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Soil Genesis

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PEDOGENIC PROCESS ON ELUVIUM-DILUVIUM SOLID CARBONATE ROCKS

Abstract. The article is dedicated to the problem of pedogenic process on eluvium-diluvium solid carbonate rocks and investigation of the formation peculiarities of morphogenetic characteristics of Rendzinas (Rendzic Leptosols, WRB, 2007) under the influence of ligneous and herbaceous agricultural vegetative formations.

One of the most important theoretical and practical problems of contemporary soil science is the pedogenic process on eluvium-diluvium solid carbonate rocks and discovering the main formation peculiarities of morphogenetic structure and functional properties of rendzinas soil profile on different stages of its ontogenetic development, as well as under the influence of various natural-anthropogenic vegetative formations [4].

The constituent part of this problem is the degree of soil change under the influence of soil formation factors which is being determined by their reflectivity (the ability to reflect the influence of a certain factor) and "sensority" (sensitivity to this influence).

Undeveloped soils do not play an essential part in general biosphere's process. Hence, they are not regarded as a category of productive soil resources. However, it's important to study them as they are the initial stage of soil formation on the land surface.

Analyzing the current soil formation on solid and especially carbonate rocks under various vegetative formations, it is possible to study the old-established soil formation on dry land when the autotrophic organism reclamation has just started.

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The study of initial soil formation enables, in general, the revelation of soil formation regularities and, mainly, the interaction of biological and geological circulation of substances, the processes of synthesis and decay, accumulation, take away, and soil formation balance [3].

The problem of initial soil formation and primary soil forming stages has been described in a number of scientific publications [1–6]. However, it has to be taken into consideration that the number of scientific publications on the problem of initial soil formation on eluvium-diluvium solid carbonate rocks and investigation of the formation peculiarities of morphogenetic characteristics of undeveloped soils under the influence of ligneous herbaceous and agricultural vegetative formations is insufficient.

A very interesting publication by Abakumov and Shelemina [1] is dedicated to investigation of soil formation on the monuments of the past. The investigations showed that during the last 300 years, full profile rendzinas (thickness ≈ 26 cm) had been formed on the walls of Coporsk fortress made of local limestone. According to their characteristic features, they are similar to Ordovytsk plateau soils, having been formed on the analogous rocks.

The publication of Chyzhykova *et al.* [2] is also to be taken into consideration as it shows the investigation results of soil formation processes and gives characteristics of morphogenetic properties of undeveloped soils formed during 33 years on the overlying loam under the influence of ligneous, herbaceous and agricultural vegetative formations in terms of the modeling experiment [6].

A new research work by Popa [5] has recently been published defining the regularities and showing the ecological evaluation of initial soil forming processes on the surface of waste heaps of Donbas mines in natural conditions under the influence of different vegetative formations.

MATERIAL AND METHODS

The territory under investigation (Bila Hora tract) in administrative relations is located in the south-eastern part of Bus'k area, Lviv region. According to physical and geographical zoning, Bila Hora tract is located within the boundaries of Voronyatsk natural area of Western Podil'sk Upland of Western Ukraine (Fig. 1).

Podil'sk strata-layer upland landscapes are dominating in the investigation area landscape structure. They are mainly covered with loess-like loamy soils, partially with clear plane carbonate rocks exposed as a result of the outwash.
In the spots where the native cretaceous marl rocks come out on the diurnal surface, formed a widely spread type of surface deposits, which is the eluvia-diluvium crust decay of these rocks. These are the deposit rocks of a mixed loamy-carbonate structure with the content of the loamy material varying from 10 to 30%, calcite – 35–90%. Therefore, the source rock on the territory

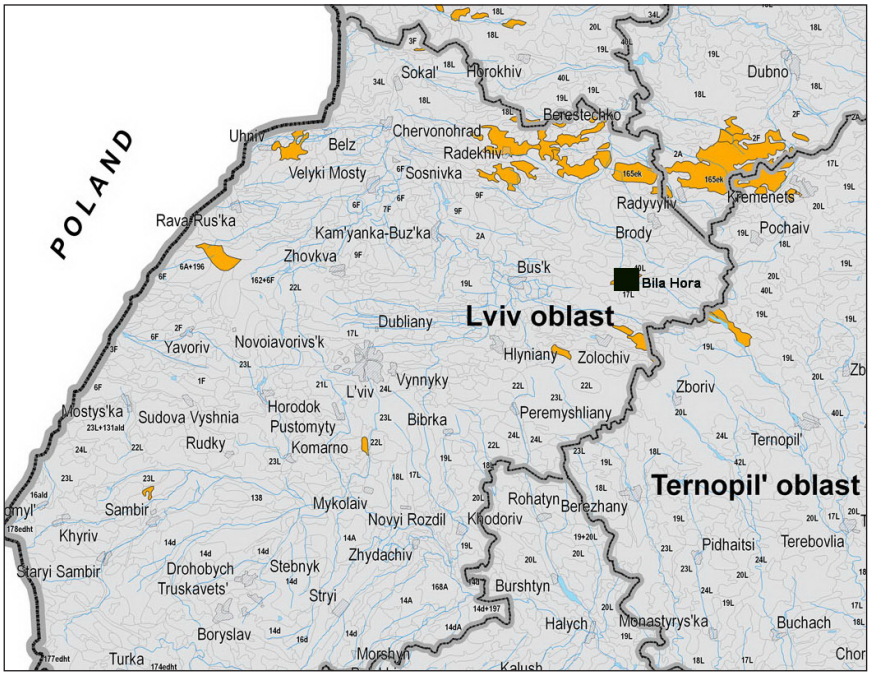

Fig. 1. Localization of soil profiles (Bila Hora – 1 BH–7 BH profiles).

under investigation is the eluvia crust of deposit weathering of the cretaceous system upper section, which is presented by cretaceous marls [3].

Taking into consideration the above mentioned the object of investigation is the initial soil formation processes on the eluvium-diluvium of cretaceous marl.

The subject is the reflective and sensory state of initial rendzinas having been formed on eluvium-diluvium of cretaceous marl under the influence of ligneous, herbaceous and agricultural vegetative formations.

Aiming to study the peculiarities of morphology, the contents and characteristics of rendzinas formed on eluvium-diluvium of the cretaceous marl within the boundaries of Bila Hora tract, we have carried out detailed phytocenotic soil investigations in different geomorphological-hypsometric terms and under different vegetative formations. In 2010, seven modal study sites of phytocenotic soil investigations were laid (each modal study sites is represented by one soil profile) within three geomorphological-hypsometric levels of Bila Hora tract (Table 1).

TABLE 1. SELECTED INFORMATION CONCERNING MODAL STUDY SITES OF RENDZINAS PROFILES

Modal study sites	Profiles	Location	Lithology	Geomorphology	Vegetation
No. 1	1 BH	Bila Hora	eluvium of the cretaceous marl	upper part of the slope of southwestern display with the level of steepness of about 15–20°	perennial herbs; soil surface is turfed
No. 2	2 BH	Bila Hora	eluvium-diluvium of the cretaceous marl	middle part of the southwestern slope with the steepness of about 20°	vegetation is absent; the surface of the soil–broken stone and gravel
No. 3	3 BH	Bila Hora	eluvium of the cretaceous marl	middle part of the southwestern display slope with the steepness of about 10–15°	*Pinus sylvestris* (age ≈ 80 years); within the crown pine (r ≈ 2.0–2.5 m), residues of needles, is observed
No. 4	4 BH	laid on 500 m distance to the south-west from the foot of Bila Hora	eluvium-diluvium of the cretaceous marl	the slope of south-western display with the steepness of about 1–3°	arable land is a fallow; soil surface is turfed (herbaceous cover is up to 30%)
No. 5	5 BH	Bila Hora	eluvium of the cretaceous marl	the lower part of western display slope, with the level of steepness of about 10–12°	*Pinus sylvestris* (age ≈ 80 years); within the crown pine (r ≈ 2.0 m), residues of needles, is observed
No. 6	6 BH	Bila Hora	eluvium of the cretaceous marl	the lower part of the southern display slope, steep about 10°	*Pinus sylvestris* (age ≈ 80 years); within the crown pine (r ≈ 2.5 m), residues of needles, is observed; soil surface is turfed
No. 7	7 BH	Bila Hora	eluvium of the cretaceous marl	the upper part of the northern display slope, steep about 10–15°	perennial herbs with moss admixture; soil surface is turfed

Soil profiles were laid as deep as the parent rock. Morphological structure in the profiles was investigated in detail. The coloring of the soils in the aerial-dry samples was determined according to Mansell's scale. Samples of soil for the laboratory-analytical investigations were chosen according to genetic levels. In the selected samples, hygroscopic water was measused using the thermostatic-gravimetric method, pH_{H_2O} – electrometrically, CO_2 of the carbonates – using the Heisler-Maksymjuk method, humus – using the Tiurin method modified by Nikitin [6].

RESULTS AND DISCUSSION

For the purpose of generalization and analysis, the data concerning the phytocenotic-soil investigations carried out within the boundaries of Bila Hora tract, morphological description of the rendzinas profile of three modal study sites characterized by a well-marked peculiarities of geomorphological-phytocenotic factors of soil formation are presented.

A system of indexes offered by Sokolovsky in 1956, for marking genetic horizons of investigated soils is used in Ukraine. The symbols of genetic horizons according to World Reference Base for Soil Resources (2007) are presented in brackets.

Modal study sites No. 1 (profile 1 BH)

Hd (Ad) 0–2 cm	– turf;
H_{Ca} (A_{Ca}) 2–19 cm	– humus-accumulating horizon, HCl (+), fresh, dark-grey with a marked tint of brown (10YR5/1-5/2), of a small-grained structure, averagely condensed, medium loamy, the roots are of the herbaceous vegetation, gravel inclusions of the initial soil formation rock, transition into the following gradual genetically level;
HP_{Ca} (AC_{Ca}) 19–23 cm	– transiting humus horizon, HCl (+), fresh, heterogeneous color, the upper part is grey touched with white and brown, the white undertone increases downwards (10YR6/1-6/2), of an indistinct smallelodded grainy structure, weakly condensed, broken stone and gravel inclusions of the initial soil formation rock, sudden transition;
P_{Ca} (C_{Ca}) 23–64 cm	– the soil formation rock is presented by eluvium-diluvium of cretaceous marl, in the upper part consisting of broken stone parts d = 3–5 cm, the cavities are filled with a paste-like eroded material, the size of eluvium of cretaceous marl rises downwards.

Modal study sites No. 3 (profile 3 BH)

H_0 (O) 0–2 cm	– forest bedding, consisting of two layers, the upper is 0–1 cm (O1), the previous year defoliation of needles of brown coloration, which didn't lose their anatomical structure; 1–2 cm (O2) – conifer needles half-disintegrated, of dark-brown and dark-grey tint, damp;
H_{Ca} (A_{Ca}) 2–4 cm	– humus-accumulating horizon, HCl (+), fresh, grey with a touch of brown and white (10YP7/1), of a hot solid small-grained structure, weakly condensed, medium loamy, sudden transition to the following horizon;
$P(h)_{Ca}$ (A/C_{Ca}) 4–6 cm	– the fragmentary weakly humused upper part of the soil formation rock, HCl (+), of white coloring with a slightly noticeable grey tint (10YR8/1), unstructured gravel and stone rock parts of the initial soil formation rock, the cavity is filled with a paste-like eroded material of a muddy-yellow coloring, the size of eluvium of cretaceous marl rises downwards;
P_{Ca} (C_{Ca}) 6–12 cm	– the soil formation rock is presented by cretaceous marl eluvium-diluvium, consisting of broken stone parts d = 5–7 cm in the upper part, the space is filled with a paste-like eroded material of muddy-yellow coloring, the size of eluvium of cretaceous marl rises downwards.

Modal study sites No. 6 (profile 6 BH)

H_0+Hd (O+Ad) 0–3 cm	– H_0 (O) – forest bedding (0–1 cm) and Hd (Ad) – turf (1–3 cm);
H_{Ca} (A_{Ca}) 3–13 cm	– humus-accumulating horizon, HCl (+), fresh, grey with a touch of brown and white (10YP7/1), small-grained structure, averagely condensed, medium loamy, herbaceous vegetation roots, gravel inclusions of the initial soil formation rock, gradual transition into the next levels;
$P(h)_{Ca}$ (A/C_{Ca}) 13–20 cm	– weakly humused upper part of soil formation rock, HCl (+), of white color with a noticeable grey tint (10YR8/1), unstructured, consisting of gravel and broken stone parts of the initial soil formation rock, the space is filled with a paste-like eroded material of a muddy-yellow coloring, the size of eluvium of cretaceous marl rises downwards;
P_{Ca} (C_{Ca}) 20–33 cm	– the soil formation rock is presented by eluvium-diluvium of cretaceous marl, the upper part of which consists of broken stone parts, the size of which rises downwards.

On the ground of obtain results the line of macromorphological features of initial soil formation is brought to light:

1. The peculiar horizon of bedding (O) and mineral humus-accumulated horizon (A_{Ca}) were formed under the ligneous vegetation and the upper weakly-humused part of soil formation rock (A/C_{Ca}) is separately distinguished. The general thickness of the profile varies from 12 to 33 cm.

2. Turfed (Ad), humus-accumulated (A_{Ca}) and transit horizons (A/C_{Ca}) were formed under the perennial herbs (with admixture of moss). Their general thickness varies from 23 to 38 cm.

3. Typical rendzinas (A_{Ca}–A/C_{Ca}–C_{Ca}) were found on the fallow. Their general thickness varies from 38 to 60 cm.

4. The washed off-up initial rendzinas (with buried humus-accumulated horizon (B (re)) formed on the bleak study sites.

On the basis of comparative analysis of physical-chemical properties of investigated rendzinas, which according to ontogenetic development of morphologic soil profile can be referred to initial and intensive stages of contemporary soil formation, distinct tendency of profile differentiation of their properties: soil organic matter content and stocks, $CaCO_3$ content, soil environment pH have been revealed. This indicates on functioning and different intensity of predominant biogenic-accumulative soil forming processes in these soils. Investigation results of some physical-chemical properties of investigated soil are shown in Table 2.

TABLE 2. SOME PHYSICO-CHEMICAL PROPERTIES OF RENDZINAS

Profiles	Horizon	Depth (cm)	SOM[a] (%)	SOM[b] (kg m^{-2})	pH_{H_2O} (min–max)	$CaCO_3$ (%) (min–max)
1 BH	H_{Ca} (A_{Ca})	2–19	3.61	15.71	8.12–8.51	31.2–31.9
	HP_{Ca} (AC_{Ca})	19–23	0.52	0.56	8.29–8.73	34.5–36.8
	P_{Ca} (C_{Ca})	23–64	-	-	8.43–9.01	40.8–41.8
2 BH	Ph_{Ca} (A/C_{Ca})	0–10	-	-	8.21–8.39	38.2–39.4
	H_{Ca} (A_{Ca})	10–16	1.23	1.96	7.98–8.08	32.6–35.3
	P_{Ca} (C_{Ca})	16–45	-	-	8.16–8.27	36.9–38.7
3 BH	H_{Ca} (A_{Ca})	2–4	1.17	0.60	8.21–8.31	30.0–32.8
	$P(h)_{Ca}$ (A/C_{Ca})	4–6	0.28	-	8.37–8.98	35.8–36.4
	P_{Ca} (C_{Ca})	6–12	-	-	8.46–9.02	45.7–46.2
4 BH	H_{Ca}op. (A_{Ca}agr)	1–14	2.20	7.15	7.99–8.06	29.4–30.7
	HP_{Ca}п/op. (A_{Ca}agr)	14–28	0.82	2.93	8.18–8.22	33.8–35.3
	Ph_{Ca} (A/C_{Ca})	28–40	-	-	8.29–8.35	40.6–41.8
	P_{Ca} (C_{Ca})	40–65	-	-	8.42–8.47	45.5–47.8
5 BH	H_{Ca} (A_{Ca})	2–5	1.18	0.89	8.23–8.30	28.3–30.0
	$P(h)_{Ca}$ (A/C_{Ca})	6–22	-	-	8.76–8.98	35.0–36.2
	P_{Ca} (C_{Ca})	22–35	-	-	8.97–9.02	44.9–46.8

6 BH	H_{Ca} (A_{Ca})	3–13	2.59	6.55	8.21–8.29	25.8–27.6
	$P(h)_{Ca}$ (A/C_{Ca})	13–20	0.41	-	8.84–8.96	36.3–37.5
	P_{Ca} (C_{Ca})	20–33	-	-	8.92–9.00	39.7–41.4
7 BH	H_{Ca} (A_{Ca})	3–17	3.60	12.80	8.47–8.51	30.1–31.9
	Ph_{Ca} (A/C_{Ca})	17–24	0.05	0.09	8.68–8.73	35.6–36.8
	P_{Ca} (C_{Ca})	24–38	-	-	8.98–9.01	39.5–40.8

a – soil organic matter, %; b - stocks of soil organic matter, kg m^{-2}.

CONCLUSIONS

1. The analysis of field and laboratory-analytical investigations data showed that in various geomorphological-phytocenotic conditions of Bila Hora tract on eluvium-diluvium of cretaceous marl, according to morphogenetic characteristics, different initial rendzinas were formed.

2. It is stated that the soil formation process on eluvium-deluvium of cretaceous marl is connected with parcelarous structure of phytocenoses and phytogenetic study site of some herbs.

3. It was discovered that the formation of genetic profile of initial rendzinas occurred under the impact of biogenous-accumulated processes of soil formation, among which the determinant factors were humus formation *in situ*, bedding-formation and turf processes.

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PROCES KSZTAŁTOWANIA SIĘ GLEB NA SKAŁACH WAPIENNYCH

W artykule przeanalizowano problem kształtowania się gleb na szczelnych skałach wapiennych. Przedstawiono osobliwości kształtowania się morfogenetycznych właściwości rędzin inicjalnych (Rendzic Leptosoils) pod wpływem drzewiastych, trawiastych i rolniczych formacji roślinnych.