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S. Skiba

SOME PROBLEMS OF THE SOIL CLASSIFICATION OF THE CARPATHIAN MOUNTAIN SOILS

Jagiellonian University, Poland

The soil cover of the Carpathians, like it is in the area of whole Carpathian arch, is connected to the regolith and to the dynamics of the morphogenetic processes as well as to the climate and the climate-derived vegetation.

In the area of the Carpathian Foothils Haplic Luvisols and Albeluvisols prevail. In the region of the Flysch Carpathians Cambisols prevail covering more than 80% of the whole area. Dystric Cambisols cover the biggest areas yet Eutric Cambisols occur as well as Cambic Leptosols, Lithic Leptosols, Regosols and Gleysols. Histosols and Fluvisols also occur in this region. In the Tatra Mts (granite parent material) – Podzols, carbonate bedrock – Rendzic Leptosols occur.

Keywords: soils of the Carpathians, pedogenesis, classification.

С. Скиба

Ягеллонський університет, Польща

ДЕЯКІ ПРОБЛЕМИ КЛАСИФІКАЦІЇ ГІРСЬКИХ ҐРУНТІВ КАРПАТ

Ґрунтовий покрив Карпат пов'язаний з реголітом і з динамікою морфогенетичних процесів, з кліматом і обумовленою ним рослинністю. В області низькогір'я переважають *Haplic Luvisols* і *Albeluvisols*, в області флішевих Карпат – *Cambisols*, займаючи понад 80 % площі. Dystric Cambisols покривають найбільші області, як і *Eutric Cambisols*, *Cambic Leptosols*, *Lithic Leptosols*, *Regosols і Gleysols*. Histosols і Fluvisols також зустрічаються в цьому регіоні. У Татрах (гранітна материнська порода) зустрічаються *Podzols*, а на карбонатних породах – *Rendzic Leptosols*.

Ключові слова: ґрунти Карпат, педогенез, класифікація.

The Carpathians stretch in an arc of roughly 1300 km from the vicinity of Vienna to the Iron Gate on the Danube. In the west geological Carpathians are called Eastern Alps and in the east they are connected to the Balkanised. Geology of the Carpathians divides the chain into older Inner Carpathians and younger Outer Carpathians (Flysch Carpathians). Carpathians are the largest, longest and most twisted and fragmented mountain chain in Europe. Stretching in an are across Central Europe, they cover parts of seven countries starting from the Czech Republic in the northwest, then running east and southwards trough Slovakia, Poland, Hungary, Ukraine and Romania, and finally Serbia in the Carpathians extreme southern reach (*Figure*).

Research concerning soil cover of the Carpathians has a considerably long tradition. The first scientific paper concerning soils of the Carpathians was Kazimierz Miczyński's *About genesis and chemical composition of the soils of the Sądecka Valley (O pochodzeniu i składzie chemicznym gleb Doliny Sądeckiej)* printed in Cracow in 1894. Since then scientific literature about soil cover of the Carpathians from all the Carpathian countries has reached the number of over 600 positions (Skiba, 1995).

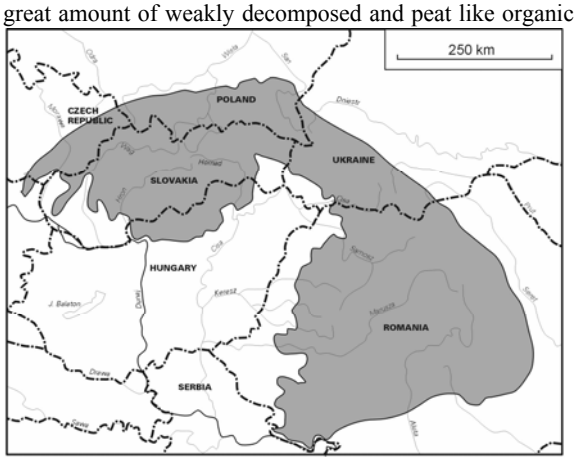
Research concerning Carpathian soils is usually carried out in the scientific centres geographically connected to this mountain chain – Vienna, Bratislava, Presov, Cracow, Lublin, Lwów, Chernovtci, Cluj. In the description of the soil cover of the Polish part of the Carpathians pedological and cartographical research and publications for the Carpathian national parks play a major role (e.g. Adamczyk, Greszta, 1982; Komornicki, Skiba, 1985, Skiba et al., 1998, 2002; Skiba, 2002; Skiba, Drewnik, 2003).

SPECIFIC CHARACTER OF PEDOGENESIS

Soils of the Carpathian Mts. like soils of other mountain system can be characterized by several common features that differentiate them from lowlands soils. The genesis of the mountain soils is strictly connected to the massive and slow weathering regolith, relief and intense morphogenetic processes that determine the fragmentary character of the soil cover. It means that among soils with a well developed soil profile rock non-soil forms and different variants of initial soils occur (Skiba, 2006). Good examples can be provided by the great Tatra Mts, Bucegi Mts. rock walls, the Western and Eastern Beskidy Mts ridge rock outcrops, or rock rubbles in the Gorgany Mts. The shallow soil profile and a considerable amount of rock pebbles in the soil mass are the characteristic features of

both the Carpathian soils and the soils of other mountain regions. It is determined by the lithological features of the bedrock and by the intensity of the morphogenetic processes. Mountain relief and regolith are also connected to the specific hydrological conditions. Lateral movement of the soil solutions causes the occurrence of numerous water exudations, moist areas and in-slope sources. These waters form the chemical characteristics of the soils and they also influence the formation of specific variants of mountain soils. Examples for this can be provided by patches of Eutric Regosols enriched with alkaline elements by the mid-cover an rock waters as well as the Carpathian Mollic Gleysols occuring on the carbonateless bedrock e.g. in the Flysch Carpathian in the *Pulmonario-Alnetum* communites in the Charnokhora Mts. (Skiba et al., 2006).

What is peculiar about the soils of all the mountain regions including the Carpathian Mts. is a great amount of weakly decomposed and peat like organic matter as well as the increase of its depth in the course of the increasing altitude above sea level. Cool an humid conditions of the mountain climate as well as the adjacent plant communities (together with the soil edaphone) determine the low rate of the decomposition of plant remains (Skiba et al., 1998; Drewnik, 2006). The occurrence of the soils with the 10–20 cm or deeper organic horizons (Ofh) on high altitude under the blueberry (Vaccinietum) and dwarf pine communities forming the tangel rankers (Umbric Leptosols) or tangel rendzinas (Foli-Umbri Rendzic Leptosols) proves the important role of climate and vegetation in the genessis of the mountain soils (Skiba, 2006) (Table 1).



Localization of the Carpathians in Europe

Table 1

Some properties of the Carpathian Leptosols

Depth	Horizon	Colour	Clasts	Texture	pH (H_20)	C:N
Tatra Mts. - granite, Pinetum mughi, 1480 m a.s.l.						
0-10cm	Ofh	7,5YR 2/3			3.9	29
10-14cm	AE	5YR 4/3	40	LS	3.6	18
14-30cm	Bs	5YR 5/6	60	LS	3.9	18
<30cm	CR	granite				
Tatra Mts. - limestone, Pinetum mughi, 1500 m a.s.l.						
0-12cm	Ofh	7,5YR 2/3			3.6	25
12-25cm	AC	10YR 2/1	30	L	5.3	20
25-30cm	ARca	10YR 4/1	70	L	7.8	18
<30cm	Rca	limestone				
Bieszczady Mts. - flysch sandstone, Vaccinietum myrtilli, 1250 m a.s.l.						
0-4cm	Ofh	5YR 3/4			3.8	22
4-20cm	A/C1	5YR 3/2	30	SL	4.0	20
20-35cm	A/C2	7,5YR 3/2	60	SL	4.0	
<35cm	R	sandstone				
Charnokhora Mts. - flysch sandstone, Vaccinietum myrtilli, 1800 m a.s.l.						
0-7cm	Ofh	7,5YR 3/3			3.6	20
7-30cm	A/C	7,5YR 5/5	70	SL	4.5	16
<30cm	R	sandstone				

LS – loamy sand

L – loam

SL – sandy loam

The acidic reaction of the surface layers (Ofh or Ah) of almost all the soils of the mountain regions including rendzinas is connected to the pedogenetic processes characteristic for the humid climatic conditions of the Carpathian Mountains and it should not be associated with the acidification of the environment caused by the so-called acid rains (Skiba, 2006).

SOILS OF THE CHOSEN CARPATHIAN REGIONS

The Carpathian region can be divided into Western, Eastern and Southern parts. There is yet another division based on the natural environment differentiation and the units are as follows: Carpathian Foothills or Flattening, Outer Carpathians (Flysch Carpathians), Inner or Central Carpathians.

Carpathian Foothills is a well formed highland belt of the Northern part of the Carpathians. The area is covered with silt formation deposited on flysch formations. These formations called Carpathian loess or loess-like formations are carbonateless and they form covers some few dozen metres deep.These formations provide bedrock for the prevailing Haplic Luvisols, Albeluvisols and the Stagnic Luvisols. These soils cover approximately 90 % of the Carpathian Foothils area. Other soils as concomitant formations cover considerably small areas and they are Gleysols and Eutric Fluvisols.

Outer Carpathians (Flysch Carpathians) include Beskidy Mts (among Western and Eastern Carpathians in the Poland and Ukraine). These ridges are situated within the nappe-fold flysch formations that belong to different structural units (nappes) built of comlexes of the alternately placed sedimentary rocks beds of a big fractional differentiation. Regolith of these formations is usually loamy and it is remodelled by the morrphogenetic processes that form the slope covers (delluvial, delluvial solifluctional). Gravitationally moved delluvial skeleton slope covers usually provide bedrock for the occurring there soils and their properties are not always related to the rock. These lithogenical pedogenetic inconsistencies are characteristics for the mountain region soils, also for the soils of the Carpathians. In the described area of the Flysch Carpathians (Outer Carpathians) on the decalcified clay slope covers mainly Dystric Cambisols have been formed. Shallow and skeleton cambic rankers (Cambic Leptosols) occur together with these soils. Eutric Cambisols occur on smaller areas usually on weathering and carbonate flysch weathering formations. They also occur in the areas of the slope covers enriched with alkaline elements by the migrating rock and mid-cover waters. They are usually Gleyic-Eutric Cambisols.

Inner Carpathians cover the central part of the Carpathian Mts with a very differentiated geological environment like the Southern Carpathians. The geological base in formed of crystalline, volcanic and metamorphic rocks, Mesosoic limestone and dolomites. The soil cover corresponds to the varied geological and orographic conditions. On non-carbonate rocks (e.g. granites, shales) acidic soils (mainly Haplic Podzols) were formed. On steep slopes podzolic rankers (Leptic Podzols) and raw-humus forms of alpine rankers (Foli-Umbric Leptosols) developed. Within the sub-alpine and alpine belts, initial soils (Lithic Leptosols) and Regosols prevail. (Table 2, 3.)

Table 2

Some properties of the organic matter of the selected Leptosols in alpine zone of the Carpathians

Depth	Horizon	Colour	pH (H_20)	C_{total} (%)	Ch:Cf	Hi
Tatra Mts. (Poland) – granite, Pinetum mughi, 1650 m a.s.l						
0–15 cm	Ofh	7,5YR 3/2	3.3	37.1	0.41	0.11
Tatra Mts. (Poland) – limestone, Pinetum mughi, 1600 m a.s.l						
0–14 cm	Ofh	10YR 2/2	4.2	37.5	0.37	0.11
Charnokhora (Ukraine) – sandstone, Vaccinietum myrtilli, 1580 m a.s.l						
0–12 cm	Ofh	10YR 2/1	3.5	18.1	0.46	0.24
Bieszczady Mts. (Poland) – sandstone, Vaccinietum myrtilli, 1250 m a.s.l						
0–11 cm	Ofh	10YR 2/1	3.5	15.2	0.36	0.30

* Skiba et al., 2004, Les conditions pedogenetiques d'humiferation des sols dans les regions Montagneuses (in:) K. Krzemień (ed.) Les transformations du milieu Montagnard-Carpates, Massif Central et autres Montagnes D'Europe, Prace Geogr., 113, 53-60.

Table 3

Chemical index of the spodic horizons of the selected Podzols of the Carpathians

Profile	Tatra Mts. 1*	Tatra Mts. 2*	Charnokhora Mts. 1**	Charnokhora Mts. 2**
1	2	3	4	5
Colour (moist)	5YR 3/2	5YR 3/2	7,5YR 3/4	7,5YR 3/4

Continuation of the table 3

1	2	3	4	5
C_{org} (%)	9.4	5.3	2.9	3.2
pH (H_2O)	4.4	4.6	4.8	4.5
Al_{ox} + 0,5 Fe_{ox} (albic)	0.28	0.48	0.38	0.13
Al_{ox} + 0,5 Fe_{ox} (spodic)	2.53	3.01	1.48	1.69
ODOE (albic)	0.32	0.39	0.20	0.20
ODOE (spodic)	1.58	1.41	0.77	1.05

* Skiba M., Skiba S., 2005, Chemical and mineralogical index of podzolisation of the granite regolith soils., Pol. Journ. of Soil Sci., 38, 153-161.
** Skiba S., Szymański W., Pozniak S., Skiba M., 2008, Soils of the Charnokhora Mts. (Ukraine), (this report).

On carbonate rocks, various sub-types of rendzinas (Rendzic Leptosols) prevail, including specific alpine variants of raw-humus rendzinas (Foli-Umbri Rendzic Leptosols). On volcanic rocks, Andi-Lithic Leptosols can be found.

CONCLUSION

1. Soil cover and its structure are strictly connected to the regolith (parent materials), relief and geomorphological processes as well as to the climatic and vegetation conditions.

2. Major mountain soils are as follows:

a. lithogenous formations – shallow soil profile and considerable amount of skeleton in the soil mass

b. geomorphic formations – destruction and accumulation of the soil profile trough erosion processes

c. climatogenic formations – specific character of the humus horizons.

3. On the silt formations of the Carpathian Foothills and in the valleys Luvisols prevail (Haplic, Stagnic, Albeluvisols)

4. In the Outer Carpathians (Flysch Carpathians) on the clay weathering Cambisols prevail (Eutric, Dystric), Spodosols are also present.

5. In the Inner Carpathians (Central Carpathians) Spodosols (Haplic, Leptic, Skeletic) have been formed on the granitoide and metamorphic rock weatherings as well as on moraine covers. On limestone weathering various forms of Rendzinas (Rendzic Leptosols) occur.

6. In the zones above upper timber line alpine variants of lithogenic, geomorphic and climatogenic soils occur.

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