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Article *in* Pakistan Journal of Biological Sciences · February 2007

DOI: 10.3923/pjbs.2007.528.536 · Source: PubMed

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Pakistan Journal of Biological Sciences 10 (4): 528-536, 2007
ISSN 1028-8880

Effects of Different Parent Material on the Mineral Characteristics of Soils in the Arid Region of Turkey

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Abstract: Physical, chemical and mineralogical characteristics of seven soils developed on four different parent materials such as basalt, limestone, marine and alluvium were studied to determine the effect of parent material on the soil characteristics in the arid and semiarid regions in the Southeast Anatolia Region of Turkey. Parent material have affected the morphology and chemistry of the soils. Carbonate contents of the soils are changing between 14.1 and 42.6%. The high carbonate contents of the soils, developed on the basalt rocks, might be attributed to eolian additions from calcareous soils. The red colour of basaltic soils might be associated with the Fe_2O_3 content of the parent material. Available Fe_2O_3 content of the basaltic soils was relatively higher than other soils and measured between 0.56 and 2.05%. Available Fe_2O_3 content of the soils on the marine was very low and changed between 0.26 and 0.37%. Total Fe_2O_3 content of the basaltic soils was higher than other soils and changed between 4.36 and 6.70%. The total Al_2O_3 content of the basaltic soils was obtained relatively higher than other soils and changed between 4.92 and 8.72%. The high Al_2O_3 and Fe_2O_3 contents of the basaltic soils may be associated with the weathering of basalt rocks. Also analysis of the basaltic rock samples has showed similar mineralogical composition. X-Ray diffraction analysis data showed that smectite was the dominant clay mineral in all the soils. Palygorskite was the second most abundant mineral after smectite. Moreover, some mineralogical properties reflected the traces of climatic changed during the Holocene. The leaching factor were determined as >1 in the Profile PL2 and as < 1 in the Profiles PL1, PL3, PL4, PL5; PL6 and PL7. The low leaching factor (< 1) may be attributed to weathering of parent material. The soils were classified according to Soil Taxonomy as Aridisol, Entisol, Vertisol and Inceptisol.

Key words: Soil classification, arid region, parent material, soil genesis

INTRODUCTION

Parent material has been recognized as an important factor in soil formation since the earliest scientific consideration of soils (Jenny, 1980). According to Joffe (1949) the formation of soil in a region can occur within a certain period of time depending on the parent material, climate, topography and vegetation of the region (Buol *et al*., 1980; Dinc *et al*., 1987). Different parent materials affect the morphology and chemistry of soils under the same conditions, such as topography and vegetation, especially in arid and semiarid regions. Differences in physical, chemical and mineralogical properties of soils are related primarily to parent material (Washer and Collins, 1988). A soil landscape pattern generally reflects the original parent material; however, saprolite was highly weathered prior to soil formation (Wysocki *et al*., 1988). The original separation of soils was based on the type of parent rock and on morphological properties.

Harran, as a local area of Sanlýurfa, is inside of The Southeastern Anatolia Region. Turkey, which has 81 administrative provinces, is divided into seven geographical regions and one of them is Southeastern Anatolia region which is generally called the Southeastern Anatolia Project (SAP, Turkish initials GAP) Region. The Southeastern Anatolia Project (SAP) is Turkey's largest and most multifaceted development project and also, one of the largest development projects of its kind in the world (Kaygusuz, 1999; Bulut, 2003). The project area covers nine provinces (Adıyaman, Batman, Diyarbakır, Gaziantep, Kilis, Mardin, Siirt, Sanlıurfa and Sırnak) of the Southeastern Anatolia Region, which is a relatively underdeveloped region in Turkey. The project covers such sectors as irrigation, hydroelectric power production, agriculture, urban, rural and agricultural

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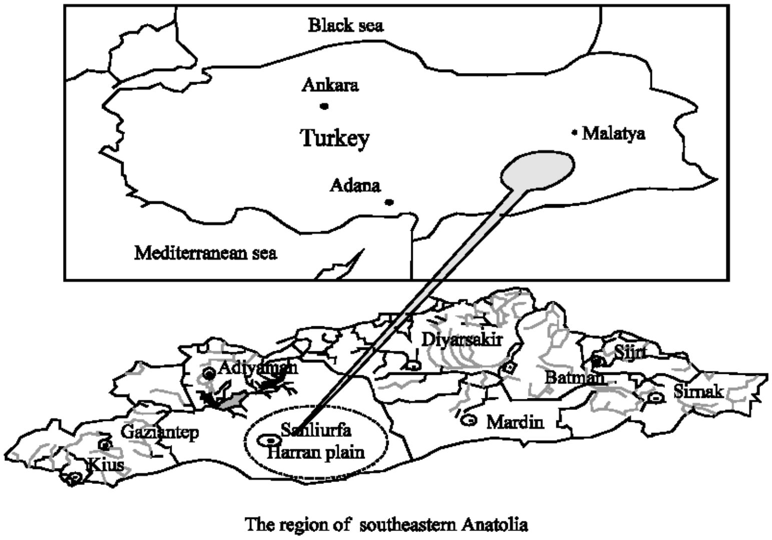

Fig. 1: General location of Harran region

infrastructure, transportation, industry, forestry, tourism, education and health. Its water resources program envisages the construction of 22 dams and 19 power plants and irrigation schemes on an area extending over 1.7 million ha (GAP, 2003). Parallel to this development, an intensive investment activity is expected to be undertaken in the region.

The objective of this study was to examine the effects of parent material on the physical, chemical, mineralogical and morphological properties of soils in the arid and semiarid regions of the Southeast Anatolia Region of Turkey (Fig. 1).

MATERIALS AND METHODS

Description of the area: The study area was characterised by arid climate and lies between 37°46′ and 36°43′ N latitudes and 37 and 39°46′ E longitudes in the Southeast Anatolia Region of Turkey. The average amount of annual rainfall is 320 mm in south of region and 400 mm in the north of region and total evaporation is 2047.75 mm. The mean annual air temperature was 17.8°C. The mean annual soil temperature at 50 cm depth was 19.9°C. The vegetations of study area were grasses, cereal and leguminous crops.

Method: The soil profiles were described in the field according to Soil Survey Staff (1993). Disturbed soil samples for laboratory analysis were collected from each horizon and air dried to pass a 2 mm sieve. The particle size distribution of each sample was determined by the pipette method (Mc Keague, 1978) after removal of organic matter and carbonates. The pH and salt content (electrical conductivity, EC) were measured on saturation extracts (Radiometer PHM 82 standard pH meter and Radiometer CDM 83 conductivity meter). Percent salt content was calculated from EC values. Organic C was measured by using a modified Walkley-Black procedure (Nelson and Sommers, 1982). Carbonate content was determined by the Sheibler calciometer method (Black, 1965). Exchangeable cations were determined after replacement with Ba (Mc Keague, 1978) and cation-exchange capacity by Mg saturation followed by NH_4 substitution. The clay fraction from each soil was analyzed by x-ray diffraction to determine the clay mineralogy. Treatments of the samples included Mg saturation and glycerol solvation and K saturation and heating to 105, 300 and 550°C (Jackson, 1974). Extractable Fe, Si and Al oxides by the citrate dithionite-bicarbonate method and total chemical analysis were carried out by the HF fussion method (Jackson, 1979). The results of total element analysis were used to determine the β leaching factor. β leaching factor was determined according to Jenny (1941) following formulation:

- β: The ba value of leaching horizon (A1)
- The ba value of parent material (C1, C2 or C3 horizon)
- The ba value was determined following formulation:
- ba value: $Na_2O + K_2O/Al_2O_3$

The soils were classified according to Soil Taxonomy (Soil Survey Staff, 2006) and the World References Base For Soil Resources (FAO ISRIC, 1998).

RESULTS AND DISCUSSION

Soil formation and morphological properties: The major morphological properties of the soils were presented in Table 1. Profiles PL1 and PL2 have developed on the limestone as a result of decomposition and fragmentation of the calcareous parent material. Secondary carbonate nodules which apparently were evidence for carbonate leaching and accumulation were identified in the profiles PL 1 and PL2. Calcic horizon has developed in the Ck1 horizon of Profile PL 1 and Ck horizon of Profile PL 2 as a result of carbonate accumulation. A Cambic B definition horizon has developed in the profiles PL 1 and PL2 as a result of structure formation and reddish brown colour. Some researchers have claimed that a cambic horizon has developed along with a calcic horizon in soils of arid and semiarid regions (Buringh, 1979; Buol *et al.*, 1980; Dinc *et al.*, 1987). β leaching factor is 0.48 in the Profile PL1 and is 1.29 in the Profiles PL2 (Table 1). The low eaching factor (< 1) in the Profile PL1 may be attributed to extensive weathering of parent material. The high leaching factor (> 1) in the Profile PL2 may be associated with the low weathering of parent material.

Profiles PL3 and PL4 have developed on the marine parent material. A Cambic B horizon has developed as a result of structure formation. The morphology of profile

Table 1: Selected some morphological characteristics and leaching factor of soils

Horizon	Depth (cm)	Colors (moist)	Texture †	Structure ‡	Special features	β leaching factor
Profile PL 1, on the limestone (Xeric Haplocalcid)						
Ap	0-18	7.5 YR 4/6	CL	2 m abk	Common biologic activity	0.48
A	18-30	7.5 YR 4/4	CL	2 m abk	Structure formation	
Bw1	30-55	5 YR 4/4	C	2 m abk	Structure formation	
Bw2	55-70	5 YR 4/6	C	2 m abk	$CaCO_3$ nodules	
Ck1	70-95	7.5 YR 4/6	C	ma	$CaCO_3$ nodules	
Ck2	95-110	7.5 YR 4/6	CL	ma		
Profile PL 2, on the limestone (Lithic Xeric Haplocalcid)						
A1	0-15	5 YR 4/6	CL	3 m sbk	Biologic activity	1.29
Bw	15-30	7.5 YR 4/4	C	2 m gr	Structure formation	
Ck	30-48	5 YR 4/6	C	ma	$CaCO_3$ nodules	
Cr	48-60	7.5 YR 6/4	-	ma		
Profile PL 3, on the marine (Vertic Haplocambid)						
Ap	0-15	7.5 YR 4/4	CL	2 m gr	Biologic activity	0.79
A1	15-30	7.5 YR 4/4	C	2 m abk	Biologic activity	
Bw	30-50	7.5 YR 4/6	C	2 m abk	Structure formation	
C1	50-70	7.5 YR 4/6	C	ma	$CaCO_3$ nodules	
C2	70-95	10 YR 6/3	-	ma		
Profile PL 4, on the marine (Xeric Torriorthent)						
Ap	0-15	10 YR 4/6	CL	1 m gr	Biological activity	0.13
C1	15-40	10 YR 4/65	CL	ma		
C2	40-60	5 Y 7/3	SC	ma		
Profile PL 5, on the alluvium (Typic Calcitorrert)						
Ap	0-28	7.5 YR 4/6	CL	2 m gr	1-10 cm cracks	0.33
A1	28-45	7.5 YR 4/6	CL	2 m sbk	1-10 cm cracks	
Bwss1	45-56	5 YR 4/6	C	3 m pr2 m pr	Slickensides	
Bwss1	56-75	5 YR 4/8	C	2 m pr	Slickensides	
Bkss	75-90	5 YR 3/6	C	ma	Slickensides	
Ck	90-125	7.5 YR 6/2	C	ma	1-5 cm $CaCO_3$ nodules	
Profile PL 6, on the basalt (Typic Haplotorrert)						
Ap	0-22	5 YR 4/6	C	3 m gr	1-10 cm cracks	0.82
A1	22-38	5 YR 4/6	C	2 m abk	1-10 cm cracks	
A2	38-50	5 YR 3/6	C	3 m abk	1-5 cm cracks	
Bwss1	50-76	2.5 YR 3/4	C	3 m pr	Slickensides	
Bwss2	76-90	2.5 YR 3/4	C	3 m pr	Slickensides	
Ck1	90-120	5 YR 4/6	C	ma	Common $CaCO_3$ nodules	
Ck2	120-150	5 YR 4/6	C	ma		
Profile PL 7, on the basalt (Typic Calcitorrert)						
Ap	0-18	5 YR 3/6	CL	3 m sbk	1-10 cm cracks	0.74
A1	18-30	5 YR 3/6	C	2 m abk	1-10 cm cracks	
A2	30-40	5 YR 3/6	C	2 m abk	1-10 cm cracks	
Bwss1	40-55	5 YR 3/6	C	3 m pr	slickensides	
Bwss2	55-64	5 YR 3/6	C	3 m pr	slickensides	
Ck	64-75	5 YR 3/6	C	ma	$CaCO_3$ nodules	
R	75 +	10 YR 6/1	-	-	Basalt rocks	

†: CL: Clay loam, C: Dlay, SC: Sandy clay . ‡: 1: Weak, 2: Moderate, 3: Strong; m: Medium; gr: Granular, abk: angular blocky, sbk: subangular blocky, ma: Massive

PL4 was similar to the profile PL3. However, surface horizon of the profile PL4 has abraded by erosion due to the sloppy topography. β leaching factor is 0.79 in the Profile PL3 and is 0.14 in the Profiles PL4. The low leaching factor (< 1) in the Profile PL3 may be attributed to weathering. The low leaching factor (< 1) in the Profile PL4 may be associated with error of analysis.

Profile PL5 has developed on the alluvium materials, deposited during the Holocene. A Cambic B horizon developed in these soils due to the prizmatic structure formation. Prizmatic structure formation was related with the shrink-swell potential of the parent material. Slickensides have developed in the B horizons of profile PL5 as a result of shrink-swelling. β leaching factor is 0.33 in the Profile PL5.

Profiles PL6 and PL 7 have developed on the basalt rocks of the Pleistocene age. Parent material has affected the morphological characteristics of these soils. Profile PL6 has the finest texture and the reddest coloured soils in the study area (Table 1 and 2). The red colour of profiles PL6 and PL 7 may be associated with the high Fe oxide content of the parent material. A Cambic B horizon developed in these soils due to the prizmatic structure formation. Prizmatic structure formation was related with the shrink-swell potential of the parent material. Slickensides have developed in the B horizons of profiles PL6 and PL7 as a result of shrink-swelling. β leaching factor is 0.82 in the Profile PL6 and is 0.74 in the Profiles PL7. The low leaching factor (< 1) may be attributed to extensive weathering of parent material.

Table 2: Selected some physical and chemical properties of the soils

					Exchangeable cations (cmol kg^{-1})					Distribution of particle size Organic < 2 mm (%)		
Horizon	Depth (cm)	pH (1/1)	Salt (%)	CEC (cmol kg^{-1})	Na$^+$	K$^+$	Ca^{++} Mg^{++}	CaCO$_3$ (%)	Matter (g kg^{-1})	Sand	Silt	Clay
Profile PL 1, on limestone (Xeric Haplocalcid)												
Ap	0-18	7.42	0.052	47.39	0.28	1.36	45.75	22.8	1.84	34.36	35.31	30.33
A	18-30	7.44	0.050	48.85	0.32	0.98	47.55	18.6	1.80	34.50	28.64	36.86
Bwi	30-55	7.45	0.046	49.02	0.28	0.81	47.93	21.6	1.58	27.20	27.07	45.83
Bw2	55-70	7.49	0.048	47.26	0.30	0.82	46.14	19.0	1.55	24.51	21.87	53.62
Cki	70-95	7.40	0.045	40.03	0.36	0.86	38.81	24.2	1.55	27.52	21.29	51.18
Ck2	95-110	7.60	0.020	23.77	0.42	0.49	22.86	32.8	1.05	46.52	20.42	33.06
Profile PL 2, on limestone (Lithic Xeric Haplocalcid)												
Ai	0-15	7.35	0.050	40.00	0.31	0.35	38.84	18.2	2.97	23.48	41.81	34.71
Bw	15-30	7.38	0.052	55.72	0.39	1.08	54.25	17.8	2.32	22.11	36.68	49.21
Ck	30-48	7.40	0.055	49.43	0.34	1.17	47.92	48.6	1.76	33.03	30.14	36.83
Profile PL 3, on the marine (Vertic Haplocambid)												
Ap	0-15	7.39	0.053	40.05	0.27	0.99	38.79	20.0	2.37	27.11	37.39	35.50
Ai	15-30	7.40	0.053	36.34	0.26	0.77	35.31	21.2	2.03	28.61	31.36	40.03
Bw	30-50	7.42	0.058	40.28	0.32	0.60	39.36	21.2	1.97	23.53	24.97	51.50
Ci	50-70	7.40	0.060	29.97	0.31	0.43	29.23	28.6	1.10	28.30	22.68	49.02
Profile PL 4, on the marine (Xeric Torriorthent)												
Ap	0-15	7.5	0.045	42.98	0.32	1.11	41.55	15.8	0.69	38.07	29.33	32.60
Ci	15-40	7.51	0.043	17.55	0.25	0.30	17.00	25.4	0.92	36.16	26.21	37.63
C2	40-60	7.55	0.042	19.28	0.29	0.35	18.64	24.3	1.05	46.03	18.61	35.36
Profile PL 5, on the alluvium (Typic Calcitorrert)												
Ap	0-28	7.40	0.045	35.58	0.32	1.27	33.99	23.5	2.00	34.7	34.16	30.40
Ai	28-45	7.42	0.050	24.04	0.51	1.20	22.33	21.1	2.29	29.63	34.55	35.81
Bwss1	45-55	7.50	0.052	26.23	0.68	0.76	24.79	22.0	2.44	33.34	26.37	40.29
Bwss2	55-75	7.55	0.048	25.67	0.78	0.53	24.36	23.9	2.44	24.65	27.90	47.45
Bkss	75-90	7.48	0.052	24.15	0.84	0.51	22.80	23.9	2.29	21.95	23.14	54.91
Ck	90-125	7.48	0.055	14.81	0.60	0.28	13.93	28.7	2.46	34.75	22.71	42.53
Profile PL 6, on the basalt (Typic Haplotorrert)												
Ap	0-22	7.60	0.030	51.34	0.50	1.21	49.63	18.4	1.85	19.27	30.06	50.67
A1	22-38	7.58	0.032	52.00	0.34	1.05	50.61	17.8	2.41	18.24	23.91	57.84
A2	38-50	7.55	0.028	54.45	0.39	0.62	53.44	17.4	2.44	19.67	19.65	60.68
Bwss1	50-76	7.56	0.037	49.73	0.35	0.85	48.53	14.4	2.09	19.62	20.19	60.18
Bwss2	76-90	7.58	0.040	50.54	0.38	0.82	49.34	16.7	1.85	17.71	23.20	59.09
Cki	90-120	7.60	0.042	56.62	0.35	0.93	55.34	14.8	2.09	16.67	21.22	62.11
Ck2	120-150	7.56	0.040	49.65	0.37	0.62	48.66	17.8	1.76	18.68	22.32	59.00
Profile PL 7, on the basalt (Typic Calcitorrert)												
Ap	0-18	7.45	0.052	53.65	0.33	1.43	51.89	16.7	1.84	25.59	38.44	35.96
Ai	18-30	7.50	0.050	56.18	0.36	1.05	54.77	16.7	1.76	24.18	29.18	46.64
A2	30-40	7.52	0.048	56.66	0.44	0.94	55.28	16.3	1.88	25.48	28.01	46.51
Bwss1	40-55	7.40	0.045	54.59	0.43	0.98	53.18	15.9	2.09	28.62	23.69	47.69
Bwss2	55-64	7.53	0.048	55.61	0.34	0.86	54.41	16.3	1.05	27.63	25.84	46.53
Ck	64-75	7.42	0.048	46.85	0.29	0.77	45.79	16.3	1.10	35.91	23.04	41.05
R	75+	7.30	0.030	20.75	0.28	0.38	20.09	14.4	1.20	69.83	10.99	19.18

The physical and chemical properties: The major physical and chemical properties of the soils were presented in Table 2. The clay content in the A horizon is slightly greater than 35 % in profiles of PL3, PL6 and PL7. The clay contents of all profiles were generally increasing with depth, especially in the B horizons (Table 2). Clay content in the surface of the all soils is lower than subsoil. The low clay content of surface soil may be associated with leaching from surface to subsoil. The clay content of the soils, developed on the basalt parent material was considerably higher than the other soils. The differences in the particle-size distribution of the soils may reflect differences in chemical composition of the parent rocks The clay content of Profile PL 6, developed on the basalt, was considerably high and change between 50.67% (in the Ap horizon) and 62.11% (in the Ck_1 horizon). Fine texture of Profile PL 6 can be attributed to extensive decomposition and chemical characteristic of the basalt material. Calcium carbonate content of the soils were high and an increase was found in the carbonate accumulation horizons (Table 2). The high $CaCO_3$ content of profiles PL1, PL2, PL3 and PL4 were associated with calcareous parent material. The $CaCO_3$ content of profiles PL6 and PL7 on the basalt rocks were high and changed between 14.4 and 18.4%. The $CaCO_3$ contents of these soils (profiles PL6 and PL7) may be attributed to eolian additions from the calcareous soils. Because, eolian additions play an important role in pedogenesis in many arid regions (Stolt *et al*., 1991). The lime content of basaltic soil (R horizon) taken from Profil 7 was very high (14.4%) as shown Table 2. Basaltic rocks do not consist of $CaCO_3$ naturally. Therefore, it was supposed that basalt contents of soil was formatted due to the inactive Volcano of Karaca Mountain and some lime layers was lain under 10 m of basaltic layer. The pH of the soils was moderately alkaline and increases with depth as a result of accumulation of $CaCO_3$ with depth. The cation exchange capacity (CEC) values of the soils change between 14.81 and 56.66 cmol kg^{-1}. The high CEC values may be associated with high clay content. Some researchers reported that high clay content have increased cation exchange capacity of soils in arid regions (Yılmaz, 1990; Irmak *et al*., 1991).

The CEC of the soils, on the basalts, were higher than other soils. The cation exchange capacity values in the profiles PL6 and PL7 developed on the basalt material, change between 46 and 56 cmol kg^{-1}. High CEC value of the soils was due to high clay content. CEC values were especially increase as depending on high clay content (Table 2). Exchangeable Ca^{++} and Mg^{++} contents of the all soils were considerably high. Exchangeable Ca^{++} and Mg^{++} account for > 95% of the exchangeable complex as a result of dissolution of carbonates and possible weathering of feldspar and ferromagnesian minerals present in the soils. The high contents of Ca^{++} and Mg^{++} may be associated with the chemical composition of the parent material. Exchangeable Na^+ and K^+ levels were rather low and K^+ level decreases gradually with depth (Table 2). The organic C content of the soils was very low and decreases gradually with depth and measured between 0.69 and 2.97 g kg^{-1}. The low content of organic C can be attributed to long arid periods and poor vegetation.

The total elemental composition of soils: The major total element analysis of the soils was presented in Table 3. Extractable Fe contents of the soils, developed on the basalts, were relatively higher than the other soils and change between 0.56 and 2.05%. The extractable Fe content of profile PL4, developed on the marine, was very low and changes between 0.26 and 0.37%. Extractable Al_2O_3 content, parallels clay content in the profiles PL5, PL6 and PL7, with a maximum in the Bwss1 horizon of PL6. The extractable Fe contents in the A horizons of profiles PL2, PL5, PL6 and PL7 may be attributed to weathering of the parent material.

Extractable SiO_2 contents of the soils were very low and change between 0.035 and 0.087%. The low SiO_2 content may be attributed to weathering of quartz. Some researchers reviewed eleven reports on the trends of extractable Fe content in B horizons with soil age. He noted that, for two of the reports, the values for the extractable Fe increased with soil age to a maximum, then decreased with further time (Jacob *et al*., 1990). Other researchers have shown that increasing rubification over time was a function of Fe oxide accumulation (Birkeland, 1974). Several researchers report that the amount of Al that substitutes for Fe in goethite may be a useful criterion to estimate the extent of soil formation (Fitzpatrick and Schwertmann, 1982).

Total Fe_2O_3 of the soils, on the basalts, was higher than the other soils and changes between 4.36 and 6.70%. The total Fe_2O_3 content of profiles PL 1 and PL 2 on the $CaCO_3$ rocks changed between 2.06 and 5.46%. The total Fe_2O_3 content of profiles PL3 and PL4 on the marine changed 1.01 and 3.52%. The total Fe_2O_3 content of PL5 on the alluvium material was similar to PL3 and PL4 and changed between 1.08 and 3.35%.

The total Al_2O_3 content of profiles PL6 and PL7 on the basalts obtained relatively higher than the other soils and change between 4.92 and 8.72%. The total Al_2O_3 content of PL3 and PL4 soils on the marine was lower than the other soils and change between 0.12 and 4.11%. The high total Fe and Al oxide contents of the soils on the basalts might be associated with the chemical composition of basalt rocks. Analysis of the unweathered basalt rock samples of profile PL7 on the basalts also was showed similar mineralogical composition.

Total MgO contents of the soils on the $CaCO_3$ rocks changed between 0.211 and 0.263%. Total MgO contents of the soils, on the marine, changed between 0.219 and 0.250%.

Total MgO contents of the soils, on the basalts, changed between 0.187 and 0.257%. Total CaO contents of the soils on the $CaCO_3$ rocks were higher than the other soils and change between 2.047 and 14.994%. The high CaO contents were related with chemical composition of $CaCO_3$ rocks. Total CaO content of the soils on the marine changed between 1.380 and 2.156%. Total CaO contents of the soils on the basalts changed between 2.338 and 9.030%. Total K_2O contents of the soils on the $CaCO_3$ rocks changed between 0.269 and 0.855%. Total K_2O contents of the soils on the marine changed between 0.235 and 0.487%. Total K_2O contents of the soil on the basalt changed between 0.371 and 0.837% (Table 3).

Clay mineralogy: The clay fraction from each soil was analyzed by x-ray diffraction to determine the clay mineralogy in the four soil profiles on the four different parent materials. The results of X-Ray Diffraction analysis were presented in Table 4. X-Ray Diffraction analysis data show that smectite was the dominant clay mineral in all the soils. The presence of smectite was in agreement with the CEC and swelling properties of the soils. The level to very gently undulating landscape and semiarid

Table 3: Extractable and total chemical analysis of the soils

Horizon	Depth (cm)	Extractable Fe_2O_3 (%)	Total Fe_2O_3 (%)	Extractable Al_2O_3 (%)	Total Al_2O_3 (%)	Extractable SiO_2 (%)	Total MgO (%)	Total CaO (%)	Total K_2O (%)	Total Na_2O (%)
Profile PL 1, on the limestone (Xeric Haplocalcid)										
Ap	0-18	0.76	4.14	0.12	6.24	0.083	0.211	10.989	0.479	0.098
A	18-30	0.48	4.65	0.07	6.75	0.066	0.233	10.379	0.496	0.144
Bw1	30-55	1.06	4.06	0.10	6.69	0.070	0.245	12.514	0.545	0.111
Bw2	55-70	0.66	5.37	0.07	6.26	0.087	0.257	14.994	0.463	0.152
Ck1	70-95	0.75	4.05	0.09	4.63	0.085	0.263	2.0470	0.455	0.179
Ck2	95-110	0.58	2.06	0.07	2.07	0.071	0.243	2.0910	0.269	0.132
Profile PL 2, on the limestone (Lithic Xeric Haplocalcid)										
A1	0-15	1.84	4.78	0.21	7.11	0.043	0.213	3.180	0.834	0.134
Bw	15-30	1.90	4.31	0.27	8.09	0.072	0.223	5.767	0.855	0.115
Ck	30-48	1.15	5.46	0.16	8.15	0.058	0.211	2.957	0.703	0.153
Profile PL 3, on the marine (Vertic Haplocambid)										
Ap	0-15	0.67	3.23	0.06	3.77	0.059	0.226	1.380	0.449	0.134
A	15-30	0.82	3.52	0.1	4.11	0.081	0.238	1.566	0.464	0.148
Bw	30-50	0.75	3.38	0.08	3.84	0.073	0.25	1.557	0.487	0.179
Ci	50-70	0.51	2.94	0.07	3.01	0.055	0.235	1.977	0.420	0.167
Profile PL 4, on the marine (Xeric Torriorthent)										
Ap	0-15	0.37	1.30	0.04	1.55	0.058	0.221	2.156	0.313	0.185
Ci	15-40	0.32	1.99	0.08	0.17	0.042	0.219	1.989	0.235	0.172
C2	40-60	0.26	1.01	0.05	0.12	0.042	0.224	1.637	0.308	0.170
Profile PL 5, on the alluvium, (Typic Calcitorrert)										
Ap	0-28	0.97	3.29	0.07	5.32	0.035	0.214	8.6890	0.765	0.144
A	28-45	0.74	3.25	0.08	5.70	0.066	0.223	9.0070	0.786	0.135
Bwss1	45-56	0.76	3.35	0.09	5.59	0.051	0.229	12.777	0.793	0.176
Bwss2	56-75	0.59	3.19	0.10	5.69	0.066	0.230	12.626	0.834	0.175
Bkss	75-90	0.90	2.94	0.13	1.65	0.039	0.257	1.1850	0.579	0.194
Ck	90-125	0.62	1.08	0.06	1.22	0.039	0.239	2.1500	0.349	0.278
Profile PL 6, on the basalt , (ypic Haplotorrert)										
Ap	0-22	2.05	5.04	0.12	8.30	0.055	0.231	4.732	0.737	0.150
Ai	22-38	1.07	6.70	0.17	5.60	0.089	0.257	5.243	0.607	0.268
A2	38-50	0.75	5.77	0.18	5.84	0.059	0.255	5.469	0.618	0.273
Bwss1	50-76	1.64	4.50	0.29	6.42	0.044	0.250	5.016	0.564	0.149
Bwss2	76-90	1.45	6.57	0.16	7.21	0.047	0.239	4.939	0.629	0.158
Ciki	90-120	1.48	4.76	0.13	5.70	0.052	0.247	7.884	0.521	0.192
C2k2	120-150	1.79	5.80	0.15	7.72	0.077	0.237	9.030	0.837	0.168
Profile PL 7, on the basalt, (Typic Calcitorrert)										
Ap	0-18	1.47	6.59	0.16	8.22	0.067	0.216	2.608	0.526	0.132
Ai	18-30	1.43	4.52	0.13	8.72	0.073	0.226	2.584	0.647	0.120
A2	30-40	1.62	6.41	0.17	7.22	0.085	0.230	2.688	0.664	0.154
Bwss1	40-55	1.96	5.09	0.26	5.43	0.049	0.227	3.112	0.552	0.156
Bwss2	55-64	1.38	6.20	0.15	7.43	0.064	0.218	4.801	0.579	0.155
Ck	64-75	1.74	4.36	0.19	4.92	0.075	0.211	7.755	0.371	0.158
R	75 +	0.56	5.29	0.08	4.22	0.069	0.187	2.338	0.168	0.121

conditions, high pH and saturation of the soils with water for a period of time may have ensured the accumulation of bases and therefore the formation of smectite and other 2:1 clay mineral (Buol *et al.*, 1980; Dinc *et al.*, 1987; Yesilsoy, 1994). Some researchers have claimed that excess Ca^{++} content in the soil of arid regions would increase the formation of smectite but decrease the formation of kaolinite (Kapur, 1975; Yesilsoy, 1994). Many researchers have reported that smectite was the most abundant clay mineral in most of the soils formed on parent material with $CaCO_3$ (Singer, 1989; Yılmaz, 1990).

Palygorskite was the second most abundant mineral after smectite (Table 4). Presence of smectite and palygorskite minerals has led to the thesis that a genetical relationship of these two minerals comes from the similar origin of parent materials (Kapur, 1975; Singer, 1989; Dixon and Weed, 1989; Irmak *et al.*, 1991). Palygorskite and smectite commonly coexist in soils suggesting that palygorskite might be transformed to smectite by weathering (Bigham *et al.*, 1980). Some researchers claimed that palygorskite has formed in the porous $CaCO_3$ grains and discharged into the soil by dissolution (Kapur, 1975; Yılmaz, 1990; Stolt *et al.*, 1991; Sumner, 2000). Palygorskite minerals exhibit weak crystal peaks that can be associated with the presence of iron oxide coatings on clay minerals and amorphous subtances in the environment.

The soils also contain, in low amounts, kaolinite and illite minerals. For kaolinite formation, the ratio of Si/Al must be under 2.0, the basic cation content must be less, pH<7.0 (Buol *et al.*, 1980; Dinc *et al.*, 1987; Dixon and Weed, 1989; Sumner, 2000). According to this theorem, the rainfall must be in a sufficient amount to translocate silicou and basic cations to a certain limit in the profile. The presence of kaolinite mineral in the basic cations-rich in study area with low amounts of rainfall can be associated with rainy climatic changes in Pliocene. Furthermore, a low amount of kaolinite mineral might have formed gradually over a very long period of time, even under current climatic conditions. Kaolinite minerals exhibit weak crystal peaks that may be associated with the weathering. Contents of illite mineral of profile PL1, developed on the limestone and profile PL3 developed on the marine was low. The low content of illite mineral may be associated with the mica content of limestone and marine. Profile PL5 developed on the alluvium material and profile PL7 developed on the basalts did not contained illite mineral. It may be associated with mineral composition of basalt and alluvium material. Some researchers have claimed that potassium-rich mica decomposition should be metamorphosed into illite mineral (Yılmaz, 1990). The others showed that the content of illite mineral was very high in the soils of arid regions (Singer, 1989).

Classification of soils: The soils were classified according to Soil Taxonomy (Soil Survey Staff, 2006) as Aridisol, Entisol, Vertisol and Inceptisol (Table 5).

Profile PL1 was classified as Xeric Haplocalcid because of it has xeric soil moist regime, contained Calcic horizon that has its upper boundary within 100 cm of the soil surface.

Profile PL2 was classified as Lithic Xeric Haplocalcid because of they have aridic soil moisture regime, contained Calcic horizon and had a lithic contact within 50 cm of the soil surface.

Table 4: Clay mineralogy of the soils

	Smectite		Palygorskite		Illite		Kaolinite	
Horizon	Dom.	Cry.	Dom.	Cry.	Dom.	Cry.	Dom.	Cry.
Profile PL 1, on the limestone (Xeric Haplocalcid)								
Ap	xxxxx*	++**	xxx	+	xx	+	xx	+++
Bw1	xxxxx	+++	xxx	+	xx	+	xxxx	+++
Ck2	xxxx	+++	xxx	+	xx	+	xxx	+++
Profile PL 3, on the marine (Vertic Haplocambid)								
Ap	xxxxx	+++	xxx	+	xx	+	xxx	+++
Bw	xxxx	++	xxx	+	xx	+	xx	+++
Ci	xxx	+	xxx	+	xx	+	xx	+++
Profile PL 5, on the alluvium material (Typic Calcitorrert)								
Ap	xxxx	+	xxxx	++	-	-	xxx	+++
Bwss1	xxxxx	+	xxxx	+++	-	-	xxx	++++
Ck	xxx	+	xxxxx	+++	-	-	xxx	++++
Profile PL 7, on the basalt (Typic Calcitorrert)								
Ap	xxxx	+++	xxx	+	-	-	xxx	+++
Bwss1	xxxx	+++	xxx	+	-	-	xx	++
Ck	xxxxx	+++	xxx	+	-	-	xx	++

* Dominance, ** Crystallization, xxxxx: Very much, xxxx: Much, xxx: Fair xx: ++++: Very good, +++: Good, ++ :Fair, Few +: Poor

Table 5: Soil Classification according to Key to Soil Taxonomy (2006) and FAO (1998)

Profiles	Order	Suborder	Great group	Subgroup	(FAO, 1998)
PL 1	Aridisol	Calcid	Haplocalcid	Xeric Haplocalcid	Haplic Calcisol
PL 2	Aridisol	Calcid	Haplocalcid	Lithic Xeric Haplocalcid	Haplic Calcisol
PL 3	Aridisol	Cambid	Haplocambid	Vertic Haplocambid	Vertic Cambisol
PL 4	Entisol	Orthent	Torriorthent	Xeric Torriorthent	Calcaric Regosol
PL 5	Vertisol	Torrert	Calcitorrert	Typic Calcitorrert	Calcic Vertisols
PL 6	Vertisol	Torrert	Haplotorrert	Typic Haplotorrert	Haplic Vertisols
PL 7	Vertisol	Torrert	Calcitorrert	Typic Calcitorrert	Calcic Vertisols

Profile PL3 was classified as Vertic Haplocambid because of xeric moist regime, in Cambic horizon and have 1-5 cm width cracks at 50 cm depth.

Profile PL4 was classified as Xeric Torriorthent because of it didn't contain definition horizon but Ochric epipedon and it has aridic moist regime.

Profiles PL5 and PL7 was classified as Typic Calcitorrert because of they have aridic moist regime, a Calcic and Cambic horizon and cracks 1-5 cm in width extending to 1.0 m below the surface.

Profile PL6 was classified as Typic Haplotorrert because of it has aridic moist regime, a Cambic horizon and cracks 1-5 cm in width extending to 1.0 m below the surface.

Profile PL1 and Profile PL2 were classified as Haplic Calcisol because of an aridic soil moist regime and contain Calcic definition horizons in the subsurface of soil (FAO, 1998).

Profile PL3 was classified as a Vertic Cambisol because of xeric moist regime, in Cambic horizon and have 1-5 cm width cracks at 50 cm depth.

Profile PL4 was classified as Calcaric Regosol because of an Ochric A epipedon but no other definition horizon and the soil matrix 20-50 cm below the surface contains calcium carbonate.

Profiles PL5 and PL7 were classified as Calcic Vertisols because of they have cracks in arid periods and a Calcic horizon.

Profile PL6 was classified as Haplic Vertisol because of it has cracks 1-5 cm in width extending to 1.0 m below the surface.

CONCLUSIONS

It was observed that parent materials of soil layer in the Harran region considerably affected the morphology and chemical contents of the soils. Especially clay layer will be affected on moisture content of soil and irrigation systems of different plant cultivations. Some chemical characteristics of the soils were affected by composition of parent rocks. The differences in the chemical properties of the soils were reflected differences in chemical composition of the parent rocks.

If suitable soil types and methods of soil preparation are used efficiently, it is certain that this region will be a potential source for plant cultivating in Southern Anatolia. However negative affects of regional erosion on soil formation, depending on irregular raining, powerful wind and meteorological conditions, being minimum levels should be prevented by using different methods. The Harran Region as an arid plain had been used for agricultural activities throughout historical ages periodically and Euphrates is an important river in Southern Anatolia; flows into the Persian Gulf; was important in the development of several great civilizations in ancient Mesopotamia. Nowadays, The Southeastern Anatolia Project (SAP) has been continuing to earn maximum profit on commercial applications.

The soils generally were found in fine texture. The soils have been classified according to Soil Taxonomy as Xeric Haplocalcid, Lithic Xeric Haplocalcid, Vertic Haplocambid, Xeric Torriorthent, Typic Calcitorrert and Typic Haplotorrert. These soils have been classified according to FAO/Unesco as Haplic Calcisol, Vertic Cambisol, Calcaric Regosol, Calcic Vertisols and Haplic Vertisols.

The cultivatings of main industrial plants such as corn, cotton, soybean, sunflower, wheat and others have been increased gradually. Especially the production of cotton for textile sector of Turkey has been reached high levels recently. For this aim, the encouragements of authorities on developing of organic agriculture will be improved to raise the quality of soil layers. Because measured organic contents of Harran Region's Soils were obtained insufficient level for agricultural activities.

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