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MINERALS IN REGOSOLS FROM NORTH BULGARIA

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Abstract

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The paper deals with the mineralogical composition of primary and clay minerals of Regosols developed mainly on calcareous loess and other soft materials from the hilly part of Danube plain. Nine soil profiles were studied and their characterization included, as well as texture, cation exchange capacity, primary and clay minerals, relief peculiarities, parent material and vegetation. Mineral contents give us a clue about soil genesis and development of Regosols in the Danube plain. Among the primary minerals micas predominate in most of the soil horizons compared to that of quartz, especially in the profiles located near the Danube River. The clay minerals are represented by smectite, mixed-layer illite-smectite, illite, kaolinite and quartz. The data from the X-ray diffraction analysis in conjunction with granulometric and physical-chemical analyses indicate that soil forming processes have had a negligible effect on the properties of the Regosols studied.

Key words: Regosols, primary minerals, clay minerals, texture, CEC

Introduction

Regosols are extensive on eroding lands, particularly in arid and semi-arid areas and hilly regions. These soils are spread over 48 500 ha in the Danube Plane in North Bulgaria. Research on mineral composition of Regosols from Lom - Svishtov region relies mainly on previous scientific studies that had been made so far concerning soils and parent materials. Analysis of the mineralogical composition will give us an estimation of primary and clay minerals which is essential to determine the genesis of the studied soils. Research of the mineralogical composition of soils from Lom and Svishtov region was carried out by some authors such as Minkov (1969), Stoilov(1984), Boneva et al. (1985, 1989) and others, but no extensive studies on Regosols in the Danube plain in relation to mineralogy and other soil properties were carried out so far.

The aim of this study was to address this gap and evaluate a broader range of Regosols in this area and relate their mineralogy with the physical and physical-chemical properties.

Materials and Methods

According to the soil-geographical zonation, the studied soils belong to the northern forest-steppe zone of the Danube Chernozem area, the middle Danube province and the Lom - Svishtov region (Koinov et al., 1972; Gurov et al., 2001). This area includes sites that are parts of the settlements - Yakimovo, Kovatchitza and Stanevo, the District of Montana;

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Opanets, and Muselievo, Milkovitsa, Pleven district and Trasetnik, Ruse District. The Lom - Svishtov region covers the Northern part of the Bulgarian Danube plain rivers, from Archar (west) to Ruse Lom (east). The studied soils have been formed on narrow ridges and deeper slopes, which has resulted in bad water regime. The depth of the soil profile is smaller due to erosion processes. The soil parent material is loess. Typical of the plain is the flat terrain with ridges and a hilly relief with a maximum altitude of 250 m. The valley asymmetry is also a feature of the prevailing geomorphology. As basis for relief formation were the Pliocene accumulative and the denudation plains (Mishev, 1959). The method of the catena was used during the field research (Modrokovich et al., 1985).

The following soils profiles were studied.

Profile 4, located at N 43’37 .428 E 23’19 .946 with an altitude of 130 m near the village of Yakimovo, District of Montana. It is at the bottom of the southern slope (12.5^{o}) and is characterised with moderate erosion. The parent material is Pliocene Gath-Pontic type with sandy-clay loam texture. The vegetation is *Chrysopogon gryllus* L., Brownray knapweed *(Centaurea jacea* L.*)*, Wild oat *(Avena fatua* L.) *and* Fescue *(Festuca pratensis* Hud.). Afforestation is with Black locust *(Robinia pseudoacacia* L.).

Profile 9, located at N 43’48 .298, E 23’20 .605 with an altitude of 125 m near the village of Kovachitza, Montana District. It is in the middle part of the Southern slope (7 ^{o}) moderately eroded. The parent material is silt loam loess. The vegetation is *Chrysopogon* gryllus *L,* wild oat, plantain *(Plantago major* L.), Cypress spurge *(Euphorbia cyparissias* L.), Mullein *(Verbascum thapsiforme* Schard.), Yellow Melilot *(Melilotus officinalis* L.) and Greater Stitchwort *(Stellaria holostea* L .).

Profile 10, located at N 43’49 .843 E 23.26.789 with an altitude of 77 m near the village of Stanevo, Montana District. It is in the upper part of the Northern slope (10^{o}) and severely eroded. The parent material is sandy loam loess. The vegetation is represented by *Chrysopogon gryllus* L., Beardgrass *(Dichanthium ischaemum* L.), Wild oat, Brownray knapweed et al.

Profile 11, which is located at N 43’37 .580 E 24.51.237 with an altitude of 64 m near the village of Muselievo, Pleven District. It is in the middle part of the Western slope (12 ^{o}) and moderately eroded. The parent material is silt loam loess. The vegetation is *Chrysopogon gryllus* L., yarrow, Brownray knapweed, wild oats, melilot, and cocksfoot *(Dactylis glomerata* L.).

Profile 16, which is located at N 43’37 .171 E 0 24.43.363 with an altitude of 73 m near the village of Milkovitsa, Pleven District. It is in the upper part of the northern slope (10$^{o)}$ and moderate erosion. The parent material is sandy loam loess. The vegetation is wild rye, bermudagrass, yarrow, brome-grass, meadow brownray knapweed, plantain et al.

Profile 17, located at N 43’27 .183 E 24’33 .872 with an altitude of 100 m near the village of Opanets, Pleven District. It is in the lower part of the southern slope (9^{o}) and moderately eroded. The parent material is sandy loam loess. The vegetation is *Chrysopogon gryllus* L., perennial ryegrass *(Lolium perenne* L.*)*, cypress *spurge*, thistle *(Onopordum acanthium* L.*)* and *yarrow*.

Profile 18, located at N 43’27 .086 E 24’34 .356 with an altitude of 114 m near the village of Opanets, Pleven District. It is in the middle part of the southern slope (10^{o}) and moderately eroded. The parent material is loam loess. The vegetation is *Chrysopogon gryllus* L., fescue, brome-grass *(Bromus inermis* Leyss), bermudagrass and yarrow.

Profile 19, located at N 43’26 .952 E 24’34 .849 with an altitude of 132 m near the village of Opanets, Pleven District. It is in the upper part of the southern slope (10^{o}) and moderately eroded. The parent material is silt loam loess; vegetation is *Chrysopogon gryllus* L., brome-grass, fescue, bermudagrass, annual meadow grass *(Poa annua* L.*)*, yarrow and black *locust*.

Profile 24, located at N 43’41 .920 E 25’49 .902 with an altitude of 120 m near the village of Trastenik, Rousse District. It is in the middle part of the northwestern slope (6^{o}); slightly eroded; the parent material is silt loam loess. The vegetation is *Chrysopogon gryllus* L., Twitch, Brownray knapweed, Cocksfoot, St. John's wort *(Hypericum perforatum* L.), fescue.

The profiles have been selected on the basis of the geomorphological and topographical features of the Lom - Svishtov region in which the studied soils are mainly distributed and compared to others (intrazonal and zonal soils) on the basis of morphological features and some physic-chemical and mineralogical characteristics.

Results and Discussion

Becoming familiar with soil mineralogy started with terrain studies. Macroscopic observations of soil formation rocks were done through assessement of colour, structure and density. As mentioned before, soil parent material (with the exception of profile No 4) is loess most probably of eolian origin (Minkov, 1968). The composition of primary minerals in the soils studied is determined by the nature of the soil formation rocks. Research on loess (Minkov, 1968 and Stoilov, 1984) has shown that quartz was the main allithogenic mineral in all types and horizons of the complex. The authors mentioned that its quantity changes in depth and width. The second type of minerals is the micas, i.e. muskovite and biotite, although muscovite is 4 to 8 times higher than biotite. Feldspars occupy the third place; sometimes they are more abundant than micas. Minkov (1968) has found that of the heavy minerals (> 0.01 mm), in greater quantities are amphibole and tremolite. The mineralogical composition of the soil profiles is presented in Table 1. In the soils studied the predominant primary minerals are quartz and micas (Table 1). In profile 4 and 16 quartz predominates in the depth. And in profiles 8 and 17 quartz dominates in the surface horizon, while micas increase in depth. In all the other profiles micas dominate. According Stoilov (1984), micas are unevenly distributed in the sediments of loess formation. The area of 10 to 30 km south of the Danube River is characterised with the highest content of micas, which sometimes reach 60-70%. In this region are situated the studied profiles (Yakimovo, Kovatchitza, Stanevo, Muselievo, Milkovitsa, Trastenik).

Feldspars are also present in all profiles, but they prevail only in the two surface horizons of profile 18. Feldspars are actually more abundant in soils that are not extensively leached, as compared to the hillside soils, where extensive leaching takes place, accompanied by erosion process, leading to higher quartz accumulation.

Chlorites, calcite, dolomite and hornblende are the other primary minerals, which also participate in the mineralogical composition of the studied soils. Chlorite is a product of secondary origin at the expense of highly changing feldspars (Mihailov, 1988). Calcium minerals are an integral part of all varieties of loess and carbonates in the soils studied.

The X-ray diffraction analysis of the clay fraction (<0.001 mm) of the Regosols helps clarify the mineralogical composition and the changes that occur during the pedogenesis. The results obtained show that in most of the profiles smectite and mixed layered smectite-illite minerals dominate among the minerals (Table 1).

Illite dominates in the clay fraction of profiles 4 and 8. In profile 4 this corresponds to the lower-cationic exchange capacity (Table 2), despite the similarity in the content of the mechanical fractions (<0.001 mm and <0.01 mm) of this profile, with the other soil profiles. These two profiles are located in the western part of the Danube plain and as it were mentioned above; hydromicas dominate (mainly Illite). In the clay fraction of the remaining soils, the smectite and mixed-layer smectite-ilite structures and hydromica (illite) dominate. The differences observed in the composition of clay minerals in the soil profiles are determined primarily by the soil parent materials. The high participation of the smectite minerals is consistent with the weak alkaline reaction of most of the soil profiles and the carbonates contents. All these conditions lead to the accumulation of minerals such as montmorilonites, which are part of the smectite family. The cation exchange capacity of Profile 16 (Table 2) is the lowest and it is determined by the lighter mechanical composition and the presence of chlorite in clay fraction (Table 1). The mineralogical composition of the soils studied actually reflects the inheritance from the loess carbonate substrates.

Table 1
Mineralogical composition of the studied soils

Profile Location	Horizon depth, cm	Primary minerals	Clay minerals
Profile 4	$A_{(h)}$ 0-20	Quartz> feldspars (orthoclase), mica, chlorite	Illite> Smectite, vermiculite, Kaolinite (Smectite-Illite *), quartz
Yakimovo	C_1 20-40	Quartz> feldspars (plagioklaz), mica, chlorite	Illite> (Smectite-Illite), Kaolinite, quartz
Profile 9	$A_{(h)k}$ 0 - 20	Quartz> micas, feldspars, chlorite, amphibole, calcite	Illite> Smectite, vermiculite, Kaolinite (Smectite-Illite), quartz
Kovatchitza	C_k 20 - 41	Mica, chlorite, calcite, quartz	Illite> Smectite, Kaolinite (Smectite-Illite), quartz
Profile 10	$A_{(h)}$ k 0-22	Micas> quartz, chlorite, feldspars, hornblende	Smectite-Illite> Smectite, Illite, Kaolinite, quartz
Stanevo	AC_k 22 - 33	Micas> quartz, chlorite, calcite	Smectite-Illite> Smectite, Illite, Kaolinite, quartz
	C_k 33 - 50	Micas> quartz, chlorite, feldspars, calcite	Smectite> Illite, Kaolinite, vermiculite (trace), quartz
Profile 11	$A_{(h)k}$ 0 - 18	Micas> quartz, chlorite, feldspars, calcite	Smectite> Illite, Smectite-Illite, Kaolinite, quartz
Muselievo	C_k 18 - 35	Micas> quartz, chlorite, feldspars, calcite	Smectite-Illite> Smectite> Illite, Kaolinite, quartz
Profile 16	$A_{(h)}$ 0 - 15	Quartz> feldspars, micas	Smectite-Illite, Smectite> Illite, Kaolinite, chlorite, quartz
Milkovitsa	C_1 15 - 30	Quartz> feldspars, micas	Smectite> Smectite-Illite, Illite, Kaolinite, chlorite, quartz
Profile 17	$A_{(h)k}$ 0 -21	Quartz, mica, calcite, chlorite	Smectite-Illite> Illite, Kaolinite, quartz
Opanets	AC_k 21 - 40	Quartz, mica, feldspars, calcite	Smectite> Illite, Kaolinite, quartz
	C_2 k 40 - 55	Micas> chlorite, quartz, feldspars, calcite	Smectite> Illite, Kaolinite, quartz
Profile 18	$A_{(h)k}$ 0 - 14	Micas> quartz, chlorite, feldspars, dolomite	Illite-Smectite **> Smectite> Illite, Kaolinite, quartz
Opanets	AC_k 14 - 30	Feldspars> mica, quartz, chlorite	Illite-Smectite **> Smectite> Illite, Kaolinite, quartz
Profile 19	$A_{(h)k}$ 0 - 15	Micas> quartz, chlorite, feldspars	Smectite> Illite, Kaolinite, quartz
Opanets	C_k 15 - 30	Micas> quartz, chlorite, feldspars, calcite	Smectite> Illite, Kaolinite, Smectite-Illite, quartz
Profile 24	$A_{(h)k}$ 0 - 19	Micas> quartz, feldspars, chlorite, amphibole, calcite, dolomite	Smectite> Smectite-Illite, Illite, Kaolinite, quartz
Trastenik	C_k 19 - 38	Micas> quartz, chlorite, feldspars, calcite, dolomite	Smectite-Illite> Illite, Kaolinite, quartz

Table 2
Texture and cation exchange capacity of the studied profiles

Profiles	Horizon, cm	Particle size, mm								CEC, $cmol_c$ kg^{-1}
		> 1	1 -0.25	0.25-0.05	0.05-0.01	0.01-0.005	0.005-0.001	<0.001	<0.01	
Profile 4	$A_{(h)}$ 0 - 20	4.7	21.9	31.5	15	7.2	8.4	11.3	26.9	21
Yakimovo	C_1 20 - 40	17.6	22.7	10	11.8	6.9	6.4	24.6	37.9	20.1
Profile 9	$A_{(h)k}$ 0 - 20	0	0.2	24.6	46.8	12.4	6.4	9.6	28.4	29.1
Kovatchitza	C_k 20 - 41	0	0.4	20.9	44.5	15.7	6.7	11.8	34.2	29.3
Profile 10	$A_{(h)k}$ 0 - 22	0	0.1	26	44	12.3	7.2	10.4	29.9	28.6
Stanevo	AC_k 22 - 33	0.3	0.1	31	40.5	11.1	5.4	11.6	28.1	28.3
	C_k 33 - 50	0	0.2	56.3	28.3	3.9	3.2	8.1	15.2	22
Profile 11	$A_{(h)k}$ 0 - 18	0	0.3	21.8	48.7	13.9	5.8	9.5	29.2	24.8
Muselievo	C_k 18 - 35	0	0	24.9	48.1	10.5	5.5	11	27	24.7
Profile 16	$A_{(h)}$ 0 - 15	0	18.2	44.3	15.7	5.8	7.3	8.6	21.8	15
Milkovitsa	C_1 15 - 30	0	25.9	49.5	8.9	1.4	4.9	9.4	15.7	9.9
Profile 17	$A_{(h)k}$ 0 -21	0	11.4	42	15.3	8.9	10	12.4	31.3	34.6
Opanets	AC_k 21 -40	0	9.6	43.1	17.6	8.6	9.8	11.3	29.7	22.9
	C_k 40 - 55	0	10.1	45.1	12.7	19.2	2	10.9	32.1	23.4
Profile 18	$A_{(h)k}$ 0 - 14	0	5.2	48.1	19.2	6.5	9.6	11.4	27.5	25.9
Opanets	C_k 14 - 30	0	2.5	42.9	28.6	4.4	10	11.6	26	21.9
Profile 19	$A_{(h)k}$ 0 - 15	0	0.6	18.8	37.2	13.3	10.8	19.3	43.4	28.8
Opanets	C_k 15 - 30	0	1	20.4	36.3	12.5	9.7	20.1	42.3	31.6
Profile 24	$A_{(h)k}$ 0 - 19	0.8	0	17.4	50.7	11.2	10.1	9.8	31.1	30.1
Trastenik	C_k 19 - 38	0	0.8	8.8	53.9	9.7	13.7	13.1	36.5	26.8

The amounts of smectite, illite, kaolinite and quartz are in different ratios, but these minerals are permanent components of the soil clay fractions. The minerals vermiculite and chlorite occur in only some of the soils and their quantity is minimal.

Conclusion

During the study of the soil profiles from the hilly part of Lom - Svishtov soil geographic region, it can be concluded that the weathering products have been inherited from the soil parent material. The primary minerals contents indicate that micas predominate in most of the soil horizons compared to that of quartz, especially in the profiles located near the Danube river. The clay minerals are represented by smectite, illite, kaolinite and quartz. The data from the X-ray diffraction analysis in conjunction with the granulometric and physico-chemical analyses indicate that soil forming processes have had a minimal effect on the properties of Regosols.

This is influenced by the hilly character of the soils studied, the neutral to slightly alkaline soil reaction and the well drained terrain with minimal water retention and cooler climate. The mineralogical composition of the soil is stable and it is determined entirely by the soil parent rock.

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