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# Morphology of Three Terra Rossa Soils in East Mediterranean Region, Turkey¶

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Morphological and chemical characteristics of three Terra Rossa soils on the Tourous Mountains in the East Mediterranean Region were studied to understand the genesis of Terra Rossa soils. All three soil profiles developed on the $CaCO_3$ rocks. Parent material and climate have affected the morphology and chemistry of soils. The most pedogenic processes are clay accumulation and leaching of carbonates. The low $CaCO_3$ contents can be attributed to the leaching of $CaCO_3$. The leaching of $CaCO_3$ from the profile were caused the red colour Bt horizon. Evidence of alluvial clay occurred as clay films on ped faces in all soil profiles. Argillic horizon have developed result of clay accumulation. The high total contents of $Al_2O_3$ and $Fe_2O_3$ of soils may be attributed to chemical composition of $CaCO_3$ parent rock. Soil pedons were classified as Typic Rhodoxeralf and Lithic Rhodoxeralf according to the soil taxonomy and chromic luvisol group to the FAO/UNESCO World Soil Map Legend.

**Key Words: Soil classification, Soil morphology, Terra rossa soils.**

## INTRODUCTION

Soils which developed the higher layer of the earth crust and formation was from the decomposition and fragmentation of parent rock and parent material. Soil in nature unite which has organic horizon and for different depth it decomposed. The soils has shown differences from parent material according to morphologic structure, physical and chemical characteristics[1]. The soils exhibit similar characteristics where these soil-forming factors are the same. Parent material affects soil characteristics especially in arid and semiarid regions[2].

Among factors of occurance the earth surface soil were, different climates, too much organismis, difference rocks, topography and various of old land. If the soils formation factor is seem the soil caracteristics will

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be seem also[3]. Some researchers found soils in which clay translocation and alluvial horizon formation apparently occurred before prismatic structure formed in the Bt horizon[4], while White[5] described soils in which the prismatic structure may formed before a significant amount of alluvial soil. Regardles of the pathway, finer textured soils tend to have more persistent columnar structure, thinner eluviyal A horizons and stronger and smaller columnar structure in the Bt horizon than coarser textured counter parts[5,6]. The objective of this study was to determine chemical, physical and mineralogical characteristics of three Terra Rossa soils in the East Mediterranean Region of Turkey.

## EXPERIMENTAL

The locality of the study area, 37º 25′ North latitude and 34º 53′ East Longitude, is 90 km to the Adana in the Southern of Turkey. The altitude of the region varies beetween 1400 and 1600 m. The mean annual rain of this region is about 703 mm. According the Soil Survey Staff[7] criteria, the soil moisture regime is xeric and the soil temperature regime is thermic.

The soil pedons were described in the field according to Soil Survey Staff[7]. Soil samples for laboratory analysis were collected from each horizon, air dried, to pass a 2 mm siever. The particle size distribution of each sample was determined by the pipette method[8], after removal of organic matter and carbonates. Total organic C were determined by the methods of Tiesse *et al.*[9]. Total salt, electrical conductivitiy and pH were measured on saturation extracts using electrodes (Radiometer CDM 83 Conductivity meter and Radiometer PHM 82 standard pH meter) exchangeable cations were obtained by replacement with $Ba^{2+}$ and cation exchange capacitiy (CEC) by the $Mg^{2+}$ saturation followed by $NH^{+}$ subsitution[8]. Carbonate contents were measured by the Sheibler Calciometer method[10]. Three soil pedons were classified according to Soil Taxonomy[7] and World Soil Map Legend[11].

## RESULTS AND DISCUSSION

The three soil pedons were developed on the $CaCO_3$ rocks. The plants for whole vegetation are pine and fir trees. The profile PL1 is placed at Kokaroba Akçatekir which distant 16 km from southwest of Pozanti, that developed on the $CaCO_3$ rocks, which takes efficient time for fragmentation and decomposition. PL1 pedon was 1400 m high from sea level, has fir trees found on surrounding of it. In the topographia at slightly slope (4-6 %). The mid depth soils were developed on the $CaCO_3$ rocks. Parent material, time and vegetation affected to the morphologic characteristics of soils. The leaching of $CaCO_3$ and fine clay in the PL1 profile is very high level. In the profile results of the leaching at $CaCO_3$ to the depth profile, were developed Cambic Bt horizon which has red colour (2,5 YR 3/4). The $CaCO_3$

leaching from profile were effected besides amount of rainfull with remaining levels of three which occur of organic acid. Especially, the decomposition of pine and fir tree levels which caused organic acid that was effected on the soluble of $CaCO_3$ and easy leaching. Also in the PL1 pedon the clay leaching was observed and accumulation of its as clay cutans. Evidence of alluvial clay occurred as clay films on ped faces in all soil profiles. The fine clays translocated with infiltration of water in the pedon, have accumulated between structure surface and on ped faces in the Bt horizon. The fine clay accumulation in the Bt horizon is at the high level occurence Argillic horizon. Clay content of alluvial horizon (A2 horizon) in the surface is 37.8 %, but in the alluvial horizon (Bt horizon) is 61.9 % level (Table-2). This was observed that the highest leaching of clay and accumulation. For this to happen, the content of clay in the Bt horizon has to be 8 % more than that in the eluvial horizon (E)[3,12]. Some studies indicated that soils in which clay translocation and eluvial horizon formation apparently occurred before prismatic structure formed in the B horizon[4,13], while, White[5] described soils in which the prismatic structure may have formed before a significant amount of eluviation[6]. These soils have relatively thick (20, 22 and 28 cm) surface horizons over well-expressed argillic horizons. Parent rock fragments were found in all horizons. The texture of A horizon in the surface soil is clay loam but subsurface soil in the Bt horizon is clay texture. The fine texture of soil matrix can be attributed to accumulation of clay. The structure of the solum changes from strong, moderate subangular blocky and finally strong, fine platy granular in the surface horizon (Table-1). The clear line boundary separating the A2 and B horizons apparently pedogenic.

The genesis and morphologic characteristic of profile PL2 soil is similar to the PL1 soils. The soil texture of A1 horizon in the surface is clay loam, C1 and C2 horizons in the subsurface are loam and soil texture of Bt horizon is clay. The leaching of carbonate and clay in the PL2 pedon has high level. These soils developed under low topographic (1200 m and 4 % slopy) at pine vegetation on the $CaCO_3$ rocks. The clay contents of the alluvial horizon (Bt) has at the level which developed Argillic horizon. The clay cutans that observed during definition profile in the Bt horizon as pedogenic has shored up to the argillic horizon. The structure of the solum changes from moderate, medium, angular blocky (breaking to moderate, medium sub-angular block) and finally strong, fine granular in the surface horizon.

Profile PL3 taken from Yanoluk Akçatekir which distant from Pozanti, has developed on the $CaCO_3$ rocks and sheyls under the pine vegetation.

TABLE-1
SOME MORPHOLOGICAL
CHARACTERISTICS OF THE SOILS

| Horizon | Depth (cm) | Colour | | †Texture | ‡Structure | Special features |
|---|---|---|---|---|---|---|
| | | Moist | Dry | | | |
| A1 | 0-10 | 7.5 YR 3/3 | 7.5 YR 3/4 | C L | 2 mgr | |
| A2 | 10-20 | 7.5 YR 2/3 | 7.5 YR 3/4 | C L | 3 mgr | |
| Bt | 20-32 | 2.5 YR 3/4 | 2.5 YR 3/6 | C | 3 msbk | clay cutans |
| C | 32-48 | 2.5 YR 3/6 | 2.5 YR 4/6 | C | ma | |
| R | 48 + | $CaCO_3$ Rocks | | | | |
| A1 | 0-30 | 7.5 YR 3/3 | 7.5 YR 3/4 | C L | 3 fgr | |
| Bt1 | 30-55 | 2.5 YR 3/4 | 5 YR 3/6 | C | 2 mabk | clay cutans |
| Bt2 | 55-70 | 2.5 YR 3/4 | 5 YR 3/6 | C L | 3 msbk | clay cutans |
| C1 | 70-120 | 10 YR 3/4 | 10 YR 4/6 | L | ma | |
| C2 | 120-150 | 10 YR 3/4 | 10 YR 5/6 | L | ma | |
| R | 150 + | Shale (claystone) + $CaCO_3$ Rocks | | | | |
| A1 | 0-22 | 7.5 YR 3/3 | 7.5 YR 3/4 | C L | 3 fgr | |
| Bt1 | 22-34 | 7.5 YR3/4 | 7.5 YR 3/6 | C | 2 msbk | clay cutans |
| Bt2 | 34-52 | 2.5 YR3/4 | 2.5 YR 3/6 | C | 2 msbk | clay cutans |
| C | 52-84 | 5 YR4/6 | 5 YR 5/8 | C | ma | |
| R | 84 + | $CaCO_3$ Rocks | | | | |

†Texture, C: clay, Cl: clay loam, I: loam
‡Structure, 2: medium, 3: strong, f: fine sbk: subangular blocky, abk: angular blocky, gr: granülar, ma: massive

TABLE-2
SOME PHYSICAL AND CHEMICAL CHARACTERISTICS OF SOILS

| Horizon | Depth (cm) | pH (1/1) | Soluble salt (%) | CEC* (cmolc $kg^{-1}$) | Exchangeable cations (cmolc $kg^{-1}$) | | | $CaCO_3$ (%) | Organic matter (%) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Ca + Mg | K | Na | | |
| A1 | 0-10 | 6.80 | 0.048 | 56.53 | 54.34 | 1.69 | 0.50 | 7.0 | 3.38 |
| A2 | 10-20 | 6.90 | 0.047 | 56.05 | 54.53 | 1.03 | 0.49 | 7.0 | 2.90 |
| Bt | 20-32 | 6.90 | 0.060 | 60.00 | 58.28 | 1.26 | 0.46 | 7.0 | 1.77 |
| C | 32-48 | 6.95 | 0.042 | 44.51 | 46.16 | 0.53 | 0.82 | 11.0 | 2.18 |
| R | 48 + | $CaCO_3$ Rocks | | | | | | | |
| A1 | 0-30 | 7.40 | 0.048 | 45.49 | 43.39 | 1.64 | 0.46 | 7.6 | 3.50 |
| Bt1 | 30-55 | 7.20 | 0.054 | 56.57 | 55.39 | 0.71 | 0.47 | 7.0 | 1.61 |
| Bt2 | 55-70 | 7.22 | 0.076 | 56.45 | 55.04 | 0.87 | 0.54 | 4.1 | 1.39 |
| C1 | 70-120 | 7.10 | 0.042 | 40.97 | 39.98 | 0.40 | 0.59 | 7.0 | 1.08 |
| C2 | 120-150 | 7.18 | 0.050 | 29.17 | 28.08 | 0.34 | 0.75 | 7.8 | 1.00 |
| R | 150 + | Shale (claystone) + $CaCO_3$ Rocks | | | | | | | |
| A1 | 0-22 | 7.15 | 0.044 | 47.26 | 45.30 | 1.40 | 0.56 | 7.0 | 3.42 |
| Bt1 | 22-34 | 7.08 | 0.062 | 53.69 | 52.29 | 0.65 | 0.80 | 4.4 | 1.59 |
| Bt2 | 34-52 | 7.10 | 0.040 | 52.49 | 51.03 | 0.70 | 0.76 | 4.8 | 1.42 |
| C | 52-84 | 6.92 | 0.035 | 35.74 | 34.72 | 0.57 | 0.45 | 17.0 | 1.21 |
| R | 84 + | $CaCO_3$ Rocks | | | | | | | |

*CEC: Cation exchange capacity

The genesis and morphology of the PL3 soil is similar to the PL1 and PL2 soils. The result of leaching calcium carbonate from profile was developed red colour (2.5 YR 3/4) of Cambic B horizon. The leaching and accumulation of clay was caused to the argillic horizon. The clay content of alluvial horizon (A2) is 36.0 % but the clay content alluvial horizon (Bt1 horizon) is 49.4 % (Table-3). The structure of the solum changes from moderate subangular blocky and finally strong fine granular in the surface horizon. The clay cutans which observed in the PL3 pedon have resulted the argillic horizon.

TABLE-3
CHEMICAL COMPOSITION AND SOME PHYSICAL PROPERTIES OF THE SOILS

| Horizon | Distribution particle-size < 2 mm (%) | | | Free $Fe_2O_3$ | Free $Al_2O_3$ | Total $Fe_2O_3$ | Total $Al_2O_3$ |
|---|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | | | |
| A1 | 37.3 | 26.8 | 35.9 | 4.10 | 0.36 | 7.70 | 7.90 |
| A2 | 39.5 | 22.7 | 37.4 | 3.26 | 0.60 | 7.58 | 7.36 |
| Bt | 19.6 | 18.5 | 61.9 | 4.48 | 0.51 | 3.64 | 10.12 |
| C | 33.4 | 22.7 | 43.9 | 3.02 | 0.35 | 6.56 | 9.29 |
| A1 | 35.8 | 26.6 | 37.6 | 2.46 | 0.23 | 1.72 | 6.47 |
| $Bt_1$ | 21.6 | 24.6 | 53.8 | 2.65 | 0.72 | 8.16 | 11.62 |
| $Bt_2$ | 31.6 | 34.4 | 34.0 | 1.98 | 0.22 | 5.86 | 7.47 |
| $C_1$ | 43.4 | 42.5 | 14.1 | 1.13 | 0.36 | 8.41 | 5.52 |
| $C_2$ | 43.6 | 42.2 | 14.2 | 0.77 | 0.28 | 9.17 | 5.43 |
| A1 | 37.4 | 26.4 | 36.2 | 2.99 | 0.38 | 6.90 | 8.07 |
| $Bt_1$ | 33.6 | 17.0 | 49.4 | 2.47 | 0.36 | 8.15 | 9.46 |
| $Bt_2$ | 23.5 | 20.8 | 55.7 | 2.49 | 0.45 | 7.56 | 9.44 |
| $C_1$ | 39.6 | 17.6 | 42.8 | 1.98 | 0.24 | 6.30 | 8.09 |

**Physical and chemical properties of soils:** The major morphological characteristics of the soils were presented in the Table-1 while the major physical and chemical properties of the soils were presented in the Table-2. General trends in physical and chemical properties could be observed with depth in all of soils studied. Except for the C horizon of profile PL2, the clay content generally increases with depth. The high clay contents in the argillic horizon relatively to the C material are due to weathering of larger particles to clay size and clay illuviation. The degree of weathering and amount of illuviation decrease in the C horizons and therefore, as clay contents decrease, sand content increase. The clay content in the A horizons is slightly > 35 % in all the studied soils. The clay contents of these soils generally increases in the Bt horizon (Table-3). This increasing may be attributed to leaching of fine clay from surface soil and accumulation in the Bt horizon. The fine texture of soils may be attributed to decomposition of parent material. Some researchers showed that the soils which developed on the $CaCO_3$ rocks, has the fine texture[3,14,15]. The $CaCO_3$ contents of the studied soils are low and changes between 4 to 17 g $kg^{-1}$. The low content of $CaCO_3$ in this soils may be attributed to the leaching of $CaCO_3$ from the pedon. The organic C contents of the soils is low and decrease gradually with depth. The cation exchange capacity value are changes between 21.17 to 60.00 cmol $kg^{-1}$. Increase of CEC in the Bt horizon may be attributed to the high content of clay. Exchangeable $K^+$ an $Na^+$ levels are rather low and changes between 0.34 to 1.69 cmol $kg^{-1}$.

**Mineralogic properties of soils:** Some mineralogical characteristics were presented in the Table-3. Except for the Bt horizon of profile PL1, total $Fe_2O_3$ contents of soils are increases in the Bt horizon. Citrate bicarbonate-extractable $Fe_2O_3$ contents of soils much higher than extractable $Al_2O_3$ content. The dithionite citrate bicarbonate-extractable Fe oxide contents in the A horizons of all soils higher than C horizons. Extractable Fe and Al oxide decreased with depth. Also, the extractable Fe oxide contents follow the same trends as clay contents. Fe oxide contents increase in the Bt horizon depending on clay content and decrease with depth (especially in the C horizons). The high extractable $Fe_2O_3$ content in the A horizons of soils may be attributed to weathering. Parent material has influenced the chemistry of soils. Total $Fe_2O_3$ and $Al_2O_3$ contents of soils may be associated with chemical composition of $CaCO_3$ parent rock. Total $Al_2O_3$ and free $Al_2O_3$ contents of soils are increases in the Bt horizon. This increase may be associated with fine clay accumulation in the Bt horizons.

Free $SiO_2$ content of soils are very low and change between 0.024 % and 0.059 %. Free $SiO_2$ contents relatively follow the same trends as sand contents. The low $SiO_2$ contents may be attributed to weathering of quartz mineral.

The total $Na_2O$ contents of soils decreases with depth and change between 0.013 and 0.039 %. Total $K_2O$ contents of soils increase in the Bt horizons and decrease in the C horizons (Table-3).

**Classification of soils:** The soils were classified according to Soil Taxonomy[7] in the Alfisol order. The profiles PL2 and PL3 were classified in the Alfisol order for consisting of ochrich A epipedon and Argillic horizon; in the suborder of Xeralf for consisting of xeric soil moist regime; in the great group of Rhodoxeralf the red colour of entire of Argillic horizon has more than 5 YR colour; in the Typic Rhodoxeralf subgroub for their diversity from the other orders. Profile PL1 was classified in the Lithic Rhodoxeralf subgroub for its has a lithic contact within 50 cm of the mineral soil surface.

According to World References Base for Soil Resources[11], all studied soils have been classified as Chromic Luvisol for consisting of Argillic B horizon that has red colour (2,5 YR ¾).

## Conclusion

It is concluded from present study that soil solution chemistry showed the translocation of fine clay and carbonates. The leaching of fine clay and carbonates in the three soil profiles are high level. The fine clay accumulation in the Bt horizon was at the level high occurence Argillic horizon.

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