Some Features of Cambisols Soil-Forming Process from Training and Experimental Forest Range (TEFR) „Petrohan" Region.

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Abstract:

Dystric/eutric Cambisols diagnostic features from TEFR Petrohan were investigated in the present study, which morphologically corresponded to Podzols. Diagnostic horizons were investigated to establish presence or absence of podsolization process and to classify the soil type according to the modern requirements of WRB, (2006, 2007; 2014). Humus forming process insitu, clearly expressed in the A_h horizon, acidification, degradation of clay minerals, formation of *E* horizon, which is clay-poor with increased content of sand, accumulation of Fe and other mobile elements in *Bw* horizon were established. The metamorphic *Bw* horizon had some diagnostic properties, which met these of *spodic* horizon. This horizon is specific for the Podzols. The content of organic carbon in it was less than 0.5 %. Cambisols properties are predominant.It was established that the soil-forming process in the investigated Cambisols is directed to podsolization process.

Key words: Cambisols, Podzols, org.C, *albic*, *spodic* diagnostic horizon

Introduction

Dystric/eutric Cambisols are significant for the forestry in Bulgaria. Depending on the combination of the main soil forming factors, in some of them are established specific processes. For example, one of them is the podsolization process that creates conditions for the formation of a new soil type called Podzols.

Some of the first sources of information for the Podzols are mentioned in Russian literature in the 1950s (Williams, 1949, Garkusha, 1951, Vilenskii, 1954, Russel, 1955, Alexandrova et al., 1958). In the following years, a number of authors (Petersen, 1976, Mokama and Buurman, 1980; Anderson et al., 1982; Petersen, 1984; Buurman, 1984; Lundström et al., 2000) studied their genesis, chemical, mineral composition and key features.

According to the World Reference Base for Soil Resources (WRB, 2006, 2007) and the International Union of Soil Sciences (IUSS) Working Group WRB, 2014 Podzols covers 485 million ha worldwide, mainly in the temperate and boreal zone of the northern hemisphere. They occupy vast territories in Scandinavia, Northwest Russia and Canada.

The first information in Bulgaria about these soils is given by Boyadzhiev in 1967. It is known that they are distributed mainly in the middle and high mountain areas. They are formed under the influence of coniferous and mixed forests, humid, cold climates and silicate rocks. According to Achkov's studies (1980, 1981), the soils that correspond to in the country are Cambisols. They can evolve at a certain stage of their development into Podzols. This statement is confirmed by other authors (Dialo, 1995; Teoharov et al., 1995). Cambisols can change and form a *spodic* diagnostic horizon, which is specific for the Podzols. In them it is formed under the influence of climate change and the dominant vegetation, anthropogenic impact, etc., which alter the processes of decomposition of the litter and lead to the accelerated formation of water-soluble organic acids (Lundström et al., 2000; Sauer et al., 2007).

In Bulgaria a podzolization process of Umbrisols was described by Achkov (1980) in the high parts of the Rila mountains - 2485 m and an initial stage of podzolization process at an altitude of 1460 m - 1470 m also in Rila (1981). The presence of a typical *spodic* diagnostic horizon is mentioned by Dialo (1995), at an altitude of 1450 m in Pirin mountains. According to Dialo (1995), these soils are still not well described in the country, but they are a separate taxonomic unit and should find a place in the soil classification of Bulgaria. Boyadjiev has also mentioned the Podzols (1994a, 1994b), when he has established a correlation between the American Taxonomic System and that of the revised FAO-UNESCO-ISRIC legend with the Basic Soil Classification in Bulgaria. It is clear that the correlation is completely possible and necessary.

According to unpublished data of Yordanov (1985) on the territory of the TEFR Petrohan there is a Podzols with clear morphological features. For this soil, no parameters have been studied so far that characterize the elementary soil-forming processes and diagnostic features to prove the *albic* and *spodic* horizons necessary for the definition of a Podzols, according to WRB requirements (2006, 2007 and 2014). The aim of the present study is to investigate the diagnostic features of Cambisols from the territory of the TEFR Petrohan, which morphologically corresponds to Podzols, to determine the diagnostic horizons, to establish the presence or absence of podzolization process and to classify the soil type according to WRB's modern requirements (2006, 2007, 2014).

Materials and Methods

The investigated soil is located at 1400 m altitude at the southern exposure. It has a depth of 30 cm and more. The soil-forming rock is granite. The litter is 1 cm, torn by grass and shrubs mainly covered by blackberry (Vaccinium myrtillus L.) and blueberry (Vaccinium uliginosum L.). When plotting the soil profile, morphological features different of these of Cambisols and typical for Podzols were established. The strongest impression was the colour change of separate horizons that point to the presence of albic and spodic diagnostic horizons. In the soil profile are defined AturfAEBC horizons by morphological features.

Parameters that characterize diagnostic albic and spodic horizons are investigated: colour by horizons (Munsell scale); Texture - Modified Kachinski method (dispersion with sodium pyrophosphate); pH (CaCl2) - ISO 10390; pH (H_2O) - ISO 10390; Organic carbon - Modified Turin's method (Kononova, 1963; Filcheva E., S. Tsadilas, 2002); exchange cations - ISO 11260 & ISO 14254, 0.1 M / l BaCl2 solution and AAS Perkin Elmer 5000; exchangeable acidity - ISO 11260 & ISO 14254 (extract with 0.1 mol / l $BaCl_2$ solution to equilibrium desorption and titration with 0.05 mol / l NaOH); Fe content - by decomposition with Aqua regia and Flame AAS (ISO 11466) Perkin Elmer 5000; cation exchange capacity - determined as a sum of the basic cations and the exchangeable acidity.

Results and Discussion

Studies on the *E* albic diagnostic horizon showed full compliance with WRB requirements (2006, 2007 and 2014). It laid directly under the humus-accumulative horizon. The distinctness between them was clear. The topography between the *E* and the *B* horizon was wavy with slightly albeluvic features. The soil's colour in the *E* horizon was bright - 10 YR 6/1 (when dry). It met the requirement for a value of less than 7 and a chroma of less than 3 WRB, (2006, 2007, 2014) (Table 1).

Table 1. *Soil colour by horizons (Munsell scale)*

Horizon	Soil Depth (cm)	Distinctness	Colour
O	1-0	-	-
A_h	0-7	clear	10 YR 3/2
A	7-14	clear	10 YR 3/3
E	14-20	clear	10 YR 6/1
B_w	20-30	clear	7.5 YR 4/4
C	30 -↓	clear	10 YR 6/3

Photo 1. *Soil Profile*

On the field, the *Bw* horizon was determined as a *spodic* diagnostic horizon. The requirements of WRB (2006, 2007; 2014) for its definition are: for colour, soil depth, amount of org. C, pH_{H2O} and absence of a *natric* diagnostic horizon, with a high content of exchangeable Na, and / or Mg.

The study showed that the soil colour in the *Bw* horizon corresponded to the requirements. It was determined as 7.5 YR 4/4 (when moist) and met the requirement for hue 7.5YR, value 5 or less and chroma 4 or less. It laid directly below the *albic* diagnostic horizon. The soil depth of *Bw* horizon was 10 cm, which met the requirements for *spodic* horizon - minimum 2.5 cm. The pH of the soil solution was - pH_{H2O} = 5.2 and also met the requirements for a *spodic* diagnostic horizon - pH_{H2O} of less than 5.8 (Table 2).

A disparity with the *spodic* diagnostic horizon requirements of the WRB (2006, 2007; 2014) was established only with respect to the amount of org. C, which was very low and did not exceed the minimum of 0.5% . The result was obtained as an average sample of the entire 10 cm soil depth of the horizon (Figure 1).

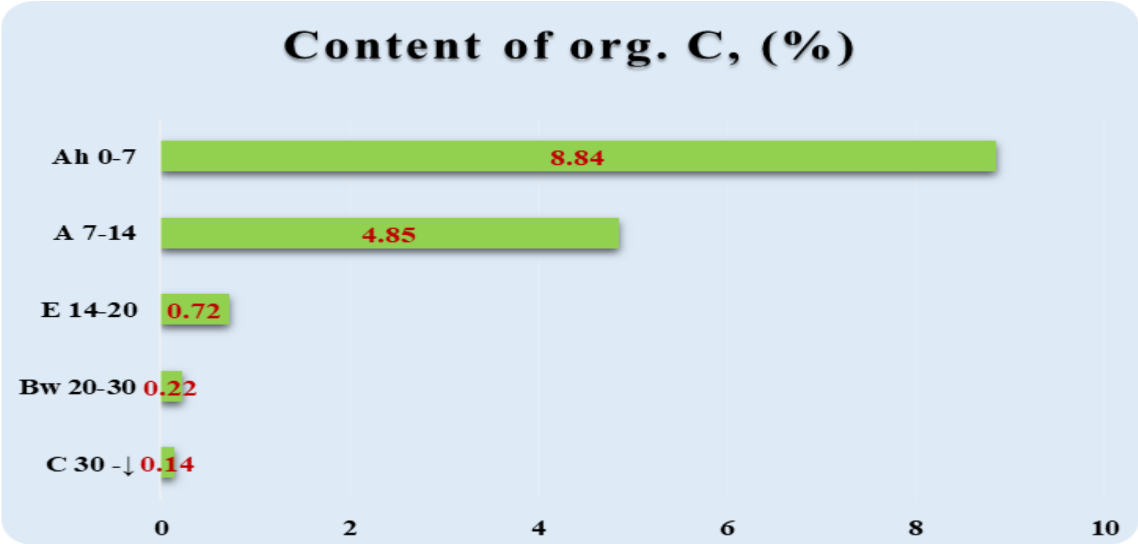

Figure 1. *Content of org. C, (%) in the soil profile*

In order to trace the distribution of org. C in *Bw* horizon, it was divided into 4 parts by 2.5 – as the required thickness for *spodic* diagnostic horizon (Figure 2).

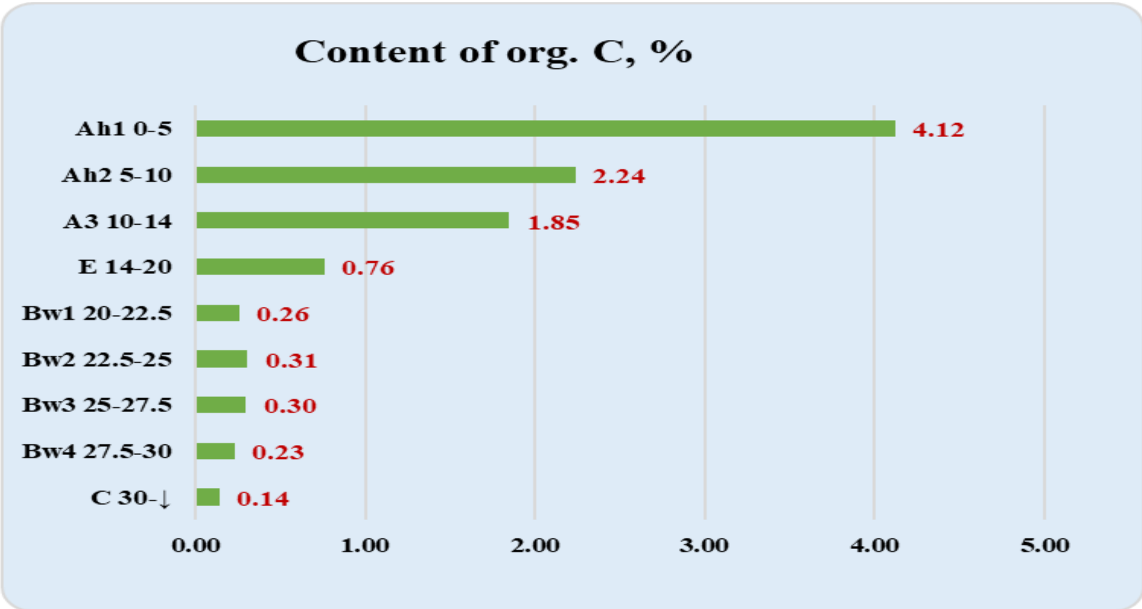

Figure 2. *Content of org. C, (%) in the soil profile*

It was found that in none of these layers the amount of org. C did not exceed 0.5%, which indicated that it could not be define as a *spodic* diagnostic horizon. The soil was determined as Cambisols. Nevertheless, there were processes, which indicated its future evolution towards podzolization, such as formation of acidic humus, acidification of the soil, destruction of clay minerals and transport of products in soil depth.

A high amount of organic matter was accumulated in the surface soil horizon. The organic matter exceeded 15% in the first part of it (*Ah* horizon). It should be noted that in the soil depth of the profile its amount decreased almost twice in the lower part of the *A* horizon, followed by a rapid decrease to *E* and *Bw* horizons. This change was due to the removal of organic matter from *E* horizon in depth. As a reason, high acidity can be noted. Soil response is an important diagnostic indicator. In the *Ah* horizon it was estimated to be very highly acidic. The soil reaction had the lowest values in it (pH_{H2O} = 4.1). The origin of this acidity was a result of the introduction of free organic acids from the decomposition of the roots that form the *Ah* horizon and partly from the litter. According to some authors (Ganev, 1990) values of pH_{H2O} below 4.8 are an indicator of the presence of free fulvic acids in the soil. Funakawa et al. (2006) point out that the pH around 4.0 is the critical limit that enhances the mobilization of org. C in the litter and in the surface soil layer. This causes its mobility into the soil depth of the profile in the form of a soluble organic substance.

In the second part of the *A* horizon the value of pH_{H2O} continued to be very low. This means that there is a removal of soluble organic matter from it. In depth of the soil profile, the pH_{H2O} values increased slightly, in *E* horizon its values remained within the range of the highly acidic spectrum. The profile distribution of pH_{H2O} showed the predominance of acidic products from the decomposition of the organic matter over the basic ones - of the weathering processes in the *C* horizon.

The exchangeable acidity values, measured as pH_{CaCl2}, showed that the soil buffer capacity was achieved due to Fe oxides dissolved as well as the weathering of secondary clay minerals (Ulrich scale, 1983). This referred to the depth from *Ah* to *E* horizon including. In the horizon, a major buffer process was the exchange of protons with basic cations. The titrimetric determined exchangeable acidity was very high. Its profile distribution is represented in Figure 3 and shows the high degree of acidification in the surface soil horizon, which is rich in humus.

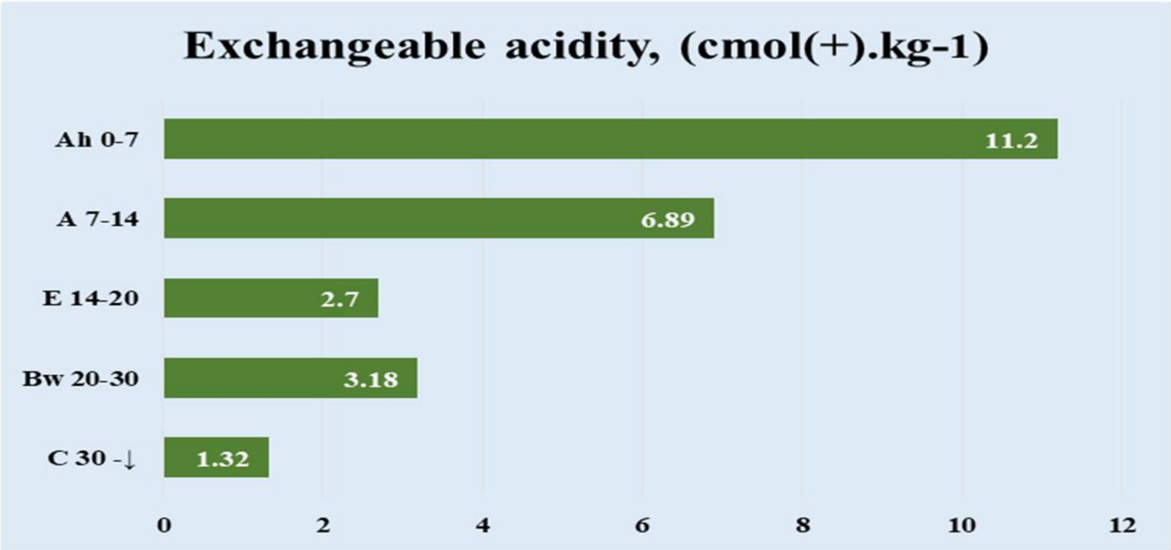

Figure 3. *Exchangeable acidity in soil profile*

Under the influence of high acidity, the soil was highly leached. Basic cation values were low, with their lowest levels in the *A* horizon. The sum of the basic cations in the *Ah* and *A* horizon was: 1.99 cmol(+).kg^{-1} and 0.42 cmol(+).kg^{-1}. Cation exchange capacity (CEC) values were highly differentiated between *A*, *E* and *Bw* horizons. In *E* horizon the CEC decreased 2.7 times compared to the *A* horizon. The results of the soil texture supported this assumption (Figure 4).

Table 2. *Soil solution reaction, exchangeable cations, cation exchange capacity (T) and base saturation (V)*

Horizons	Soil Depth	pH	pH	Exch. acidity	Exch. Ca	Exch. Mg	Exch. K	Exch. Na	Exch. Fe	Exch. Mn	Sum of basic cations	CEC T	BS V
	cm	H_2O	$CaCl_2$	cmol(+).kg^{-1}									%
A_h	0-7	4.1	3.3	16.80	1.29	0.45	0.23	0.02	0.27	0.01	1.99	19	11
A	7-14	4.3	3.6	10.33	0.17	0.13	0.11	0.01	0.13	0.00	0.42	11	4
E	14-20	4.7	4.1	4.05	0.17	0.07	0.04	0.02	0.03	0.00	0.30	4	7
B_w	20-30	5.2	4.3	4.76	7.00	1.35	0.03	0.06	0.02	0.01	8.45	13	64
C	30 -↓	5.4	4.3	1.99	6.22	1.59	0.03	0.07	0.02	0.01	7.90	10	80

The profile distribution of the amount of clay showed its rapid decrease from *A* to *E* horizon - 6.7 times. The differences were slightly expressed in the soil depth. *Bw* horizon contained 0.6% less clay than *E* horizon, at the expense of the amount of silt that increased 1.4 times. The amount of sand in the *E* horizon was commensurate with that in the *C* horizon.

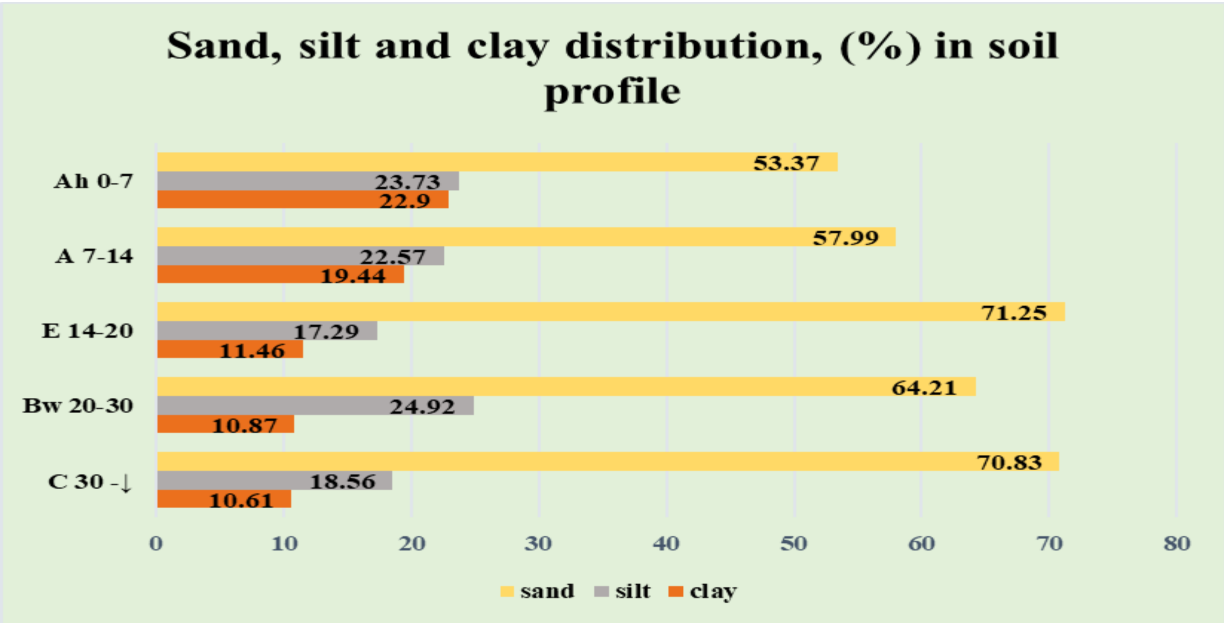

Figure 4. *Sand, silt and clay distribution, (%) in the soil profile*

Thus, an *E* horizon was formed, which was clay-poor with an increased amount of sand. It had a coarse texture (sandy loam) than that in the *Ah* horizon (sandy clay loam). It could be assumed that the change of the texture began in the *A* horizon, where due to the loss of clay it was considered as sandy loam. The changes in clay content in the soil profile were accompanied by changes in cation exchange capacity. In *E* horizon CEC decreased rapidly - 2.7 times compared to *A* horizon and 3.2 times compared to *Bw* horizon. This was due to the loss of colloidal particles - organic (Figure 2) and mineral (Figure 4). A podzolization process occurred in the soil.

Some features of podzolization process were also shown by the Fe distribution. It was found to accumulate in Bw horizon, where its values reached 39 144 mg/kg (Figure 5).

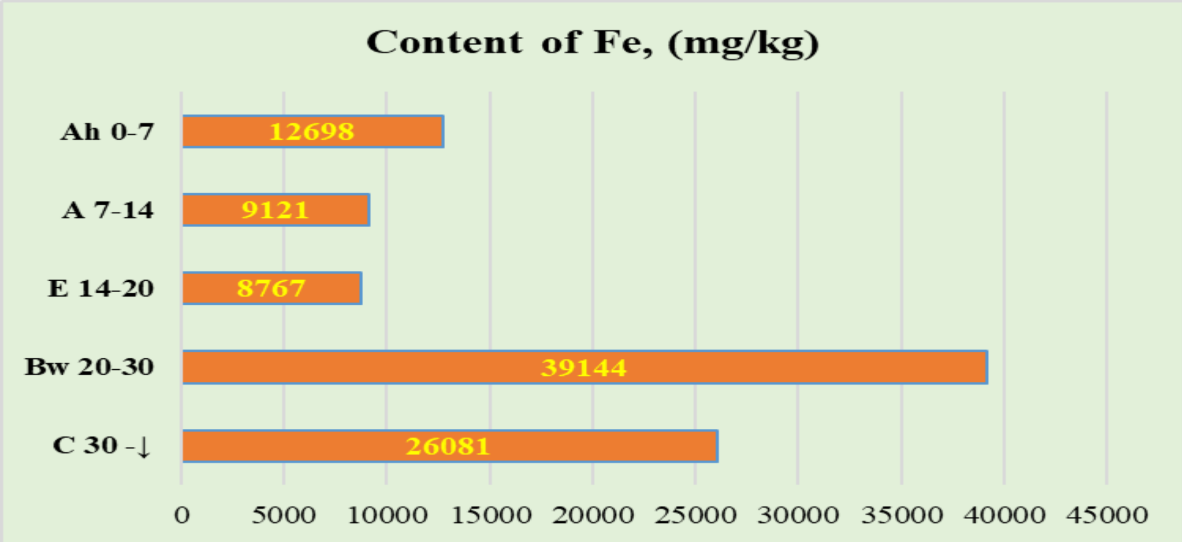

Figure 5. *Content of Fe, (mg/kg) in the soil profile*

Conclusion

The analysis and assessment of the diagnostic features of the investigated soil did not prove the presence of a *spodic* diagnostic horizon, which did not allow the definition of Podzols. Processes such as: accumulation of acidic humus insitu, removal of org. C, acidification and loss of silicate clay, degradation clearly expressed by the accumulation of Fe in *Bw* horizon, were established. The evolution of Cambisols is related to a complex of specific processes, whose direction is pointed towards podzolization.

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