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MECHANICAL COMPOSITION AND CHEMICAL PROPERTIES OF CALCOMELANOSOLS AND CALCOCAMBISOLS ON THE JABLANICA MOUNTAIN

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Abstract
Differences in mechanical composition of two soil types on hard limestone and its subtypes were investigated in order to get closer look on variability and dynamics of this soil property over long period of pedogenesis of these soils. Soils on hard limestones on Jablanica Mountain were select as a case study. During the field survey campaign on different locations 18 basic soil profiles of calcomelanosols were excavated, with the following subtypes: organogenic (5) organomineral (12) and brownized (1) and 4 soil profiles calcocambisols with a typical subtype. Field survey and laboraotry testing was implemented according standard methods adopted in our country and the Former Yugoslavia. Clay content is generally high and increases from organogenic subtype towards brownized calcomelanosols and calcocambisols subtypes. During the process of evolution of the calcomelanosols into brownized calcomelanosols and calcocambisols, the content of soil organic matter decreases. The fine earth of examined soil samples usually is non-carbonate, but in a limited number of soil samples a very small quantities of $CaCO_3$ were detected. In terms of its soil reaction, the examined soils can be classified into three categories (very strongly acid, moderately acid and neutral). The content of total nitrogen in the examined soils is high and vary in the ranges of 0.21-1.95% in calcomelanosols and 0.31-0.56% for hor. A and 0.18-0.27 for hor. (B)rz of the calcocambisols. The examined soil samples are with low content of easy available phosphorus and optimal content of potassium.

Keywords: soil, clay, humus, pH, total nitrogen.

Introduction

In this article, data related to the mechanical composition and some chemical properties of calcomelanosols and calcocambisols on Jablanica Mountain are presented. During the field survey campaign on different locations 18 basic soil profiles of calcomelanosols were excavated, with the following subtypes: organogenic (5) organomineral (12) and brownized (1) and 4 soil profiles calcocambisols with a typical subtype. On the highest parts of the Mountain the organogenic calcomaelanosols has been excavated. In the lower parts of the mountain the organomineral and brownized calcomelanosols are spread, while calcocambisols are identified as a comlex with the former ones on more falt relief forms. A detailed data for the soil forming factors, genesis, evolution and classification of the investigated soils are presented in our previous reports (Andreevski et al. 2013). Data related to the mechanical composition and some chemical properties of the calcocambisols and calcomelanosols of Jablanica Mountain are presented in the works of Петковски et al. (1995), Андреевски (1996) and Мукаетов (1996). Data related to the mechanical composition and chemical properties of soils on hard limestones on Jablanica Mountain and other locations can be find in the previous works of Маркоски (2013) and Markoski et al. (2015). Filipovski sums up all existing results from previous investigation of these soil types in his Monograph's (Филиповски, 1996, 1997). The mechanical content and chemical properties of the investigated soils are of particular importance for its production potential. With these investigations we will contribute to gaining a better understanding of these fairly prevalent soils in our country.

Material and methods

Field examinations have been performed according to accepted methods in Former Yugoslavia (Filipovski ed. 1967). The laboratory analyses have been done according to the standard adopted methods in Former Yugoslavia and Republic of Macedonia, as follows:

- Mechanical composition of soil has been determined according to the international A-method, and the peptization has been carried out with 0,1M sodium pyrophosphate (Resulović ed. 1971). The separation of the mechanical elements in fractions has been done by the international classification.
- pH (reaction) of the soil solution has been determined with glass electrode in water suspension and in NKCI suspension (Bogdanović ed. 1966)
- Easy available forms of P_2O_5 and K_2O were determinate by Al method (Bogdanović ed. 1966)
- Content of calcium-carbonate was determined using Scheibler's calcimeter (Bogdanović ed. 1966)
- The content of humus has been determinate at the base of total carbon by the method of Tjurin modified by Simakov (Орлов and Гришина 1981)
- The total N has been determinate by Kjeldahl micro method (Bogdanović ed. 1966).

Results and discussion

Mechanical composition

Data for the mechanical composition of the investigates soils are presented in Tab. 1. The mechanical composition of the tested soils, depends on the residue released by the dissolution of the limestone, the characteristics of the rock itself (limestone, dolomite, silicate limestone), the deposition of other materials from the higher terrains, the processes that cause the texture differentiation, the eolian deposition of tiny particles and selective erosion of clay from the hor. A. The average content of skeleton in calcomelanosols is 6.62% (4.30% in organogenic and 8.51% in organomineral). The hor. A of the calcocambisols contains an average of 7.81%, while the contents of skeleton in the cambic horizon, decreases and account for 6.78%. It can be concluded that the skeleton content is low. From the data in Tab. 1, it can be seen that the fine earth content, dominates the skeleton in all profiles. The most common fraction in the calcomelanosols and hor. A of the calcocambisols is clay. Then follows, the fractions of fine sand, silt, and the coarse sand with lowest content. Similarly, in the cambic horizon of the calcocambisols, the dominant fraction is clay, but in this case silt is on a second place, followed by fine and coarse sand. In all examined soil samples, physical clay (<0.02mm) is more common than physical sand. The content of physical sand in profiles 2, 10 and 21 (calcocambisols formed on plain limestone with horn is higher compared to prof. 1 (calcocambisol formed on dolomitized limestone) and is due to the presence of horn material. The content of clay in the calcomelanosols is in average 38.63%. Going from the organogenic to the organomineral and browned calcomelanosols and the calcocambisols, the clay content increases. The average content of clay in organogenic calcomelanosols is 31.1%, in organomineral 39.65% (hor A. of browned calcomelanosol contains 50.8%) and in hor. A of calcocambisols the clay content yields 41.20%. The clay content in the cambic horizon of brownized calcomelanosol and calcocambisols is increasing. In calcocombisols it is in average 51.93% and in brownized calcomelanosol 58.6%. The increase in the clay content in the cambic horizon can be explained by clay formation processes, with selective erosion of the fine particles from the hor. A as well as the eolic application of dust particles. According to Маркоски (2013), the average clay content in the organogenic calcomelanosols from the Republic of Macedonia is 22.27%, in the organomineral 32.68%, in the hor. A of the brownized 36.60% and in the hor of A. the calcocambisols 38.19%. According to the same author, the cambic horizon of brownized calcomelanosols contains an average 41.03% clay, while the calcocambisols contains 46.00% of clay. Examined soils, especially calcomelanosols and hor. A of the calcocambisols are rich in humus. From the literature data it is known that without the combustion of organic matter, full peptization cannot be achieved, and therefore lower values for the clay content are obtained.

Table 1 Mechanical composition of soil

			In % of fineearth						
Profile No	Horizon and depth cm	Skeleton > 2mm	Coarse sand 0.2 - 2mm	Fine sand 0.02 - 0.2mm	Coarse + fine sand 0.02 - 2mm	Silt 0.002 - 0.02mm	Clay* <0.002mm	Silt + clay <0.02mm	Clay** <0.002mm
Calcomelanosol organic									
9	A 0-25	0,23	0,5	40,5	41	11,7	47,3	59	16,5
38	O 4-24	7,05	3,1	47,4	50,5	15,8	33,7	49,5	2,1
8a	A 0-22	0,07	0,3	42	42,3	23,5	34,2	57,7	3,8
60	A 0-10	12,27	19,1	48,2	67,3	14,7	18	32,7	2
61	O 0-12	1,90	12	54,7	66,7	11	22,3	33,3	4,4
Organomineral									
3	A 3-28	14,60	19,2	28	47,2	18,4	34,4	52,8	29,3
4	A 4-40	20,11	12,6	34,6	47,2	21,1	31,7	52,8	21,7
5	A 3-26	20,40	17,5	40	57,5	16,6	25,9	42,5	21
7	A 0-21	1,87	7	28,8	35,8	25,8	38,4	64,2	28,5
11	A 0-27	2,56	0,9	23,2	24,1	23,5	52,4	75,9	33,2
20	A 0-18	7,25	1,6	26,8	28,4	15,1	56,5	71,6	37,4
22	A 0-30	9,41	19,7	31,2	50,9	20,8	28,3	49,1	13,9
30	A 0-29	4,17	10,3	39,4	49,7	19,2	31,1	50,3	23,6
33	A 0-18	3,19	0,7	26,3	27	22,7	50,3	73	37,2
	A 18-36	0,10	1	22	23	25,2	51,8	77	21,7
35	A 0-27	13,79	5,7	21,7	27,4	32	40,6	72,6	4,4
4a	A 0-25	0,60	0,7	26,6	27,3	23,5	49,2	72,7	7,5
62	A 0-18	12,53	24,8	37,2	62	13,1	24,9	38	2,7
Brownized									
8	A 0-8	0,12	1	36,5	37,5	18,2	44,3	62,5	31,9
	A 8-36	0,20	2,3	21,9	24,2	18,5	57,3	75,8	40,7
	(B)rz 36-52	0,35	3,3	20,3	23,6	17,8	58,6	76,4	50
Calcocambisol									
1	A 2-21	3,76	6,40	23,60	30,00	13,00	57,00	70,00	38,7
	(B)rz 21-55	0,85	2,10	13,60	15,70	19,10	65,20	84,30	54,7
2	A 3-20	15,73	13,80	29,40	43,20	31,00	25,80	56,80	23,3
	(B)rz 20-35	11,97	18,00	17,60	35,60	23,10	41,30	64,40	38,9
	(B)rz 35-70	13,19	17,00	14,60	31,60	20,40	48,00	68,40	46,1
10	A 0-24	8,65	5,30	28,50	33,80	23,80	42,40	66,20	30,5
	(B)rz 24-58	6,58	7,60	19,50	27,10	22,00	50,90	72,90	49
	(B)rz 58-70	7,11	7,30	14,10	21,40	13,10	65,50	78,60	63,3
21	A 2-21	3,12	8,10	24,50	32,60	27,80	39,60	67,40	28,4
	(B)rz 21-73	1,00	6,50	21,90	28,40	30,90	40,70	71,60	40,4

*SOM combusted with H_2O_2
**SOM is not combusted

For comparison, we performed mechanical analysis without combustion and by combustion of SOM with H_2O_2. From the data presented in tab.1 it can be seen that the clay content is higher when the organic matter was previously combusted. For the same soil samples, the content of clay is 8.39 times higher in organogenic subtype when organic matter is combusted, in organomineral 3.10 times higher, while in hor. A of calcocambisols 1.34 times. In the cambic horizons (low humus content) of the brownized subtype of calcomelanosols and calcocambisols, the differences in the clay content according to the applied methods are negligible. According to Павићевић, cited by

Филиповски (1996) for 18 soil samples of calcomelanosols from Montenegro, the content of clay is 2.5 times higher than those where the organic matter has not been combusted.

Chemical properties

The data for the chemical properties of the examined soils are presented in Tab. 2

Table 2 Chemical properties of soil

Profile No.	Horizon and depth in cm	$CaCO_3$ %	Humus %	Total N %	C/N	pH H_2O	pH MKCl	Easyavailable mg/100g soil P_2O_5	Easyavailable mg/100g soil K_2O
Calcomelanosol organic									
9	A 0-25	0,00	18,74	1,14	9,55	6,25	5,50	3,00	17,40
38	O 4-24	0,23	27,36	1,21	13,08	6,75	6,25	7,00	26,70
8a	A 0-22	0,12	17,38	1,07	9,46	6,65	5,70	1,80	18,70
60	A 0-10	0,00	15,15	0,91	9,67	5,85	5,10	5,60	23,40
61	O 0-12	0,00	36,61	1,95	10,89	6,10	5,60	16,20	33,30
Organomineral									
3	A 3-28	0,00	7,11	0,45	9,28	5,55	4,60	2,50	16,10
4	A 4-40	0,00	11,15	0,63	10,22	6,40	5,65	<1	19,20
5	A 3-26	0,00	5,49	0,37	8,58	6,50	5,80	<1	12,20
7	A 0-21	0,00	10,5	0,55	10,99	6,30	5,65	4,20	34,20
11	A 0-27	0,22	7,75	0,44	10,23	7,10	6,15	1,80	29,60
20	A 0-18	0,46	8,45	0,45	10,92	7,15	6,30	5,40	30,80
22	A 0-30	0,11	12,34	0,73	9,81	7,05	6,20	4,00	22,50
30	A 0-29	0,00	4,5	0,21	12,4	6,15	4,85	1,00	10,00
33	A 0-18	0,34	7,1	0,42	9,81	7,10	6,25	1,50	26,70
	A 18-36	0,45	4,79	0,31	8,93	7,30	6,15	1,00	17,00
35	A 0-27	0,00	6,27	0,42	8,77	6,20	5,30	2,40	15,20
4a	A 0-25	0,34	10,09	0,64	9,21	6,95	6,10	1,80	31,70
62	A 0-18	0,34	14,55	1,01	8,38	7,00	6,20	2,30	11,70
Brownized									
8	A 0-8	0,00	20,41	0,98	12,12	5,95	5,20	7,20	39,20
	A 8-36	0,00	7,69	0,46	9,61	6,30	5,30	1,20	13,90
	(B)rz 36-52	0,00	3,36	0,27	7,19	6,95	6,20	1,00	17,00
Calcocambisol									
1	A 2-21	0,00	9,51	0,56	9,83	6,75	6,05	2,00	31,70
	(B)rz 21-55	0,00	2,91	0,27	6,37	6,90	6,10	1,30	20,80
2	A 3-20	0,00	4,26	0,31	8,08	5,50	4,40	<1	6,2
	(B)rz 20-35	0,00	2,42	0,23	6,2	5,60	4,45	1,30	12,20
	(B)rz 35-70	0,00	1,64	0,19	5,03	5,65	4,50	15,00	13,00
10	A 0-24	0,00	8,9	0,43	12,06	4,95	4,00	3,00	16,10
	(B)rz 24-58	0,00	3,67	0,23	9,38	5,00	4,05	<1	15,20
	(B)rz 58-70	0,00	2,61	0,2	7,73	5,05	4,05	<1	12,20
21	A 2-21	0,11	7,48	0,42	10,45	6,70	5,80	3,60	17,00
	(B)rz 21-73	0,11	1,93	0,18	6,14	7,00	5,85	12,70	19,60

The chemical properties of the soils tested depend on the residue released by dissolving of the solid lime rock (limestone, dolomite, silicate limestone), the relief conditions especially altitude, vegetation and the degree of degradation, cultivation, the depth of the soil profile, deposition of materials from the higher parts, erosion, the previous stage and evolution. The investigated soils are non-carbonate. Only some profiles contains minimal amounts of carbonates, which is due to the physical decomposition of the rock. These are
actually sandblasted particles from the limestone cork. Therefore, they do not have a major impact on the soil reaction. The humus content in the calcomelanosols averages 12, 6%. The average humus quantity in hor. A on 134 profiles from the republic is 11, 19% (Филиповски, 1996). The humus content in the organogenic calcomelanosols is highest and averages 23,04%, organominerals 8, 46%, brownized 14, 05% and hor. A of the calcocambisols 7, 53%. As a result of reduced flow of organic waste and improved conditions of mineralisation, the humus content reduces in the cambic horizon of the brownized calcomelanosols (3, 36%) and calcocambisols (average 2, 53%). According to Маркоски (2013), organogenic calcomelanosols of the Republic of Macedonia on average contain 19, 47% humus, organominerals 13, 17% and brownized hor.A 12, 44% and hor. (B)rz 6, 66%. According to the same author, the humus content in hor.A of calcocambisols averages 8, 50%, and cambic horizon 5, 18%. The humus content in calcomelanosols under оак vegetation (average of 5 profiles) is 8, 19%, and under beech vegetation (average of 8 profiles) 13, 69%. Equally in calcocambisols under beech vegetation the humus content is higher (average of two profiles under оак and beech vegetation for hor.A) and is 8, 19%, and under оак vegetation 6, 88%. The production of plant waste is higher in beech phytocenoses, and plant waste is more difficult to decompose. On the other hand, beech phytocenoses are prevalent at higher altitudes (lower temperatures, more freezing days), where mineralization is difficult. For these reasons, the content of humus in beech phytocenoses is higher. The average content of total nitrogen in the calcomelanosols is 0,71%. Organogenic calcomelanosols contain 1,25% and organominerals 0,51% total nitrogen. Horizon A of brownized calcomelanosol contain 0,72% and cambic horizon 0,27% total nitrogen. Calcocambisols (hor. A) contain an average 0, 43%, and cambic horizon 0, 21% total nitrogen. The C/N ratio is an important indicator of the conditions in which the organic matter is being transformed. In adverse climate conditions (low temperatures, big number of icy days, extremely dry conditions), cold expositions, organic waste with wide ratio of C/N and poor in ash substances the transformation of organic waste is hindered, and the C/N ratio is wider. This ratio in organogenic calcomelanosols is 10,53 and in organominerals 9,81. The C/N ratio in hor.A of the brownized calcomelanosol is 10,86 and in hor.A of calcocambisol 10,10. This ratio in the cambic horizon of the brownized calcomelanosols is 7,19 and in the caclocambisols is on average 6, 80. The C/N ratio narrows in the depth of the profile as a result of the advanced degree of decomposition of organic matter. According to Филиповски (1997) the C/N ratio in hor.A of the calcocambisols is 10, 05 and in the cambic horizon 8, 23. The C/N ratio in the calcomelanosols under beech vegetation is 10, 66 and under oak 9, 54. Calcocambisoles (hor.A) developed under a beech vegetation are characterised with wider ratio (11,25) in relation to the ones under oak vegetation (8,95). This relates to the hindered conditions of transformation of the organic waste in beech phytocenoses. However, under all plant communities humus is of the mull-humus type. Soil reaction in water in the calcomelanosols on average is 6,53. The average pH value in the organogenic calcomelanosols is 6,32, in organominerals 6,67, hor.A of the brownized 6,13 and hor.A of the calcomelanosols 5,98. The reaction on the soil increases in the cambic horizon of the brownized calcomenalosol (6,95) and calcocambisols (on average 6,14).The upper layer of the profile is absolutely older and was exposed longer time on acidification , and on the other side the impact of the lime base is expressed stronger on the cambic horizons, hence hor.A has lower pH values. According to Маркоски (2013), the soil reaction in water in organogenic calcomelanosols is 6.99 on average, organomineral 6.93, brownized hor.A 6.12 and hor. (B) rz 6.68. According to the same author the reaction of the soil into water in the hor.A and a hor. (B) rz of calcocambisols is 6.63. With the evolution of the calcomelanosols to the calcocambisols, debasification and acidification progress, resulting in acidification of the soil

solution. The reaction of soil in water in calcomelanosols under beech vegetation is on average 6.36, and under oak 6.84. The same tendency is present in the calcocambisols, under beech vegetation 5.83 and under oak 6.13. The organic wastes of beech vegetation are poorer with basic substances, while on the other hand the soils are prevalent at higher altitudes and colder exposures (more humid climate) that causes stronger acidification. An insufficient supply of easyavailable phosphorus is striking. From the data in the table it can be seen that only one soil sample of the calcomelanosols and two of the calcocambisols are with medium content of easy available phosphorus. The rest are poorly supplied with easy available phosphorus. This is not a worrying fact, since most of the soils are under forest vegetation, and trees have the ability to consume even more difficult phosphorous compounds. Phosphorus fertilizing can be considered for lawns and small surface areas that are cultivated. The content of easy available potassium is on satisfactory level. One soil sample is poorly provided, 18 soil samples have a medium content of easy available potassium and the rest of 12 soil samples, are well provided with this element.

Conclusion

Fine earth dominates the skeleton in all the examined profiles. The most common fraction in the calcomelanosols and hor. A of the calcocambisols is the clay fraction, followed by the fine sand, silt and clay. In the cambic horizon of the calcocambisols, the clay fraction is the most present fraction of the fine earth, followed by silt, fine sand and coarse sand. In the examined soils, physical clay (<0.02mm) has higher content than the physical sand. The clay content is several times higher when preliminary combustion of the organic matter was carried out. Therefore, the international A method is recommended for these soils. The investigated soils are non-carbonate. Only a small number of soil samples contains a minimal amounts of carbonates. Humus content is higher in calcomelanosols and calcocambisols under beech vegetation compared to soils under oak vegetation. The ratio C/N in soils formed under beech vegetation is wider compared to soils under oak vegetation and is in accordance with the difficult conditions for transformation of organic matter. In the examined soils, the humus is of the type mull-humus. pH values in water are lower in soils formed under beech plant communities compared to soils under oak communities. With the evolution of the calcomelanosols to the calcocambisols, debasification and acidification progress, because the soil solution is acidic. The examined soils are insufficiently supplied with easily available phosphorus, while with easily available potassium are sufficiently supplied.

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