

GEOGRAPHIC AND BIO-LITHOGENIC FEATURES OF GENESIS AND DISSEMINATION OF RENDZINAS IN THE WESTERN UKRAINIAN REGION

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Abstract

Investigations of geographic and bio-lithogenic features of genesis and dissemination of rendzinas in Western region of Ukraine have been conducted. Given soils are intrazonal bio-lithological soils, formed in periodical wash and wash type water regimes, mainly under mixed and broad-leaved forests canopy, with well-developed herbaceous cover on eluvium-diluvium products of chalk, cretaceous marl, and marl, and Upper Baden limestone weathering. It has been stated that the largest overall extension areas of Rendzinas are concentrated in Turiys'k-Rorzhyshchens'k natural area, Volynian Polisia region, Polisia territory. It has been found that rendzinas lie on elevated relief elements (denudation plains, floodplain rivers, watersheds, limestone and chalky remnants, steep and declivous river sloping) where quaternary deposits are washed out and eluvium-diluvium crust of cretaceous marl weathering appear on the surface. Complexity and mosaic of rendzinas bedding in soil cover structure determine optimization character of given soils rational usage in Western Ukrainian region.

Key words: Rendzinas (Rendzic Leptosols, WRB), relief elements, soil carbonate parent rocks, morphogenic properties

INTRODUCTION

Ukraine occupies a leading place among the Central-Eastern European countries, the territories of which are rich in rendzinas. Rendzic Leptosols and carbonate chernozems on eluvium carbonate bedrock, which at the beginning of the 60s of the last century were called shallow and deep humus-carbonate soils, respectively, as well as rendzinas, occupy more than 12 000 km² in Ukraine, which is 2.2% of the Ukrainian areas under cultivation. According to the profile capacity, they are divided into carbonate chernozems with the horizons Aca + ACca > 50 cm, and rendzinas Aca + ACca < 50 cm. [8]

Rendzinas on eluvium carbonate bedrock have shallow properly humus profile with the capacity of 30–70 cm, humus content and deposit of which instantly decreases downwards. They are characterized by slightly alkaline and alkaline soil reactions, persistent to external influence and favourable for growth of agricultural crops, by agrophysical and agrochemical properties,

comparably high gross content of the most important elements of root plant nutrition (N, P, K), thus, being of high potential fertility. Parent rock fragments, the number and diameter of which grow downwards, are available on the surface of or in the humus-accumulating horizon. This is connected with the name “rendzinas”, which comes from the Polish word “rend-zyk”, meaning “to clank”, i.e., while cultivating the land, rock materials broke against agricultural implements and produced that sound. In Ukraine, these soils are named “hromyshi”, originating from the words “to rattle”, “to thunder” [5].

Taking into account soil classifications turf-carbonate soils (Ukraine, 1977), Petrozems and Litozems (Russian Federation, 2004), Rendzic Leptosols (WRB) are considered to be the analogue of rendzinas. According to the International Union of Soil Sciences Working Group WRB (2007, 2014), the soil is classified as Rendzic Leptosols developed on straight-bedded limestone and marls. Soil profiles are thin, developed on weathered parent rock enclosing approximately 45% of

gravel and stones. Soils having continuous hard rock within 25 cm from the soil surface; or a mollic horizon with a thickness between 10 and 25 cm directly overlying material with a calcium carbonate equivalent of more than 40 percent, or less than 10 percent (by weight) fine earth from the soil surface down to a depth of 75 cm; no diagnostic horizons other than a mollic, ochric, umbric, or yermic horizon [16].

In Western region of Ukraine both rendzinas and carbonate chernozems, formed on eluvium carbonate bedrocks, occupy the area of 1 622 km² or 13.5% of corresponding soils area in Ukraine. 83.2% are arable lands. The given soils are the most cultivated ones and there are practically no potential sources of arable land area extension [13].

The territory of Western Ukraine administratively is divided into eight regions: Volyn', Rivne, Lviv, Ternopil', Khmel'nytsk, Ivano-Frankivsk, Chernivtsi and Transcarpathian (Figure 1). The total area is 128,900 km² that makes 21.4% of the total area of Ukraine. Considerable extension of Western Ukrainian territory from north to south and from east to west favoured the formation of natural conditions peculiarities and their spatial differentiation. According to physic-geographic scheme of Ukraine regionalization, the given territory is allocated within such azonic regional landscape units as the territory of Polisia, Western Ukrainian territory and Ukrainian Carpathians [10].

Natural factors with spatial heterogeneity and contrast range caused by geographic position, geological structure, geomorphologic and bioclimatic peculiarities play an important role in soil cover functioning, intensive development of soil processes and regimes, formation of soil properties and conditions of their usage. In different regional landscapes, different factors are predominating in soil forming processes. In Polisia territory, the most sufficient soil formation factors are parent rock lithology, vegetation, and surface and soil humidification conditions.

In Western Ukrainian territory, with uniform less loam cover, the soil formation is influenced, primarily, by climatic peculiarities and vegetation, and the relief, as the major

factor of different level of erosion processes display.

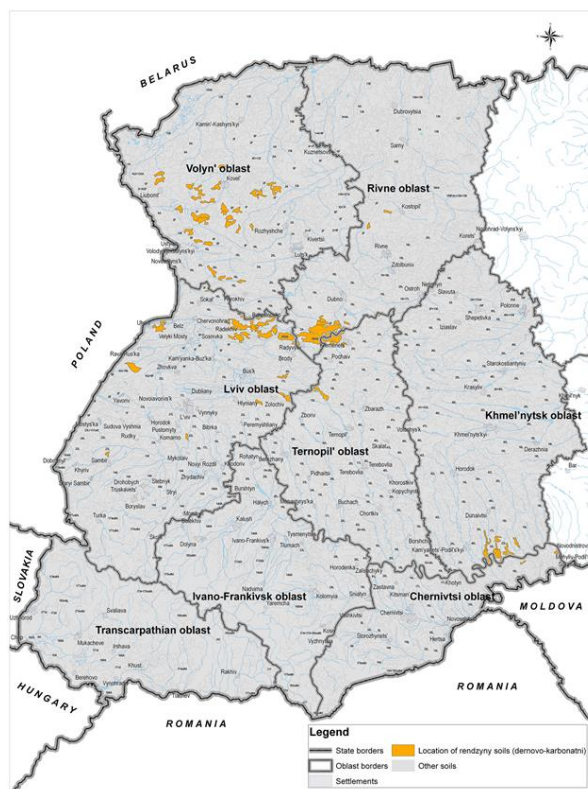


Fig. 1. Map of administrative districts and Rendzinas distribution

Source: Author's map

In Ukrainian Carpathians the character and direction of soil forming macro-process are largely caused by absolute altitude, relief, slope exposition and the character of soil parent rocks.

According to agricultural aspect, the given territory occupies the zones of mixed and broad-leaved forests, forest-steppe and the Carpathian province with vertical soil-vegetative cover belt [18].

Rendzinas reclamation and their long-term intensive use as arable lands lead to agro degradation lying in humus content decrease (dehumification), considerable nutritive balance disturbance (depletion), internal soil weathering intensification and decarbonation (chemical degradation), considerable deterioration of water-air regime, over-condensation and disaggregation (physical degradation), erosive outwash of upper humus horizons (profile degradation), soil cover structure complication at the expense of dimensional uneven growth of the given

processes (geographic degradation) [8].

The investigation of geographic regularities of Rendzinas distribution, their composition and property change under intensification of agricultural production, which led to acceleration of soil degradation processes, is an urgent problem allowing the elaboration of modern adaptive nature-oriented and environmentally friendly systems and methods of land management which are of vital importance during the present agrarian reform.

MATERIALS AND METHODS

For the analysis of peculiarities of Rendzic Leptosols distribution in Western region of Ukraine we used comparative-geographical, cartographical and morphologo-genetical methods. Expedition and semi stationary methods were used in field investigations.

In order to study geographic peculiarities of rendzinas in Western region of Ukraine we analysed soil maps 1:200 000 scale of Volyn' (1969, 2007), Rivne (1970), Lviv (1967), Ternopil' (1969), Khmel'nytsk (1968), Ivano-Frankivsk (1969), Chernivtsi (1969), and Transcarpathian (1969) regions, Western Ukrainian region soil map (2010) 1:200 000 scale, Malyi Polisia (2010) soil map scheme 1:10000 scale, partly materials of large-scale soil investigations and further updatings conducted in 1957–1961, 1965–1966, and 1985–1986 by researchers of Lviv branch of Ukrzemproekt Institute (UAAN) and Ivan Franko National University of Lviv Laboratory of soil geographic investigations. Scientific publications of H. Mahov [9], S. Miclashevski [11], F. Terlikovski [17], A. Musierovich and A. Vondraush [12], I. Gogolev [4], H. Andrushchenko [1], A. Humenyuk [15], N. Lisovyj [7], N. Vernander [18], B. Dobrzanski et al. [2], D. Kovalyshyn [15], Z. Zagorski [19] and others have been analysed.

Primary investigations of rendzinas in Western region of Ukraine, within the boundaries of Volynian Polisia in particular, were carried out at the beginning of the 20s of the last century by the well-known Ukrainian soil scientist professor H. Mahov (1930). The

results of these investigations are presented in the monograph "Soils of Ukraine". During the 30s fragmentary investigations of rendzinas in Western region of Ukraine have been conducted mostly by the Polish scientists, especially by S. Miclashevski (1930), F. Terlikovski (1932), A. Musierovich and A. Vondraush (1936) and others. Major attention was paid to the role of natural factors and, primarily, to the properties of parent rock in the formation of rendzinas agricultural qualities and characteristic of some varieties of these soils as to their agricultural use.

A. Musierovich and A. Vondraush (1936) claimed that the most wide-spread rocks on which rendzinas were formed are upper cretaceous marls of grey-white colouring, locally named "opoka". The scientists stated that "...in the areas, where cretaceous marl bedrocks appear on the surface, prevalent type of surface strata has emerged on the territory under investigation. This type of strata is eluvium-diluvium weathering crust of these bedrocks. It has been proved that in the upper part of the rocks (5–10 cm) cretaceous marl is softened. Density and size of cretaceous marl fragments increase with depth". According to the scientists, this causes the formation of relatively low-capacity rendzinas profile, high content of detritus and unfavourable physical-mechanical and agronomical properties of these soils.

The main achievements made by I. Gogolev include the study of soil formation factors and dominant processes resulting in formation of the given soils in Western Ukraine. The scientist stated that "... within the boundaries of the investigated territory the main factors of "dark-coloured" soils formation are forest vegetation (broad-leaved forests) and lithological composition of parent rock, represented by eluvium genesis cretaceous marl products with admixture of fluvioglacial material in Verhnjo-Bus'k Polisia and limestone of Upper Baden in Rostochchya. Simultaneously, the turf soil forming process is considered dominant. This causes the formation of low-capacity profile, availability of considerable humus content (7.61–9.23%) and reserves, weak acid reaction in the upper horizon (pH_{KCl} 6.3) persistent to the external

influence and favourable agrochemical properties for agricultural crops growth and development, high gross content of root plant main nutritious elements and comparably high potential fertility". The works of Gogolev contained the most detailed description of "dark-coloured" soils (rendzinas). The scientist distinguished relatively powerful transitory humus horizon (8–10 cm) in the profile lower part, he also gave a detailed description of its formation. The author claimed that "... because of the flat territory and weak surface waters flow, intensive soil leaching takes place. This causes soil parent rock acceleration leaching processes and formation of more powerful humus rendzinas profile" [5].

Rendzinas on cretaceous marls are morphologically very similar to Malyi Polisia chernozems and those of the southern part of Volynian Polisia, that is why they are called "polisyan chernozems" [1]. Soils that have been formed from marly opoka are described in the monograph by Zagorski (2003) and named according to the soil systematization in Poland – chernozem rendzinas. [19]

The investigations of Gogolev proved that genetic development of the so-called "polisyan chernozems" considerably differs from that of common chernozems. As soil forming process occurs on dense carbonaceous rocks under the forest canopy, humus accumulation occurs in soil profile, which makes rendzinas similar to chernozems. Their similarity is only morphologic, though, and there is no sufficient grounds to place rendzinas in one type with chernozems. Similar conclusions were found in publications of Ponomaryova and Maslenikova investigating rendzinas humus state on Syluriysk plateau [15].

In his monograph "Soils in Western region of USSR" H. Andrushchenko (1970) characterised rendzinas as "... intrazonal biolithological soils, formed on eluvium weathering crust of cretaceous marls under the simultaneous action of arboraceous and herbaceous vegetation of water regime wash type". The author gave detailed characteristics of rendzinas morphogenetic peculiarities and persuasively proves their "forest" origin based

on a detailed analysis of one and a half oxides redistribution in the given soil profile. He stated that "... the connection of different elementary soil forming processes under sufficient humidity leads to undifferentiated profile formation, characterised by humus accumulating horizon rich in colloids and one and a half oxides and their gradual decrease down the profile, with the exception of calcium, which increases in the same direction. Such redistribution of one and a half oxides and calcium is typical for soil forming processes under arboraceous vegetation, occurring in the direction of podsolization. At the same time, distinct phosphorus (P) accumulation takes place in the upper horizons, being the most essential characteristics of soil formation" [1].

Generalized results of soil ecological and soil genetic investigations of rendzinas in Western region of Ukraine are presented in monographs by A. A. Kyrylchuk, S. P. Pozniak "Turf-carbonate soils (rendzinas) of Malyi Polisia" [8], O. V. Haskevych, S. P. Pozniak "Soil Cover Structure of Holohory-Kremenets Highlands" [3] and O. M. Pidkova, M. H. Kit "Lithological-Genetic Conditionality of Soil Cover Formation in Rostochchya" [14].

Soil genetic investigations of initial rendzinas in different geomorphogenic–phytocoenotic conditions of Bila Hora tract and anthropogenically disturbed rendzinas of artificially formed terraced complexes in Voronyaky and Berezhany Opilya were conducted in recent years. It has been found out that ontogenetic rendzinas reproduction occurs under the influence of biogenetic accumulative soil forming processes, bedding and turf processes being of major importance. At the same time, anthropogenic processes are dominant soil-forming processes in anthropogenically disturbed rendzinas of artificially formed terraced complexes [7].

RESULTS AND DISCUSSIONS

Rendzinas of Western Ukrainian region are intrazonal bio-lithological soils, formed in periodically wash and wash type water

regimes, mainly under mixed and broad-leaved forests canopy with well-developed herbaceous cover on eluvium-diluvium products of chalk, cretaceous marl, marl, and Upper Baden limestone weathering.

In Western Ukrainian region the most wide spread rendzinas subtype is typical rendzinas with undeveloped and normal (modal) types of structure profile (H_k (Ahpca) – HP_k (Ah/Cca) – Ph_k (A/Cca) (Designation of genetic horizons of investigated rendzinas is given according to Sokolovsky (1956), and in brackets – according to WRB (2007)) [6]. Weak washed off and average washed off rendzinas occupy fewer areas. Podzolic rendzinas were not found [8].

On the basis of generalization and analyses of morphologic structure data of representative soil profile laid within the investigated area and shown on photos 1-4, a number of macromorphologic peculiarities of investigated soils are given:

- the capacity of humus (organic matter) containing rendzinas profile within watersheds is about 66 cm;
- a sufficient part of humus containing profile falls on humus-accumulative (mollic) horizon H_k (Ahpca): agroheterogenic, residually-carbonaceous (MO-2-10%, CaCO₃), content of organic matter - 2-5%, the capacity is about 35 cm, dark-grey with brown colouring (10YR6/1). Texture dribnozem – SL. It has been stated that 80-90% of cretaceous marl detritus are of effective diameter (d) from 20 to 7 mm; 20-10% falls on detritus with d < 7 mm.



Fig. 2. Rendzinas developed from chalk, Volynian Polisia region



Fig. 3. Rendzinas developed from cretaceous marl, Malyi Polisia region



Fig. 4. Rendzinas developed from marly opoka, Western Podolia region



Fig. 5. Rendzinas developed from Upper Baden limestone of Rostochchya region

Well-developed structure (usually angular blocky or fine sub- to angular blocky structure), pH_{H2O} 7.62-7.73. Bulk density – 1.45-1.52 Mg/m³. In the lower part of the horizon (depth 20-25 cm) bulk density – 1.48-1.63 Mg/m³;

- transitional humus horizon HP_k (Ah/Cca), residually-carbonaceous (ST-10-25%, CaCO₃), content of organic matter – 1.5-3.5%, is of ≈17 cm capacity. Grey with brown and white colouring (10YR6/1-7/1). Texture dribnozem – SL. It is characterized by a

sufficient increase in quantity and size of cretaceous marl detritus, 70-80% have the diameter (d) more than 20 mm, 30-20% - from 20 to 7 mm and less. The structure of the dribnozems part is cloddy (SB).

– transitional humus horizon Phk (A/Cca) consists of two thirds of coarse-detritus eluvium-skeletal material (diameter of cretaceous marl detritus is from 30-50 to 70 mm) and of a third – dribnozems, being clay-organic matter – material mixed with amorphous products of cretaceous marl weathering. Its capacity is usually about 14 cm. The dribnozems part is unstructured.

– according to rubbly surface, rendzinas belong to surface weak rubbly (<10%) and surface medium rubbly (10-20% of projective cover). In “Manual to the soil description” (2012) the quantity of detrital material on the surface of investigated soils is described as average (C) – 5-15% and more (M) - 15-40%. Medium gravel predominates (M) - 0.6-2 cm.

The total area of Rendzinas in Western region

of Ukraine, calculated according to large-scale soil investigations data in different years, makes 1,019 km², 810 km² of which are arable lands. Ploughed land – 79.5% (Table). The overall rendzinas area of Western Ukraine was calculated based on digitized Soil Map of Western Ukraine 1:200 000 scale and ArcGIS 9 programme is 1 466 km². Different areas size was determined by their specification during further corrections of soil investigations and inclusion into total rendzinas area soil complexes, in which given soils are considered dominant. It has been found that there are 77 continuous rendzinas outlines in Western Ukraine; the area of the biggest is 315 km², the smallest 2 km². The average area of rendzinas is 18 km².

The largest Rendzinas area is found in Volyn’ region, which is 415 km² or 40.7% of the total regional rendzinas area, 359 km² of which are arable lands or 44.3% of the total arable rendzinas area (Table 1).

Table 1. The areas of Rendzinas in Western Ukrainian region, km² (the numerator – total, denominator – arable lands)

Soils	Administrative districts						Total	Ploughed, %
	Volyn’	Rivne	Lviv	Ternopil’	Khmel’nytsk	Chernivitsi		
Rendzinas on eluvium carbonate bedrock (map code 165)	$\frac{415}{359}$	$\frac{231}{189}$	$\frac{227}{192}$	$\frac{27}{24}$	$\frac{36}{2}$	$\frac{83}{44}$	$\frac{1019}{810}$	79.5
Carbonate chernozems on eluvium carbonate bedrock (map code 78)	-	$\frac{111}{107}$	$\frac{312}{296}$	$\frac{118}{79}$	$\frac{62}{58}$	-	$\frac{603}{540}$	89.6
Total	$\frac{415}{359}$	$\frac{342}{296}$	$\frac{539}{488}$	$\frac{145}{103}$	$\frac{98}{60}$	$\frac{83}{44}$	$\frac{1622}{1350}$	83.2

Source: Own calculation.

It has been stated that the largest overall areas of rendzinas extension are concentrated in Turiys’k-Rorzhyschens’k natural area, Volynian Polisia region, Polisia territory, or within such administrative districts as: Turiys’k, Lyuboml’, Kovel’, Volodymyr-Volyns’k, Ivanychykivs’k, less – in Horohiv and Rorshyshe. Rendzinas are mostly allocated on the elevated relief elements, where quaternary deposits covering eluvium-diluvium chalks are washed out. The given

soils are found as separate lots among podzolic soils (Fig. 1 and 2). Depending on bedding conditions, rendzinas differ by the profile structure, grain-metric composition and other properties.

On the chalky hills and slopes, they are characterized by heavy broken stone humus horizon. Broken stone consists of parent rock, sometimes with a substantial admixture of flint. Solid chalk or cretaceous marl plate lies on the depth of 35–50 cm. On the upland lots

of watersheds, rendzinas have somewhat more powerful upper humus horizon (25–30 cm), and the depth of solid chalk plate is 50–70 cm.

Within the inter-watershed lowlands, rendzinas profile capacity can reach 1 m and its underneath is usually clayish.

Extensive arrays of continuous rendzinas are found in Radehiv-Brody and Kulykiv-Bus'k areas of Malyi Polisia region of Polisia territory, Voronyaky area of Western Podil'sk upland region and Holohory area of Roztochchya-Opilya upland region of Western Ukrainian territory.

Concerning rendzinas area, Rivne and Lviv regions take the second and the third place – 231 km² (or 22.7% of all rendzinas area, 189 km² of which are arable or 23.3% of all region arable rendzinas) and 227 km² (or 22.3% of the region area, 192 km² of which are arable or 23.7% of all region arable rendzinas), respectively (Table 1, Fig. 1 and 3-5).

In Rivne, region rendzinas are mostly concentrated in Radyvyliv and Ostroh districts and in Kostopil denudation plain. They are spread in floodplain rivers, in small spots, where parent rock is meadow marl.

According to administrative division, rendzinas in Lviv region are concentrated in Radekhiv, Brody, Zolochiv, Busk and Rava-Rus'ka districts. Extensive arrays of these soils are found within boundaries of Bug-Styr wavy denudation plain, where they occupy upper lots of interfluvial areas with absolute altitude of 240–260 m, and in the watershed of Raty and Solokia rivers near Uhniv. They are formed in conditions of plain-hill relief on eluvium-diluvium crust of cretaceous marl weathering, under arboraceous and herbaceous vegetation, in water regime washing type. Most widespread are deep humus type rendzinas with a chernozem profile structure. The allocation of these soils on the upper interfluvial lots causes genetic profile formation without any traces of claying.

In Ternopil' (Zboriv, Pochaiv, Kremenets districts), Khmelnyts'k (Volochnyts'k, Horodok, Dunaiv districts) and in Chernivtsi (Zastavniv and Sokyryany districts) regions rendzinas areas make 27, 36 and 83 km² or

2.6, 3.5 and 8.2% of all region rendzinas area, correspondingly. A distinctive feature of rendzinas massive areas in Ternopil' region is that they are close to limestone hills of Malyi Polisia, where less thickness is washed off and the products of limestone and cretaceous marl weathering, which become soil parent rocks, appear on the surface (Table 1, Fig. 1, 4).

In Khmelnyts'k region continuous rendzinas areas lie on the steep and declivous river sloping of the Dniester, Zbruch, Smotrych, Ternava, Ushytsya, Kalyus, where eluvium of cretaceous marl and Upper Baden limestone is the soil parent rock (Table 1, Fig. 1, 5).

The characteristic feature of continuous rendzinas areas in Chernivtsi region is that they are disposed in a narrow stripe form along the Dniester valley, on steep slopes of different exposition (Fig. 1).

CONCLUSIONS

The analysis of rendzinas geographic dissemination in Western region of Ukraine allows to make the following conclusions:

(i) Rendzic Leptosols (rendzinas) of Western Ukrainian region are intrazonal biolithological soils, formed in periodical wash and wash type water regimes, mainly under mixed and broad-leaved forests canopy, with well-developed herbaceous cover on eluvium-diluvium products of chalk, cretaceous marl, marl, and Upper Baden limestone weathering.

(ii) The most widespread rendzinas subtype in Western Ukrainian region is typical rendzinas with undeveloped and normal (modal) types of structure profile. Weak washed off and average washed off rendzinas occupy fewer areas.

(iii) It has been stated that the largest overall extension areas of Rendzic Leptosols (rendzinas) are concentrated in Turiys'k-Rorzhyshchens'k natural area, Volynian Polisia region, Polisia territory.

(iv) It has been found that Rendzic Leptosols (rendzinas) lie on elevated relief elements (denudation plains, floodplain rivers, watersheds, limestone and chalky remnants, steep and declivous river sloping) where quaternary deposits are washed out and

eluvium-diluvium crust of cretaceous marl weathering appears on the surface.

(v)Complexity and mosaic of Rendzic Leptosols (rendzinas) bedding in soil cover structure determine the optimization character of rational usage and soil safe infrastructure establishment in Western Ukrainian region.

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