 typical brown soils (Calcaric Cambisols), 2 acid brown soils (Dystric Cambisols) and 2 typical grey-brown podzolic soils (Haplic Luvisols).

Granulometric composition and chemical properties of the investigated soils were determined according to the following laboratory analyses: granulometric composition determined by *Bouyoucose-Casagrande*-Prószyński [4] pH in 1M KCl, organic carbon according to Turin, content of calcium carbonates according to Scheibler and available phosphorus and potassium using the Egner-Riehm method [17].

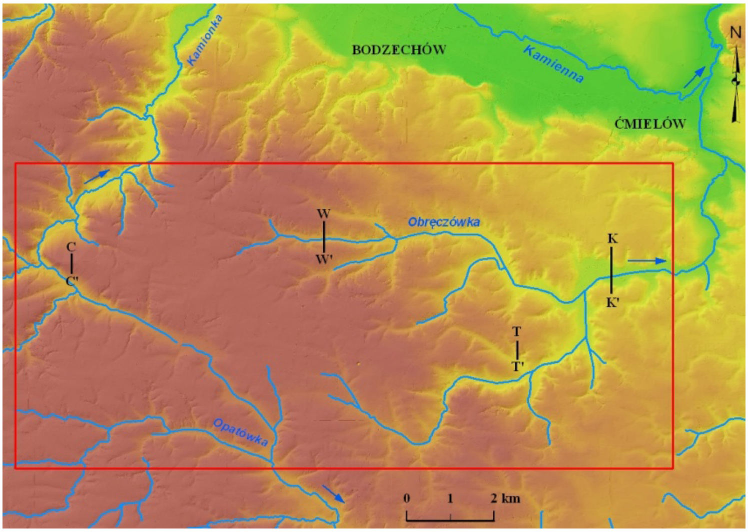

Fig. 2. Situation of soil transects on the background of the investigated area: Krzczonowice (K-K'), Trębanów (T-T'), Wszechświęte (W-W') and Czerwona Góra (C-C').

RESULTS

Granulometric composition

The results of the laboratory analyses of selected soil profiles have been shown in Table 1. The soils derived from loess within the investigated area are characterized by predominance of silt particles of 0.1–0.02 mm diameter, the participation of which varies between 43 and 67%, maximally in upper horizons of meadow soils in Wszechświęte 70%. Meadow bottom soil horizons in Krzczonowice surroundings contain the lowest amounts of silt particles (26%). Considering the situation concerning the slope, the lowest amount of fine fractions is found on the slopes of the loess valleys, slightly more on the hill top, and less at the bottom of the slope.

TABLE 1. GRANULOMETRIC COMPOSITION AND SELECTED CHEMICAL PROPERTIES OF CHOSEN SOILS OF THE OPATÓW UPLAND

Profile No. Type/subtype of the soil	**Horizon**	**Depth** (cm)	**Content of the main fractions (%)**				**$CaC0_3$** (%)	**pH KCl**	**C (%)**	**Available mg/100g soil**	
			1–0.1 mm	**0.1–0.02** mm	**<0.02** mm	**<0.002** mm				**P_2O_5**	**K_20**
K7 weakly developed soil, strongly eroded (Calcaric Regosol)	**ApCca**	0–15	1	59	40	17	2.7	7.3	**0.94**	18.69	12.2
	Cca1	15–30	4	43	53	18	12.5	7.6	0.18	0	5.4
	Cca2	30–50	4	56	40	17	11.5	7.6	-	1.74	5.5
W1 typical brown soil (Calcaric Cambisol)	**Ap**	5–15	1	63	36	17	-	4.4	**0.86**	5.91	11.3
	Bbr1	30–35	0	58	42	25	-	5.4	0.32	5.86	8.9
	Bbr2	45–50	0	64	36	20	-	5.7	0.21	4.79	7.0
	Bbr2C	55–70	0	65	35	18	-	6.0	-	5.45	6.6
	Cca1	70–80	0	67	33	14	1.3	7.4	-	6.99	6.1
	Cca2	90–100	1	64	35	13	11.5	7.6	-	3.85	5.3
T1 weakly developed soil (Calcaric Regosol)	**A**	5–10	1	54	45	17	2.4	7.3	**1.42**	5.66	12.2
	ACca	10–20	1	52	47	20	4.1	7.4	0.99	4.01	9.5
	Cca1	25–35	1	55	44	18	10.9	7.6	0.24	3.37	6.0
	Cca2	40–60	2	55	43	16	11.0	7.7	-	2.50	5.7
K6 typical deluvial soil (Eutric Fluvisol)	**Ap**	5–15	8	58	34	13	3.6	7.3	**1.19**	25.19	18.5
	Ade	25–35	5	59	36	13	3.7	7.3	0.98	19.54	10.3
	Ade	40–50	2	60	38	16	0.8	7.4	0.78	7.54	7.0
	Ade	60–80	2	59	39	16	0.8	7.3	0.75	8.96	5.8
	Ade	100–110	2	60	38	15	0.9	7.4	0.78	4.51	5.6
	Ade	110–120	2	57	41	18	1.6	7.3	0.66	8.47	6.2

TABLE 1. CONTINUATION

W8 leached brown soil, weakly eroded (Dystric Cambisol)	**ApBbr**	5–15	1	56	43	18	-	4.9	**1.07**	7.28	17.6
	Bbr1	25–35	0	52	48	27	-	5.2	0.29	4.67	8.4
	Bbr2	50–65	0	58	42	18	-	6.3	0.15	5.52	7.6
	C	70–80	0	63	37	15	-	6.5	-	3.78	7.4
	Cca	90–115	1	61	38	16	11.0	7.6	-	4.31	5.7
K4 gleysol (Haplic Gleysol)	**Agg**	0–25	1	53	46	13	4.5	7.2	**1.68**	5.38	2.7
	G1	25–40	7	57	36	11	4.9	7.4	0.24	3.37	4.3
	G2	40–80	1	63	36	12	4.2	7.5	0.26	6.55	3.3
	G3	80–110	1	56	43	14	3.5	7.3	0.28	6.48	3.6
	G4	110–130	1	44	55	18	2.3	7.1	0.83	34.7	6.1
T2 initial pararendzina (Calcaric Regosol)	**A**	0–10	21	44	35	16	9.3	7.3	**1.65**	4.49	16.0
	ACca	10–20	23	42	35	19	9.2	7.5	0.55	3.44	9.9
	Cca1	25–35	45	22	33	22	11.9	7.5	0.14	4.28	8.0
	Cca2	45–60	42	23	35	22	10.8	7.5	-	3.44	8.0
CG2 typical grey-brown podzolic soil (Haplic Luvisol)	AEet	3–10	1	65	34	12	-	3.5	1.90	5.24	8.3
	Eet1	25–40	1	61	38	10	-	4.0	0.48	4.42	3.6
	Eet2	40–55	1	61	38	10	-	3.9	0.32	5.50	3.7
	EetBt	65–75	1	51	48	19	-	3.8	0.24	6.89	7.0
	Bt1	80–100	2	52	46	25	-	3.9	0.20	11.77	9.5
	Bt2	105–115	4	51	45	23	-	4.0	-	10.33	9.6
	Bt3	110–115	0	56	44	21	-	4.1	-	9.44	8.7
	Bt3C	145–155	0	61	39	17	-	4.2	-	5.98	7.2
	C	165–180	5	57	38	16	-	5.1	-	9.23	7.3
	Cca	190–200	2	56	42	14	8.2	7.4	-	3.55	6.3

Maximum amounts of the fine fractions are concentrated in the illuvial horizons of the forest soils (54%) and bottom parts of the meadow soils in Krzczonowice surroundings situated at the bottom of the slopes (74%).

In the case of the investigated soils, we can notice some regularities in the distribution of colloidal fractions in the soil profiles situated along the transects crossing the valleys:

– the highest concentrations of colloidal fractions are observed on the tophill and slopes in B horizons, both in arable soils (up to 27%) and forest soils; in the case of forest soils in the illuvial horizon we notice similar amounts (up to 28%),

– the highest concentrations of colloidal fractions in Ap horizons result in a decrease in the silt fraction,

– lower content of particles <0.002 mm is noticed on strongly eroded slopes with a reduced B horizon, as well as in deluvial soils,

– minimum content of particles <0.002 mm is noticed in A, Et horizons of the forest grey-brown podzolic soils (average 11%) and in humus and sod horizons of meadow soils (7–13%).

A significant increase in the percentage content of colloidal clay is noticeable in the bottom parts of the meadow soil profiles – up to 37%. It is especially pronounced in the soil profiles situated in the immediate proximity of cultivated soils.

pH

The pH value of the investigated soils is closely related to their state of preservation.

On the hilltop, the lowest recorded pH value in arable soils in the Ap level was 4.4. Weakly developed soils, strongly eroded due to exposed carbonate levels, have an alkaline reaction reaching a maximum pH of 7.8 in parent material and an average of 7.5 in the arable horizon.

Equally high reaction was noticed in parent material of typical brown soils. Deluvial soils horizons situated at the bottom of the slope have a slightly lower alkaline reaction. It is related to the total reduction of B horizons situated on the slope, thus exposing the parent material (carbonate level).

On the slopes in Wszechświęte, there are fragments of B horizons which had been mixed with the arable horizon. The soil reaction in this location shifts vertically from acid trough lightly acid towards the carbonate level. Locally, we can encounter profiles where soil horizons with a slightly acid reaction change into horizons with an acid reaction (pH = 5.4) (Wszechświęte, profile No. 7).

The lowest values of pH can be found in forest soils (on the hilltop and slope) situated along the transect, which was made in the Las Górny forest next to Ruszków and Czerwona Góra villages. The minimum value of 3.5 was observed in A horizon for all the investigated profiles. In the case of CG2 profile, we can observe deep soil decaltification (180 cm). Within this depth, the reaction increases only to 5.1 in the parent material. Below, in the carbonate horizon, the reaction increases to 7.4. In the profile situated on the hilltop in the Las Górny forest, a decrease in the reaction was noticed from 3.6 in the A horizon to 4.1 at the depth of about 80 cm, just above the carbonate horizon. The surface of the hilltop must have been cultivated in the past and later afforested again, which is evidenced by the reduction of the Et soil horizon by about 15 cm. This could also be a result of the inclination of the hilltop slope.

In summary, there are distinct differences noticeable in the reaction between the forest and the arable soils. The reaction of the forest soils in the loess deposit is within strong acid limits, while in the arable soils – acid to slightly acid.

Within the investigated meadow soils, both in Krzczonowice and Wszechświęte, the average value of the soil reaction in the humus and sod horizons is 7.2, i.e. neutral. In some profiles below that horizon, the pH changes to alkaline (maximum value 7.5) only to become neutral with depth. The average value of the pH for most of the meadow bottom soil is 7.1.

Calcium carbonate

In the case of leached brown soils in the northern slope of the Opatów Upland, moving downwards vertically we can observe a decrease in the content of carbonates within the soil profile. Sometimes, the carbonates do not occur until the parent material. Deep two-meter zones of decalcification are noticed in the investigated grey-brown podzolic soils in the Las Górny forest. Lack of carbonates in the whole profile (acid brown soils) is typical of arable soils developed on the slope and exposed to the north (Wszechświete, profile No. 7).

Currently, the presence of carbonates in the whole soil profile is noticed in strongly eroded soils with a thin illuvial horizon and in weakly developed soils, strongly eroded, situated on the slope, as an effect of long lasting human activity within the soil cover of the loess upland areas.

The average carbonate content in the parent material oscillates in the range 10–12%. These results overlap with those from previous researche carried out within the investigated area. The maximum carbonates content in the Cca horizon was noticed on the slope, in profile No. 2 in Wszechświęte (16.5%) and below, in profile No. 3, in the bottom of the deluvial soil (15.6%). In this case, similar values of the carbonate content prove the occurrence of a one-meter deluvial layer above the parent material in profile No. 3.

In profile No. 6 in Krzczonowice, an increase in the carbonate content towards the top of the soil profile is a result of a reduction of the carbonate horizons on the slope in profile No. 7 above. In the case of gleying, carbonates do not occur (Wszechświęte, profile No. 6) or occur only in the upper parts of deluvial soils without traces of gleying processes (Trębanów, profile No. 3).

In the meadow soils in Wszechświęte and Krzczonowice, we can observe a decrease in carbonates in a downward direction, which is connected with an increase in the gleying processes and the accumulation of deluvium at the bottom of the valley from the primeval upper soil horizons, containing less $CaCo_3$.

Organic carbon

The eroded soils of the Opatów Upland vary significantly in terms of the organic carbon content depending on their degree of modification and localization within the slopes and the bottom of the valley. In arable soils, the maximum content of organic carbon can be found in Ap horizons of typical brown soils – the maximum value of 1.63% occurred in profile No. 8 in Krzczonowice. In the eroded soils on the hilltop, the content of organic carbon decreases correspondingly to the extent of erosion – to 0.86%. Profiles within the Trębanów area are an exception (1.45%: 1.65%: 1.94%); such an increase in organic carbon lengthwise is connected with the long-term lying fallow and the growth of xerothermic plants after the removal of the loess cover and abandonment of horse ploughing.

Similar lying fallow of a strongly eroded arable field in Wszechświęte (profile No. 9) caused an increase in organic carbon in the soils on the slope up to 1.57%.

The lowest content of organic carbon (0.65%) was noticed on the slope in the soil profiles, in which, as a result of erosion, Ap horizons lie directly on the parent material. In deluvial soils, we can observe a renewed increase in organic carbon to a maximum of 1.40% in the arable horizon. In the deluvial soils below the Ap horizon, there is a gradual decrease in its content, unlike the strongly eroded soil where this decrease is very slump.

The content of organic carbon is much higher in the A horizon of the forest soils situated on the slope. The average value for both of these investigated profiles is 2%. The lower content of organic carbon in such soils on the hilltop in Czerwona Góra profile No. 1 (1.25%) could be a result of a temporal conversion of the forest soils to arable soils [12] and the hilltop inclination, which fosters surface wash.

The average content of organic carbon in the humus and sod horizons of the investigated meadow soils is 1.80%. Below this horizon, this content rapidly decreases. We can observe higher values in Krzczonowice, where, in mineral and organic components in horizons of profiles No. 3 and No. 5, with inserts and additives of peat, the value of organic carbon is the highest and varies between 4.05 and 6.13% (the average value for all investigated bottom of most horizons is 2.62%)

Available phosphorus and potassium

The content of available phosphorus is usually the highest in hilltop soils, lower at the base of the slope, and the lowest on the slope. This dependence could also be applied to the investigated soils. The arable soils in Krzczonowice have a much higher content of P_2O_5 than is the case in the other investigated transects, regardless of the localization within the slope. This is caused by much higher fertilization applied by owners of these fields.

The highest values of available phosphorus are noticed in the whole typical brown soil profile in Krzczonowice (profile No. 8) in horizons: Ap (33.85 mg/100g), Bbr (90.54 mg/100g) and Cca (31.26 mg/100g). It is worth mentioning that this area, due to localization on a watercourse, is characterized by high concentration and overlapping of multicultural archeological sites.

The arable and forest soils in Trębanów, Wszechświęte, and Ruszków surroundings contain much lower amounts of available phosphorus, which in most cases does not exceed 12 mg/100g in all horizons in the arable soils and 13 mg/100g in the forest soils.

The lowest amount of available forms of phosphorus was stated in Cca horizons, especially in strongly eroded soils. In meadow soils, in the silty-clayey and clayey bottom parts of the soil profiles, the concentration of P_2O_5 rises to a maximum of 112.71 mg/100g (Krzczonowice, profile No. 3). The content of aluminum, iron, magnesium and phosphorus increases as the granulometric fractions decrease.

Ap horizons of the investigated eroded soils affected by fertilization show a two or three times higher content of potassium available for plants, in comparison with subsurface horizons. The strongly eroded soils contained more available potassium than the non-eroded soils, and the weakly and medium eroded soils contained less of this element. In grey-brown podzolic soils, the concentration of K_2O below the A horizon is low and increases in a downward direction to the illuvial horizon, and subsequently decreases.

The enrichment of the deeper meadow soil profiles situated in the Krzczonowice surroundings, in available potassium (profile No. 3) is related to the close proximity of arable fields, on the slopes of which we can observe the total reduction of illuvial horizons affluent in potassium. Apart from the described profile, the content of available potassium in meadow soils is the lowest among all investigated soil profiles.

DISCUSSION

Arable brown soils, weakly eroded, frequently occur within hilltops and their gentle slopes with a 2–3° inclination. According to the slope gradient map, an increase in the slope inclination of arable soils to 7–12° entails the occurrence of brown soils with a preserved thin illuvial horizon, as well as weakly developed soils. Such soils, with 30 cm thickness, lying immediately on the parent material are under constant cultivation. As a result of the total reduction of soil profile on the slopes with a 14° inclination, locally we can encounter exposed postglacial material, rich in carbonates, which presently regulates the formation of the initial pararendzina soils, which had not previously occurred within the investigated soil cover of the Opatów Upland. In the contemporary rural landscape, on the basis of investigated profiles within the recognized fragment of the Opatów loess patch, the occurrence of arable grey-brown podzolic soils was not asserted.

In comparison, the forest grey-brown podzolic soil in the Las Górny forest retained all of its primary soil horizons, and the carbonate level in profile No. 2 in Czerwona Góra did not occur until the depth of approx. 2 meters. It played the role of the model profile for the investigated area. Similarly, within the Opatów-Sandomierz loess patch, forest grey-brown podzolic soils occur in all forest complexes of the loessic area, both on the hilltop and on the slopes of the valleys, even with a 20% inclination [2]. Numerous investigations of the forest soil carried out within the Lublin Upland and partially in West Wolyn, showed that the soil cover in the properly maintained forest (undamaged, mainly overgrowing loess deposits), is practically independent of relief and slope inclination [13]. This means that both the soil typology and the thickness of genetic horizons on different elements of the relief do not change or undergo slight modification. Grey-brown podzolic soils affected by ploughing change into secondary acid or leached brown soils, whereas in forest soils such typological changing processes do not exist [28]. Moreover, it is also the microrelief and the S-N exposure of the loess soils that regulate the surface variability of the soil cover. As a result of the typological changes, the granulometric composition and chemical properties of the investigated soils are also modified.

The soils of the northern slope of the Opatów Upland, in comparison with the profiles of soils occurring in the Opatówka river valley, contain more fine and colloidal fractions, as well as the fine silt fraction; they are also characterized by a lower sand content [19, 29].

The content of the carbonates in the investigated soils, especially in their parent material, coincides with the results of the investigations carried out in the closest correlative areas. The average content of carbonates determined for the investigated soil profiles oscillates within the 10–12% range, reaching the maximum value of 16%. Identical results were obtained for the calcaric eroded regosols within the Sandomierz loess patch (8–12% $CaCo_3$, and 16% in the parent material) [2].

The carbonate content in loesses plateau facies in Kunów surroundings in II b level (Vistulian loesses) does not fall below 6–7% [6]. These results are also confirmed by Klatka's investigation in Szwarszowice sourroundings, where the

$CaCO_3$ content increases from 6% to 10% in a downward direction, and in the bottom loess puppets occur.

In the stratigraphic exposures of the loess in Krzczonowice surroundings, neighboring Glinka and Buszkowice, $CaCo_3$ content in 1.5 m soil layer is 3–5% on average (norm PN-55/B-04482, where we can observe a ground reaction after pouring a drop of 20% hydrochloric acid) [5].

In the contemporary soil cover, we can observe deep – 2 m zones of decalcification, albeit only in the forest soils. Deep zones of decalcification above 3m depth do occur, but only in the fossil soils of the investigated region, in the Kunów surroundings, i.e. in the chernozem boreal soil and brown forest soil of the Early Glacial – Eem pedocomplex [6]. Contemporarily, even on gently inclined slopes (3–4°), the decalcification zone in general does not exceed 0.5–1 m; sometimes, it disappears completely, which indicates the contemporary activity of strong erosional processes [6].

The reaction of the investigated forest soils of the north margin of the Opatów Upland, derived from loess, varies in the range of strong acid; in the case of arable soils in ranges from acid to slightly acid.

The organic carbon content for the investigated typical brown arable soils is maximally 1.63% and falls into the range of 1.5–2%, proved for the brown soils of the Opatów Upland. Weakly developed soils contain up to 1.5% of humus in the Ap horizon [2, 24]. The increase in the content of organic carbon in the A horizon lying fallow fields is a natural response of the edaphic environment to encroaching xerothermic plants.

The content of available phosphorus and potassium in the investigated arable soils is low. At present, their spatial variability depends mainly on the amount of applied fertilizers. These values are the highest in the soils on the hilltop, much lower at the base of the slope and the lowest on the slope. This relation corresponds to the period of cultivation of the soils (300–600 years), which were investigated in the Lublin Upland [12]. Higher content of available phosphorus and potassium is related to the exposure of illuvial horizons rich in potassium.

In comparison with the soils of the Holy Cross Mountains region derived from loess [8,9], the soils of the investigated area contain a lower amount of sand, and more fine and colloidal fractions. Similarly to the investigated soils in the Obręczówka river valley, the soils developed from loess in the Holy Cross Mountain region are characterized by the predominance of fine silt and coarse silty clay. The lowest degree of soil erosion in the Holy Cross Mountain region, visible in better preserved soil horizons, is related to the subsequent development of settlement in those areas.

The content of fine fractions in the loesses of the Kielce-Sandomierz Upland varies between 6 and 40%. The values of 12–30% are common. The content of fine fractions, as well as clay, is spatially diversified. The lowest content of fine fractions is typical of valley loesses (within the Kamienna river terraces, the average content is about 20%). In loesses that built the slopes of the largest valleys, this content is the highest – 25–28%. In plateau loesses, it is about 30%. Upper parts of the soil cover in most cases have less fine fractions than the horizons lying below. The clay content in the Kielce-Sandomierz Upland loesses varies from several to 20%; most often it ranges within the 10–15% limit. The lowest colloidal clay content is typical of valley loesses, usually below 10%; more can be found in slope and plateau loesses. The upper parts of the loess profiles contain less colloidal clay than the bottom in most parts [18].

The soils of the investigated area have a higher content of colloidal clay than the average for the Kielce-Sandomierz Upland. As for the carbonate content in soils derived from loess within the Kielce-Sandomierz Upland, it varies within much broader limits – 0–18% than in the investigated area [18].

The soils of the Opatów Upland are similar to those from the Lublin Upland, where also the highest content of the colloidal fraction in the soil was stated on the slope, lower on the hilltop, and the lowest in the deluvial zone [12]. The content of colloidal clay in Ap horizons of the Opatów Upland is similar (in some cases the same) to the values achieved for the soils investigated in Elizówka [21]. For non-eroded grey-brown podzolic soils, the content of clay equals, on average, 9%; in weakly and strongly eroded soils – 15%; and in medium eroded soils – 18%.

Moreover, in comparison with the soils of the Lublin Upland derived from loess [12, 14, 23], the investigated area has fewer silt particles (fine silt prevails over coarse silt), and more of the fine and colloidal fraction.

Similar values of the reaction for arable and forest soils derived from loess for the Lublin Upland were revealed in studies, in which the Lublin Upland was the main subject of investigations [12, 26, 27].

CONCLUSIONS

1. The spatial evolution of the soil cover of the Opatów Upland was reflected in the mosaics of the slope and valley soils. This spatial variability of the soil cover is manifested in the reduction of soil horizons (E, B), distinctive thickness of the deluvial material (above 1.2 m) at the base of the slope and the occurrence of carbonates in the surface layers of arable soils. While comparing the humus horizons of the arable soils with the forest soils, it appears that they have higher thickness, different granulometric composition, higher pH values and lower content of organic carbon, while the content of available phosphorus and potassium is higher.

2. The investigated area is mainly occupied by secondary typical brown soils, acid and leached, on weakly developed and strongly eroded slopes.

3. As a result of reduction of the soils horizons situated on the slopes of the investigated valleys, at present, the redeposited loess material forms within valley bottoms a distinct mineral horizon with thickness of approx. 1.5 m, covering the organic horizons. Alluvial soils were transformed into deluvial-aluvial soils.

4. The preserved grey-brown podzolic forest soils in the Las Górny forest situated in the vicinity of Ruszków prove the existence of loess patch grey-brown podzolic soils in the past, within the northern slope of Opatów.

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WSPÓŁCZESNY STAN ZACHOWANIA ORAZ PRÓBA REKONSTRUKCJI POKRYWY GLEBOWEJ W SILNIE URZEŹBIONYM TERENIE LESSOWYM NA PRZYKŁADZIE WYŻYNY SANDOMIERSKIEJ W OKOLICACH OSTROWCA ŚWIĘTOKRZYSKIEGO I ĆMIELOWA

W pracy podjęto próbę rekonstrukcji pokrywy glebowej północnego skłonu opatowskiego płata lessowego na podstawie analizy morfologii 23 profili glebowych i ich właściwości chemicznych. Stwierdzono, iż współcześnie badany obszar zajmują głównie wtórne gleby brunatne właściwe, kwaśne i wyługowane, a na stokach słabo rozwinięte, silnie erodowane. Holoceńskie profile reperowe gleb płowych występują jedynie na obszarach leśnych, między innymi w Lesie Górnym koło Ruszkowa. Dna dolin lessowych wypełniają głównie gleby deluwialno-aluwialne powstałe w wyniku długotrwałej działalności człowieka rozpoczętej w neolicie.