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PEDOLOGICAL DEVELOPMENT ON FOUR DIFFERENT PARENT MATERIALS

M. USUL[1]   O. DENGİZ[2,*]

[1]Soil Fertilizer and Water Resources Centre Research Institute, 06172, Ankara-Turkey
[2]Ondokuz Mayıs University, Faculty of Agriculture, Soil Science Department, 55139, Samsun-Turkey
***e-mail: odengiz@omu.edu.tr**

Abstract: The influence of parent materials on soil properties has long been recognized. Early pedologists and soil geographers based their concepts of soils largely on its presumed parent material. Later, parent material was viewed simply as a factor that influences soil development-an influence that diminishes in importance with time. The main objective of this study is to research the influence of four different soil parent materials on some soil physical, chemical, mineralogical and morphological properties of the study area located in the Southeast Anatolia Region of Turkey. Four soil profiles were investigated. Soil samples were analyzed using standard procedures. The results show that basalt and lime stone-marn derived soils have relatively deeper profiles, lower bulk density, higher clay content, organic matter, exchangeable bases, micronutrients and weatherable minerals. They are also higher in their CEC and base saturation percentage while available water capacity, hydraulic conductivity and natural water content are more adequate in them. The parent materials of around soils are basalt, lime stone-marn, sand stone materials and alluvium materials. It was observed that soil pedons formed on lime stone-marn and basalt parent materials were well developed while; pedons formed on sand stone and alluvial deposit have weak pedogenesis process. Development of B horizons (Bw, Bss and Bk) and carbonate accumulation were main pedogenic processes in subsurface horizons and vertic and orhric epipedon were developed on top surface. The most abundant clay mineral was smectite, followed by and illite and kaolinite. Four soil pedons were classified as Entisol, Vertisol and Aridisol according to Soil Taxonomy.
Key Words: Soil parent materials, Soil properties, Soil classification

1. INTRODUCTION

The influence of parent materials on soil properties has long been recognized. Early pedologists and soil geographers based their concepts of soils largely on its presumed parent material. Jenny (1941) stated that parent material is one of the five main factors. Later, parent material was viewed simply as a factor that influences soil development-an influence that diminishes in importance with time (Schaetzl and Anderson, 2007). Besides, soils develop as various pedogenic, geomorphic and biologic processes act on initial materials changing in to a soil that location in time. Parent material is the framework for the developing soil profile. There have been many studies on examining morphologic, physical, chemical and mineralogical properties of soils developed on different parent materials. For instance, chemical and mineralogical composition of the parent material can have effect on soil texture that may have influence on movement of fine soil particles and plant nutrients together with water within the soil profile, on weathering, on types of vegetation growing and organisms living in the soil (Jacobs, 1998). Another study carried out in Nigeria indicated that soils derived from basalt parent material with volcanic ash were the best agricultural soils compared to soils of granite parent material (Olowolafe, 2002). In addition, Gökbudak and Özcan (2008), in their study they investigated to compare some selected hydro-physical properties of soils developed from different parent materials were selected in the northeast part of Turkey and to present significant differences in the soil characteristics. According to their results all properties studied except for saturation capacity and particle density of soils differed significantly with respect to the parent materials. Compared to other soil types developed from the parent materials, granite formed soils with greater sand and lower silt contents, numerically greater porosity, and significantly higher dispersion ratio and organic matter. On the other hand, soils formed on arkose parent materials had the lowest pH value, numerically the greatest available water content and saturation capacity and organic matter percentage.

The main objective of this study is to research the influence of four different soil parent materials on some selected soil physico-chemical, mineralogical and morphological properties of the study area located in the Southeast Anatolia Region of Turkey.

2. MATERIAL AND METHODS

2.1. Site Characteristics

The study area is located between 675005-4224686 E and 706779-4181675 N coordinates (UTM) (Figure 1) in Batman province of the Southeast Anatolia Region of Turkey. It ranges in elevation from 475m to 987 m above mean sea level. Site topography is generally flat and gently flat and some part of it hilly. The underlying bedrocks within the study area consist of lime stone-marn, basalt, sand stone and alluvium materials.This area is characterized by arid and semiarid climate. The average amount of annual rainfall is 479 mm. Total evaporation is 1581 mm. The mean annual air temperature is 16.6 ^{o}C. According to the Soil Taxonomy (1999) criteria, the soil moisture regime is aridic the soil temperature regime is thermic (Figure 2 and Table 1).

2.2. Methods

Morphological properties of these four profiles in the field were identified and sampled by genetic horizons and classified according to Soil Survey Staff (1993 and 1999). Soil samples were taken to investigate for their physical and chemical properties at the laboratory.

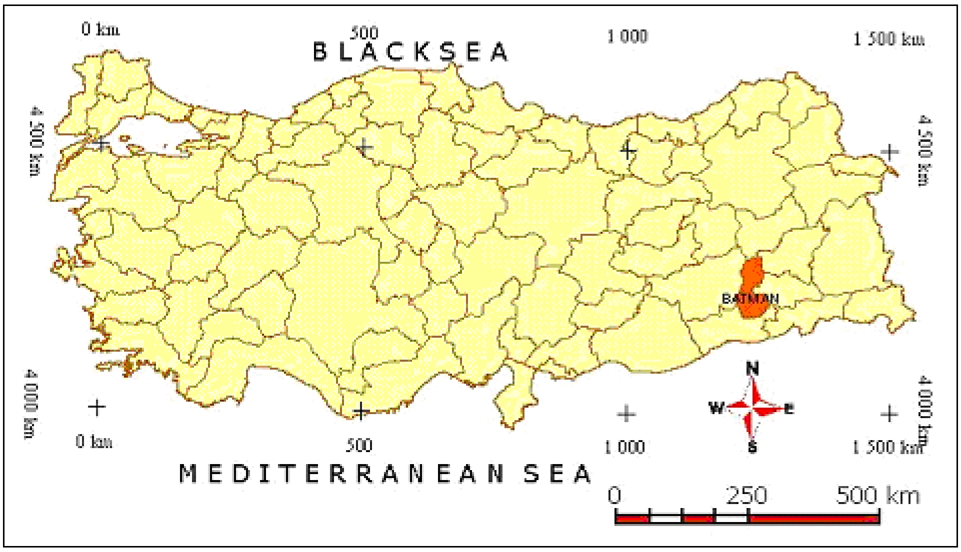


Figure 1. Location of the study area

Table 1. Meteorological data of the study area

Month	1	2	3	4	5	6	7	8	9	10	11	12	Annual
T °C	3,40	5,20	9,60	15,10	20,10	26,80	31,30	30,30	25,10	17,80	10,10	4,60	16,62
P, mm	56,20	67,60	81,80	69,40	40,70	7,60	0,30	0,40	2,60	26,70	54,50	72,10	479,90
PE, mm	0,54	1,77	12,65	49,18	124,34	284,79	447,00	381,38	198,13	68,62	11,92	1,25	1581,58
P-PE	55,66	65,83	69,15	20,22	-83,64	-277,19	-446,70	-380,98	-195,53	-41,92	42,58	70,85	
W, mm	100	100	100	100	16	0	0	0	0	0	42,58	100,00	
R, mm											42,58	57,42	100,00
S, mm	55,66	65,83	69,15	20,22								13,43	224,29
U, mm					83,64								83,64
D, mm						277,19	446,7	380,98	195,53	41,42			1341,82

T: Temperature P: Precipitation R: recharge water S: surplus water U: Utilized water D: Deficit water

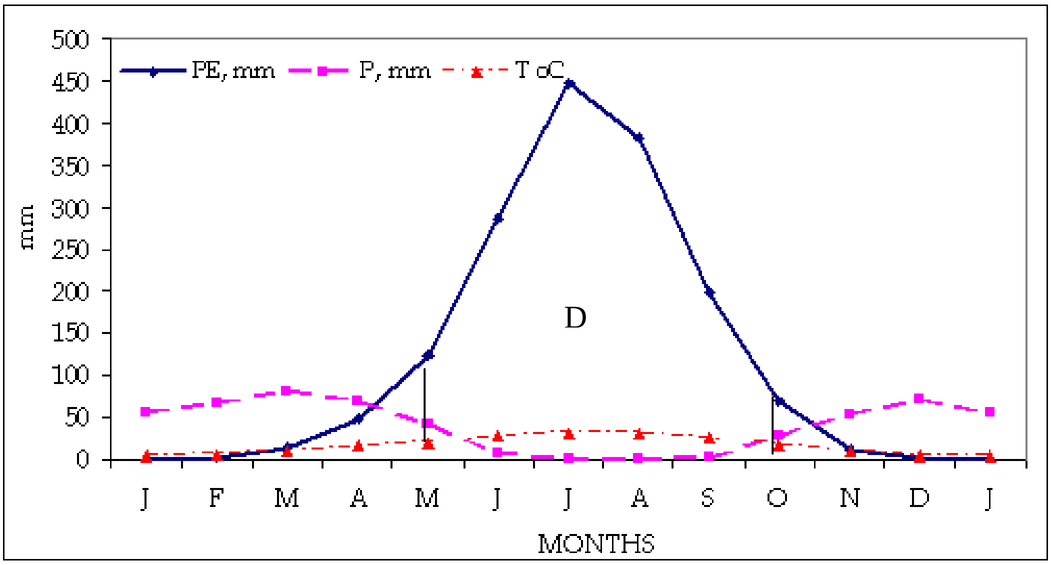


Figure 2. Soil water budge chart of the study area

Disturbed soil samples were then air-dried and passed through a 2 mm sieve to prepare for laboratory analysis. After soil samples were then air-dried and passed through a 2 mm sieve, particle size distribution was determined by the hydrometer method (Bouyoucos, 1951) after removal of organic matter with 30 % H_2O_2, of sulphate by leaching salts with distilled water, of carbonates with 1 M NaOAC at pH 5, and dispersion by agitating the sample in 10 ml of 40 % sodium hexametaphosphate (calcon) (Gee and Bauder, 1986). Bulk density (Blacke and Hartge, 1986) and water retention (field capacity-FC and permanent wilting point-PWP) (Klute, 1986) were determined from undisturbed samples. Available water capacity (AWC) was calculated from taking difference between FC and PWP. Hydraulic conductivity measurement was determined by saturated soil condition (Oosterbaan, 1994). Organic matter was determined in air-dry samples using the Walkley-Black wet digestion method (Nelson and Sommers, 1982). pH, EC-electrical conductivity (of the saturation) by method of the (Soil Survey Labrotory, 1992). Lime content by Scheibler calsimeter (Soil Survey Staff, 1993). Exchangeble cations and cation exchange capacities (CEC) were measured using a 1 N NH_4OAC (pH 7) method (Soil Survey Labrotory, 1992). Pearson correlation coefficients were estimated to investigate the relationships among the soil properties.

3. RESULTS AND DISCUSSIONS

Different parent materials affect the morphology, mineralogical and physico-chemical characteristics of soils under the same conditions such as biosphere, topography and climate especially in arid and semiarid regions. Therefore, differences in these properties of soils are related primarily to parent material (Washer and Collins, 1988).

3.1. Soil Physical and Morphological Properties

Soil physical and morphological properties that have been taken into consideration in this study showed variability as a result of dynamic interactions among natural environmental factors such as parent material under the same climate. Parent material, through its impacts on texture and surface area, also affects rates of pedogenesis. Leopold and Miller, 1956, Graf, 1982 and Alexander et al., 1999 indicated that alluvial lands and floodplains formed under ephemeral flow regimes, especially in arid and semiarid regions, lack many of the same relationships between hydrology, sedimentology, and morphology that obtain in perennial rivers. According to these authors, the concept of pedogenic maturity is used to infer sediment accumulation rates at different locations in ancient floodplain environments: weak soil development is assumed where sedimentation rates are rapid and strong development is presumed where sediment accumulation is slow. The same results were also observed in the study area. The major physical and morphological properties of the soils are presented in Table 1 and Figure 3. There is an abrupt textural transition in Profile 1 that contains silty loam and loam textures. This changing has also effect on structural development owing to loss of organic matter and fine texture, structural developing of Typic Torrifluvent is moderate and weak, fine and very fine granular. Sub surface soil texture of Lithic Torriorthent has also silty loam however; slope contributes to greater runoff, as well as to greater translocation of surface materials down slope through surface erosion and movement of fine soil. Typic Haplotorrert has the highest clay content (64%) while, Typic Torrifluvent has the highest sand content. This high clay content also causes slickensides features in Typic Haplotorrert. All soil profiles color is 10 YR except Typic Haplotorrert that has more reddish due to iron oxidation derived from basaltic parent material. In addition, soil color of Typic Haplocambid becomes lighter from top surface to sub surface horizons. Top surface of it is 10 YR 4/3 while, due to carbonate accumulation in depth color was change to 10 YR 7/3 in sub surface horizons. Bulk densities of the soils formed on four different parent materials ranged from 1.10 to 1.48 g/cm^3 and they were significantly different each other. Soils from basaltic parent material had the lowest while those from alluvial soil had the greatest bulk densities due to the soil textural variety. Typic Haplotorrert has the highest aggregate stability while, due to low clay and organic matter content aggregate stability is low in Typic Torrifluvent.

3.2. Soil chemical properties

Soil chemical properties considered in this study are pH, Electrical Conductivity (EC), Organic Matter (OM), Cation Exchange Capacity (CEC), exchangeable cations, calcium carbonate and macro and micro nutrients. Soil chemical properties on parent material were significantly affected by the degree of soil development and leaching processing (Table 3 and Table 4). In this study, it was found that pH values of soils developed from four different parent materials changed between 7.40 and 7.89 and a very high base saturation. Soil pH is generally greater at depth than at the soil surface whereas, EC values increased in top surface soil. However, there is no problem about salt accumulation for al pedons. Organic matter levels in soils of basalt, sand stone and alluvial areas are below 2.0% except lime stone-marn that has slightly higher than 2%. This is due to high temperature in most period of the year, leading to high rates of decomposition, mineralization and disappearance of organic materials, thereby preventing appreciable accumulation of organic carbon in the soils. Calcium carbonate content of the soils was found to be high. The calcium carbonate content was even much more higher in the horizons with carbonate accumulation (i.e. calcic horizons) (Table 3). The low amount of $CaCO_3$ in Typic Torrifluvent and Lithic Torriorthent can be explained by leaching of $CaCO_3$ in the profiles. High CaCO3 content in the other soils was a result of basalt and lime stone parent materials with rich carbonate content. Soil total cation varied between 8.6 to 45.8 cmol kg^{-1}. The soil with the highest total cation was Typic Haplotorrert with high clay content, while the lowest value was determined in in Typic Torrifluvent soil. Concerning exchangeable cations, Ca and Mg are the dominant cations at the exchange sites of basalt soils. Compared to these two, K and Na levels are not as high. According to Loue (1968) and Lindsay ve Norvell (1978), the two groups of soils (Lithic Torriorthent and Typic Haplotorrert) are low in their total nitrogen contents. Rapid mineralization due to high temperature of the arid region must have contributed to low levels of total N. Concerning soil available makro and micronutrient elements, particularly P, B and Zn, deficiencies exist in all soils perhaps because of the relatively low organic matter content of the soils and low levels of these elements in the parent rocks (Table 3). However, available Cu is found in sufficient quantities in soils derived from basalt and so do not constitute limitation to crop production. In addition, soils derived from basalt appear to be relatively higher in total iron than the other soils. There is no problem in terms of heavy metal concentration (Cd and Ni).

Coordinate: 679 509 E - 419 40 66 N
Parent Material: Alluvial deposit

Horizon Definition

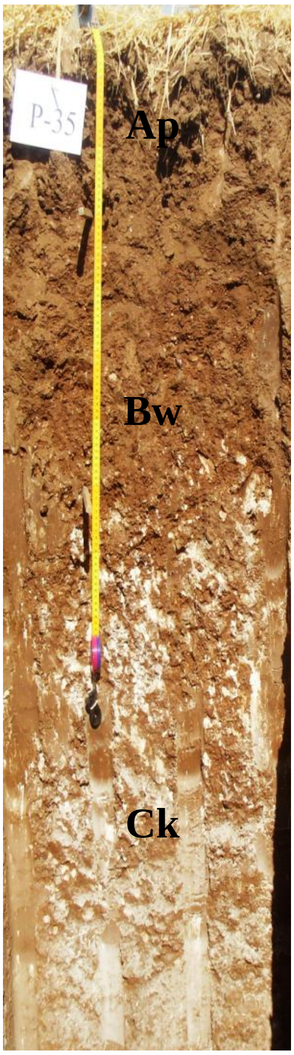
Pale brown (10 YR 6/3, dry), yellowish brown (10 YR 5/4, moist); silty loam; medium, medium granular structure; slight hard in dry, hard in moist; sticky when very moist; very lime; no-rock; medium common secondary roots; marked smooth border.

Pale brown (10 YR 6/3, moist); loam sandy; massive structure; loose in dry, individual in wet, no sticky when very moist; very lime; no-rock; medium common secondary roots; marked smooth border, sand band.

Brown (10 YR 4/3, moist); loam; massive structure; hard in dry; slight sticky and slight plastic in very moist; very lime; no-rock; medium common secondary roots; marked smooth border, oxidation spot started

Brown (10 YR 4/3, moist); loam; massive structure; tight when moist; slight sticky and slight plastic when very moist; very lime; no-rock; medium common secondary roots; humidity started.

Coordinate: 690 724 E - 419 38 41 N
Parent Material: Lime stone-Marn



Horizon Definition

Brown (10 YR 4/3, dry); dark brown (10 YR 3/3, moist); clay medium, medium, granular structure; hard when dry, tight when moist, sticky when very moist; very lime; thin common secondary roots; marked smooth border.

Yellowish brown (10 YR 5/4, dry), brown (10 YR 5/3, moist); clay; medium, medium subangular blocky structure; very hard when dry, very tight when moist, sticky when very moist; very lime; low rocky; very thin very loose secondary calcium carbonate nodules, marked smooth border

Very pale brown (10 YR 7/3, dry), very pale brown (10 YR 7/3, moist); clay; massive structure; very hard when dry, very tight when moist; sticky when very moist; high lime content ; low rocky; marked smooth border, secondary calcium carbonate nodules

Figure 3. Morphological description of the soil profiles

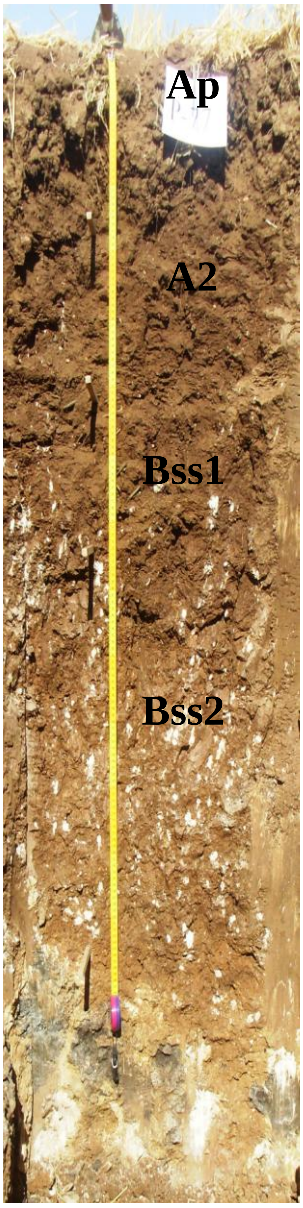
Coordinate: 692 013 E - 421 06 74 N
Parent Material: Sand stone

<u>Horizon Definition</u>

Yellowish brown (10 YR 5/4, dry), dark yellowish brown (10 YR 4/4, moist); silt loam; medium, small, granule structure; hard when dry, tight when moist, sticky when very moist; very lime; no-rock; thin, common secondary roots; marked wavy border.

Sand stone

Coordinate: 700 718 E - 419 63 33 N
Parent Material: Basalt



<u>Horizon Definition</u>

Dark brown (7,5 YR 3/3, dry), dark brown (7,5 YR 3/3, moist); clay; medium, medium, granule structure; hard when dry, tight when moist, sticky when very moist; very lime; no-rock; thin, common secondary roots, marked smooth border

Dark brown (7,5 YR 3/3, dry), dark brown (7,5 YR 3/3, moist); clay; medium, medium, subangular blocky structure hard when dry, tight when moist, sticky when very moist; very lime; no-rock; thin, very loose secondary roots, marked wavy border

Dark brown (7,5 YR 3/3, dry), dark brown (7,5 YR 3/3, moist); clay; medium, medium, subangular blocky structure hard when dry, tight when moist, sticky when very moist; very lime; no-rock; thin, very loose secondary roots, slicken sides marked wavy border

Dark brown (7,5 YR 3/3, dry), dark brown (7,5 YR 3/3, moist); clay; massive structure; very hard when dry; very tight when moist, very plastic when very moist; very lime;no-rock; very thin, very loose secondary roots; marked wavy border; small slicken sides and $CaCO_3$ nodules by 0.5 cm.

Figure 3. continue.

Table 2. Selected physical properties for four representative profiles

Horizon	Depth (cm)	Color (Dry, wet)	Particle size				Aggregate stability (%)	Bulk Density (g m^{-3})	*Clay minerals
			Clay (%)	Silt (%)	Sand (%)	Texture class			
Profile 1. Typic Torrifluvent									
Ap	0-26	10 YR6/3 10 YR5/4	16	52	32	SiL	21.03	1.24	I-S-K
C1	26-50	10 YR7/3 10 YR6/3	6	16	77	LS	21.26	1.49	I-S-K
C2	50-86	10 YR5/3 10 YR4/3	16	46	37	L	21.35	1.23	K-I-S
C3	86-154	10 YR5/3 10 YR4/3	8	46	46	L	21.48	1.29	I-K-S
Profile 2. Typic Haplocambid									
Ap	0-30	10 YR 4/3 10 YR 3/3	42	34	24	C	58.31	1.14	S-I-K
Bw	30-71	10 YR 5/4 10 YR 5/3	48	22	30	C	59.15	1.10	S-K-I
Ck	71 +	10 YR 7/3 10 YR 7/3	44	22	34	C	58.01	1.19	S-K-I
Profile 3. Lithic Torriorthent									
Ap	0-21	10 YR 5/4 10 YR 4/4	24	52	24	SiL	63.58	1.19	S-K-I
Cr	21+	-	-	-	-	-	-	-	-
Profile 4. Typic Haplotorrerts									
Ap	0-26	7,5 YR 3/3 7,5 YR 3/3	64	16	20	C	72.16	1.11	S-I-K
A2	26-51	7,5 YR 3/3 7,5 YR 3/3	64	18	18	C	71.54	1.10	S-I-K
Bss1	51-73	7,5 YR 3/3 7,5 YR 3/3	58	26	16	C	70.36	1.12	S-I-K
Bss2	73-135	7,5 YR 3/3 7,5 YR 3/3	52	30	18	C	71.94	1.17	S-I

*S: smectite, I: illite K: kaolinite L: Loam, C: Clay, SiL: Silty Clay, LS: Loamy sand

Table 3. Selected chemical properties for four representative profiles

Horizon	Depth (cm)	pH	EC (dS m^{-1})	O.M (%)	Calcium Carbonate (%)	Exchangeable cations (cmol kg^{-1})		
						Ca+Mg	Na	K
Typic Torrifluvent								
Ap	0-26	7.40	1.21	1.42	9.48	20.1	1.2	2.1
C1	26-50	7.75	0.42	0.38	8.69	7.3	0.8	0.5
C2	50-86	7.72	0.74	0.57	9.95	19.5	1.4	1.1
C3	86-154	7.89	0.26	0.26	5.53	8.1	1.1	1.0
Typic Haplocambid								
Ap	0-30	7.65	0.81	2.04	15.96	32.1	0.5	11.4
Bw	30-71	7.67	0.79	1.72	21.33	29.5	2.0	8.3
Ck	71 +	7.76	0.78	0.38	21.96	30.2	1.0	4.5
Lithic Torriorthent								
Ap	0-21	7.51	0.29	0.96	9.32	23.05	1.1	4.8
Cr	21 +	-	-	-	-	-	-	-
Typic Haplotorrerts								
Ap	0-26	7.55	0.47	1.12	6.64	25.2	0.5	20.1
A2	26-51	7.79	0.39	0.66	9.64	26.7	0.5	14.3
Bss1	51-73	7.64	0.38	0.98	22.36	28.4	0.5	8.3
Bss2	73-135	7.65	0.41	0.47	15.88	22.1	0.5	7.6

Table 4. Macro and micro nutrient elements of the four representative profiles

Horizon	Total N (%)	P mg kg-1	B mg kg-1	Total Fe %	Zn mg kg-1	Cu mg kg-1	Ni mg kg-1	Cd mg kg-1
Typic Torrifluvent								
Ap	0.14	4.50	0.478	1.688	0.271	0.713	0.412	0.004
C1	0.02	6.00	0.033	1.184	0.266	0.946	0.685	0.005
C2	0.03	5.10	0.057	1.349	0.342	0.318	0.784	<0.001
C3	0.01	4.10	0.019	1.411	0.120	0.635	0.452	<0.001
Typic Haplocambid								
Ap	0.11	7.70	1.035	1,209	0.315	0.203	0.691	<0.001
Bw	0.10	3.80	0.036	1,523	0.195	0.367	0.560	0.003
Ck	0.02	2.80	0.055	1,718	0.288	0.216	0.548	0.003
Lithic Torriorthent								
Ap	0.05	5.00	0.072	1,849	0.256	0.299	0.453	0.004
Cr	-	-	-	-	-	-	-	-
Typic Haplotorrerts								
Ap	0.06	2.43	0.186	1,939	0.291	0.242	0.327	<0.001
A2	0.04	7.45	0.026	1,876	0.518	1,152	0.741	0.005
Bss1	0.05	9.50	0.088	2,073	0.362	0.062	0.446	0.004
Bss2	0.02	8.00	0.355	2,961	0.322	0.922	0.207	<0.001

4. CONCLUSION

After comparing the soils formed on four different parent materials it can be concluded that physico-chemical, mineralogical and morphological properties of soils examined varied each other depending on type of parent material. This relationship has been especially well illustrated by a comprehensive review of by Dahlgren et al (2004). This review highlights the fact that soils derived from volcanic and carbonate rocks that possess distinctive physical, chemical and mineralogical characteristics that are usually not found in soils developed in each other (Wilson, 2006). In addition, it is widely recognized that parent material may be responsible for the origin of some unusual chemical soil properties such as the high exchangeable Mg/Ca ratio or heavy metal content of their. However, parent material can not be said to be major criterion for soil development. For most systems, soil type is based on a number of different criteria related to pedogenesis, stressing particularly the nature and intensity of the process, as controlled largely by combinations of the other soil-forming factors, namely climate, topography, biota and time.

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