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PEDOGENESIS AND ECOLOGY OF KARSTIC LANDS

PEDOGENEZA IN EKOLOGIJA KRASA V TURČIJI

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Page:54-67

Izvleček

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Ibrahim Atalay: Pedogeneza in ekologija krasa v Turčiji

Članek podaja glavne značilnosti nastanka in razvoja prsti na izbranih lokacijah v jugozahodni in zahodni Turčiji. Ker so značilnosti prsti odvisne od značilnosti matične kamnine, so v prispevku tudi fizikalne in kemijske lastnosti apnencev, predvsem njihova prepokanost. Na razpokanih apnencih, še posebej, če vključujejo lapornate oziroma peščeno-meljaste plasti, je prst globlja, kot na masivnih apnencih. Večina kraških rdečih plasti v Turčiji je nastala tekom terciarja oziroma v toplih in vlažnih obdobjih kvartarja.

Ključne besede: pedologija, pedogeneza, krasoslovje, ekologija, Sredozemlje, Turčija

Abstract

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Ibrahim Atalay: Pedogenesis and ecology of karstic lands in Turkey

Characteristics of evolution and development of soils from chosen locations of southwestern and western Turkey are presented in the paper. Because the characteristics of the soils depend on basic rocks, the paper includes phisical and chemical properties of limestone too, their fissuring emphasized.On fissured limestones, specially if they include marl and sandy-silty layers, the soils are deeper than on massive limestones. In Turkey, most of the red karst soils developed during the Tertiary and the hot and humid periods of the Quaternary.

Key words: pedology, pedogenesis, karstology, ecology, Mediterranean, Turkey

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INTRODUCTION

Red Mediterranean soils are not found on the steep slopes of the karstic lands which are widespread in the Taurus mountains, in southern Turkey. But these land surfaces are densely covered by a forest and maquis where natural under the natural conditions. There are two major questions that deserve some explanation.

Although the land surface is very steep there may be thin soil cover under the forest canopy. The presence of thin and stony soils is attributed to erosion, especially when natural balance has been affected by man. As a result of this process, the bare and rocky surfaces of karstic lands were exposed. One can explain that bare karstic lands were exposed due to soil erosion, and transportation of soil materials which were accumulated within wide cracks and in the karstic depressions. But, this explanation is not true. According to author's study the soil formation has not developed on the inclined surfaces because of the fact that all rain infiltrates along the cracks (Atalay, 1988, 1991). One can clearly see there is no run-off even if heavy rainfall occurs. Indeed, although the mean annual precipitation is over 1500 mm on the upper slopes facing south in the Taurus Mountains, there is no run-off evidence.

Crack position and chemical composition of limestone appear to be very significant in soil formation. It is known that water easily infiltrates along the cracks. Therefore, soil formation does not proceed on the steep slopes because of the fact that water is not detained on the bare surfaces and also weathered materials are transported along the slopes. Soil develops along the cracks and between the layers due to the fact that water remains in thin cracks and between the sedimentary layer surfaces. Clay, which is the minor constituent in the limestones and the other materials such as quartz remain in place when $CaCO_3$ is dissolved. The residue is generally clayey, and soil derived from this material is also clayey in texture. As a general rule, it can be stated that the main material remaining in karstic lands is clayey and thus the soil material is of clay and clayey in texture.

The main purpose of this paper is to explain how Red Mediterranean soil develops in the karstic lands.

2. MATERIALS AND METHOD

Almost all parts of the karstic region of Turkey were examined during the field observations. The stratigraphic and lithologic properties of the karstic areas were taken into consideration. Especially, the relationships between soil formation and karstification processes were studied. Soil samples were collected from the different parts of the karstic areas.

Laboratory analysis such as pH (1:1 H_2O) and cation exchange capacities were determined according to Richards (1954). The $CaCO_3$ content by Black (1956), and mechanical analysis by Bouyocous (1952). These analysis were made by Forest Soil Research Laboratory at Eskişehir. Determination of clay minerals were carried out on suspended slides by Jackson (1979)'s method using a PHILIPS X-ray difractometer at the Laboratory of Soil Department, Faculty of Agriculture, Çukurova University. In order to reveal the ecological properties of karstic land, field observations were made.

3. RESULTS AND DISCUSSIONS

Soil forming process in the karstic lands

The factors affecting pedogenesis in karstic lands are as follows:

The position of the crack structure and stratification system, thickness of the layers, and chemical composition of the limestone, especially the amount of the clay and climatic condition determine the soil formation and its physical and chemical properties in karstic lands.

3.1 Crack structure of limestone

Crack structure is a very important factor for soil formation in the Taurus mountains. In fact, weathering and dissolution processes take place along the thin cracks. Also some kind of lapiés develops along the vertical cracks (Fig. 1).

The extent of the crack is mainly dependent on the chemical composition and age of the limestone. As a general rule, the cracks in limestones were mostly produced by tectonic movements. The hard and pure limestones which were subject to tectonic movements were dissected by cracks. For this reason, the extent of cracking in sandy and pure limestone is much more than in clayey limestone or marl. For example, Paleozoic and Mesozoic limestones contain more abundant cracks than the clayey or marly limestones belonging to Tertiary, in general (Atalay 1987b).

The limestones which were dissected by cracks are richer in terms of soil content than the less dissected one (Atalay 1973, 1987 a, 1987 b, 1988, 1989 and 1991).

In the Taurus Mountains, Red Mediterranean soils are found in the cracked limestone because of the fact that soil has formed along the cracks (Figure 1).

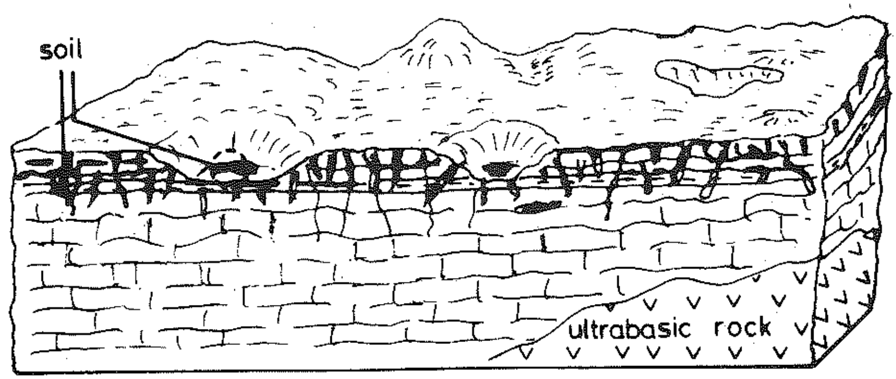

Figure 1. Soil formation along the cracks. This figure represents the Mesozoic hard limestones (location 2 and 6 in Table 1), in the western part of Taurus Mountains.

3.2 Chemical composition of limestone

Pure limestone dissolves more quickly than clayey limestone. That is why, if limestone contains more residue such as silicious sand and clay, the degree of solution decreases. When limestone has been completely dissolved, the clay-sized residues are left behind. Although the residual clay content of the limestone is less, rich soils are found on this type of limestone (Site 2 from

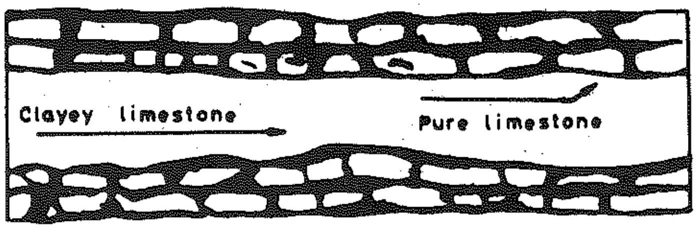

Figure 2. The differences between marl and cracked limestones. Black places show red soils. This figure is prepared from the Karaburun Peninsula, Western part of the Aegean region.

table 1, and Fig. 2). Sandy limestones produce sandy soils which are widespread on the Taşeli plateau, Middle Taurus. Soft limestone form Rendzina soils.

In the Taurus Mountains the thick and abundant soils occur on the rather pure limestones belonging to Lower Miocene and Mesozoic which are common in the Middle and the western part of the Taurus Mountains, especially the Davras and Dedegöl Mountains. The thin and stony soils are seen on the limestones containing $MgCO_3$, hard and crystalized limestone; sandy soils are found on the sandy limestones.

3.3 Stratification properties of limestones

When the clayey, marly and sandy layers lie alternately, in karstic lands the water is mostly held along the bedding and/or weak surfaces. Therefore soil formation generally has been developed between the bedding surfaces. On the other hand, there is no considerable difference among the soils which are found along the bedding surfaces. But, clayey loam textures are dominant in the soils which are developed both on the surface and along the cracks, while the texture is clay in the bedding surfaces (Table 1, site 2 and Fig. 3).

Our observations showed that soil formation is more active in the thin bedded limestone formation, while the soil-forming process may be slow in the

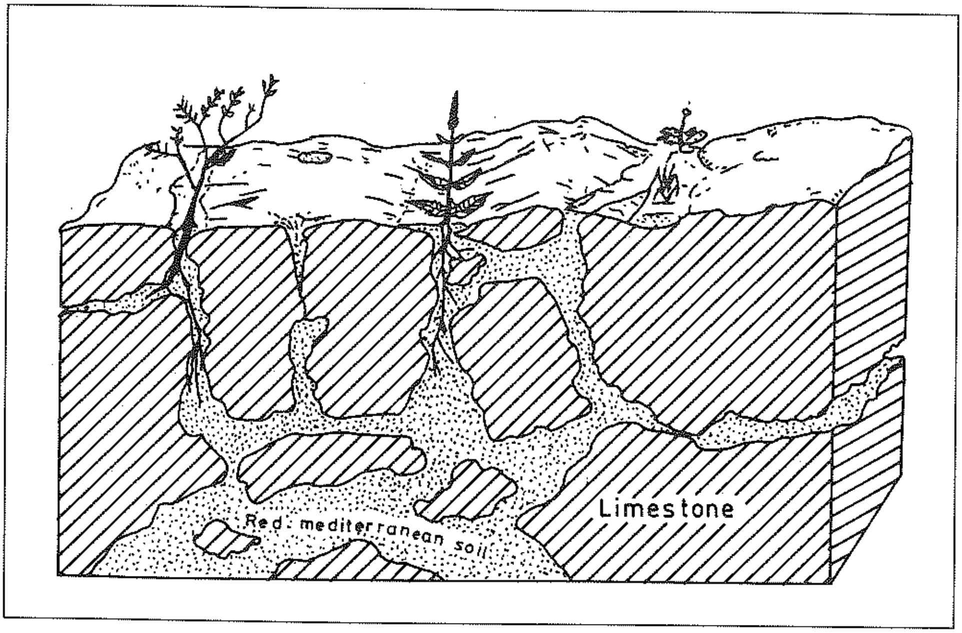

Figure 3. The relationships between soil formtion and stratification. Black places show the reddish soils. This figure is drawn in the vicinity of Akseki, western part of the Middle Taurus.

thick or massive limestones which may be more widespread. However, soils are found along the cracks within the blueish and hard limestones representing Mesozoic in the western part of the Taurus Mountains, Çeşme and Karaburun peninsulas in the Aegean region, western part of Turkey. Thin and stony reddish soils are only common at the bottom of the "V" shaped dolines. The inclination of the layer determines the soil formation as shown in Fig. 3 (Sites 1 and 2 in table 1). In the horizontal and thin-bedded or stratified areas, soil layers resemble a wall built by bricks. Soil follows the weathered zones or layers (Atalay et al 1988, 1990).

3. 4 Relationships between karstification and soil formation

There is a close relationship between soil formation and karstification events. Karstification processes occur in cracked limestones, because of the fact that dissolution events continue along the crack (Jennings 1985, Atalay

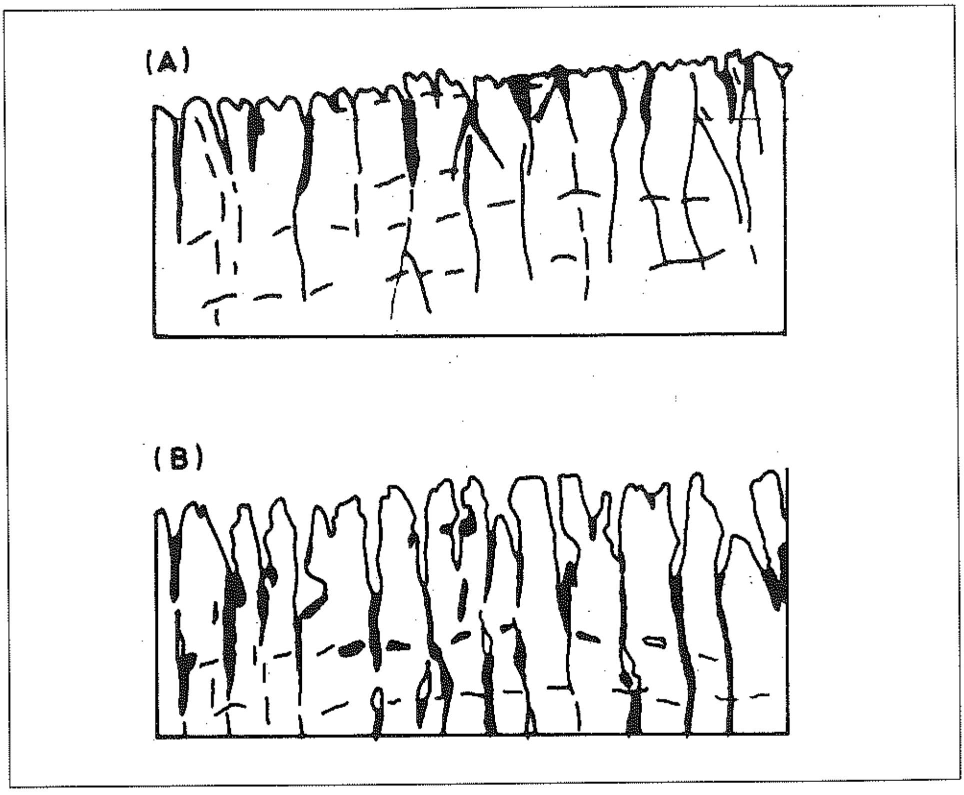

Figure 4. (A) Soil developed along the cracks, and (B) vertical transport of the soil with the widening of cracks. This figure represents Gidengelmez Mountains, made up of Mesozoic limestone and extending between Seydişehir and Manavgat towns, western part of Middle Taurus Mountains.

1989). The dissolution of limestone along the cracks leads to the widening of the cracks. Soils which have been developed along the cracks are transported further down by the widening of the cracks. This shows that the soil mass may be moved from the upper zones towards the lower in the vertical direction. Such soils are found in the rather pure limestones of the Gidengelmez mountains in the western part of the middle Taurus Mountains (Fig. 4). This position explains why the soil is found in the deeper section of karstic lands (Sari et al, 1986; Atalay, 1988, 1989).

While the clay and clayey layers may prevent the karstification activities, especially in horizontal formations, soil formations may be rapid in this material. In the horizontal structure areas, the bottom of the karstic depressions such as dolines and poljes is generally composed of clay and/or a clayey layer on which a thick soil can be found (Atalay 1989) These soils are common in the poljes of the middle and eastern parts of the Taurus Mountains, especially Taşeli plateau (Table 1, sites 4 and 5)

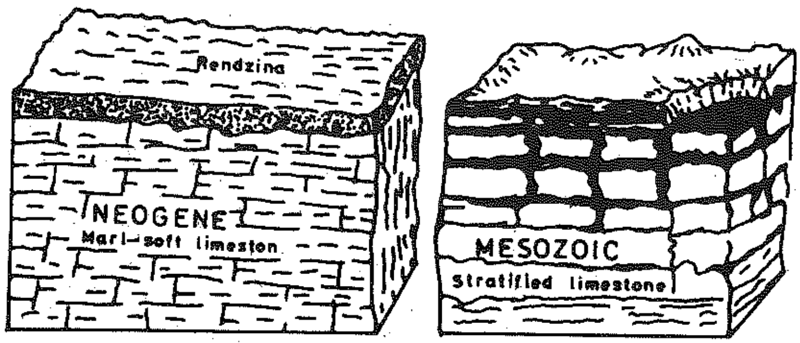

Figure 5. The prevention of soil forming process on the marl layer in the some polje areas. This figure represents Taşeli plateau composed of clayey and limestone layers lying in horizontal structure.

A rocky appearance is generally dominant in the places where intense karstification events have occured. In the Taşeli (Rocky country) plateau, in the middle part of the Taurus Mountains, soils are common along the weak zones in which they have been formed (Fig. 5 and 6).

3.5 Physical and chemical properties of karstic soils

The clay content of karstic soils is generally much more than that of other soils. For example, soils which have been developed on the gneiss are of sandy loam texture; the soils occurring on the marl are generally loam and clayey loam; and the soils which have developed on the peridotite are of clayey loam. But karstic soils are of clay and rarely clayey loam texture, because, the materials remaining on karstic land are of clay, in general. As it is known that bauxite deposits have developed by a dissolving of the limestones and accumulation of the clay.

Site and parent material, elevation (m)	**Hor.**	**Texture**	**pH**	**$CaCO_3$ (%)**	**CEC (cmolc kg^{-1})**
İzmir-Çeşme road,	A	C	8.0	1.5	36.2
limestone, 400	A	C	7.8	-	34.2
Karaburun peninsula					
W of Aegean region,					
limestone cracks		Cl	7.0	1.5	31.5
Bedding surfaces		C	8.2	1.5	31.3
Top soil, 20 m		Cl	7.6	-	40.7
Davraz Mountain, W					
of Taurus in doline areas	A	Cl	7.0	0.4	-
Middle Taurus, 1600 m					
Dümbelek düzü, Middle	A	Si C	6.6	0.0	43.5
Taurus, 2300 m	B	C	7.5	3.0	46.0
Başkonuş dağı	A1	C	7.7	2.8	41.3
E of Taurus,	A3	C	6.5	2.4	47.7
1300 m	B1	C	7.5	0.8	45.5
near doline	B3	C	7.3	0.2	53.1
Beydağı (W.of Taurus)	A	C	7.4	1.6	52.1
Çığlıkara, 1600 m	B	C	7.1	1.2	50.2
Gazipaşa (Middle of	A	C	7.2	0.8	48.5
Taurus), Karatepe,	B	C	7.2	0.8	53.2
1700 m					

Abbreviate: C: Clay, Si: Silty, SiC: Silty clayey Cl: Clayey

Table 1: Physical and chemical properties of the red mediterranean soils

In addition to this, the clay content of the B horizon is more than horizon A due to illuviation process. The amount of the rounded silt particles in horizon A is generally more than in horizon B. This may be responsible for the eolian accumulation. Indeed, during the last glacial period under the dry and cold climate, eolian materials coming from the Arabian-Syrian and Sahara deserts accumulated on the soils. These soil samples are found in the eastern part of the Bornova Plain and the eastern part of Karaburun peninsula, in the western part of Turkey (Atalay, 1992).

Under the humid mediterranean climate, $CaCO_3$ is completely leached out from the solum of the mature mediterranean soils. But the formation of secondary carbonates may be found in the downslope areas.

The reaction of these soils found in karstic areas changes from slightly acid to alkaline (pH 6.1 to 7.7), and it has generally neutral reaction. But under the same climatic regime the soils which have been developed on the marl have an alkaline reaction.

The CEC of the karstic soils varies between 25 and 40 me/100 g, supporting that they contain a substaintial amount of smectites. These values are less than in the soils developed on the peridotite and gneiss and quartzite which seem to have more smectite in them (Atalay et al. 1990).

4. ECOLOGICAL PROPERTIES OF KARSTIC LANDS

Although the surfaces of the karstic lands are of stony and rocky appearance, in general all plants grow on the karstic land. Besides, some plant communities grow very well and some relic communities are found in the karst. As mentioned before, the runoff does not occur on the cracked limestone in the slope areas due the fact that its infiltration capacity is very high. Most atmospheric water is absorbed by the soils which are found in the pockets, cracks and bedding surfaces. Meanwhile capilllary action does not occur due to the crack structure. The reflection of the sun's radiation is higher than with some materials such as basalt, gneiss and andesite. These pecularities produce a somewhat more humid habitat than that of the other parent materials. Indeed, the roots of plants easily develop and penetrate along the cracks. In other words, karstic lands produce a suitable habitat for plants that have deep root systems. It can be said that karstic lands form a suitable habitat for some trees and shrubs such as *Quercus coccifera, Pistacia lentiscus, Ceratonia siliqua, Arbutus andrachne* having vertical extension of the root system. For this reason, the plants with deep root grow easily in karstic terrains because of the fact that there is mostly sufficient water for the plants from the soils found in cracks and pockets.

Stony and/or rocky karstic lands prevent the growth of the herb vegetation due to the fact that adequate water is very low in the surface. In other words, the plants with finely dense lateral root systems quickly develop but dry up in the short time because the water holding capacity of the surface is very low. For that reason the herb vegetation density of the karstic lands is generally very low in the Taurus Mountains. But the seeds of conifer trees come rapidly to generate on the bare surfaces due to the fact that this surfaces gets the required radiation for the seeds to germinate. The seeds germinate on the soils which are found in the crack or pockets, providing adequate water. Indeed, cedar *(Cedrus libani)* seeds easily germinate on karstic lands, especially protected from grazing. Thus the karstic lands, in the Taurus Mountains are extensively covered by cedar plants because cedar roots easily penetrate and develop along the cracks. The root lenght is measured to be 80-90 cm in one year old cedar plants.

Karstic depressions and canyon valleys present a special habitat for the growth of some hydrophytic vegetation and provide a refuge or shelter areas for relic species. According to our observation, dolines which are found in the oro-mediterranean belt are the main refuge areas of the relic species belonging to Euro-Siberian elements. For example, *Tilia rubra* (basswood), *Fagus orientalis* (beech), *Sorbus torminalis, Euonymus latifolius, Buxus sempervirens* are found in the doline areas, because these plants obtain adequate water

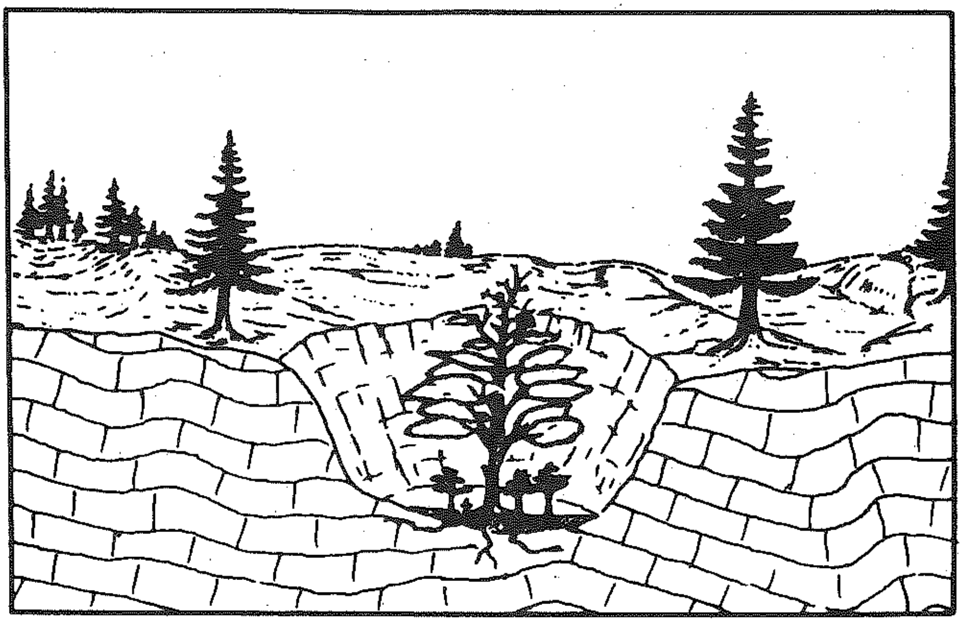

Fig. 6. Dolines provide a favourable habitat for the growth of hygrophytic and endemic plants. In this figure, Quercus vulcanica, an endemic oak species, grows only within doline, Davras Mountain, western part of Taurus.

from the deep soils found in the bottom of the dolines. In addition to this, doline walls protect them against the cold and severe winds. The best example may be given as *Quercus vulcanica,* being both endemic and relic oaks. This oak only grows in the doline areas in the Davras Mountains, W of Lake Egirdir (Fig. 6).

On the other hand, *Celtis australis* stands only occur in the deeply opened valley. One can come across *Celtis australis* clusters in the karstic depressions NW of Maraş province, E of Taurus. Canyon valleys are also rich in terms of hydrophytic vegetation. Such vegetation appears in the canyon valleys extending in the Taurus Mountain. For example *Taxus baccata, Cornus mas, Corylus avellana* belonging to Euro-Siberian or Black Sea phytogeographical region are found in the Cehennem valley in the Taşeli plateau in middle Taurus. At the same time, small karstic depressions can be termed as a treasure of distinct plants. These areas protect the plants against the destruction activities of human beings and cold and severe winds. That is why, special vegetation including relic and endemic plants grow in such areas. For example, the memorial trees which are composed of *Cornus colurna, Buxus sempervirens, Acer,* and *Tilia* are found in the karstic areas of the Black Sea region. These trees also indicate the natural paleoenvironmetal conditions.

One of the most important aspects of the karstic areas is to maintain the growth of climax and subclimax vegetation. Because even if maquis vegetation is completely destroyed, its roots remain in cracks and again the natural reproduction occurs via stool shoot. Indeed, since climax trees and shrubs growing on the soft soil and other parent material are destroyed they are replaced by different ones. But in the karstic lands, destroyed vegetation may again regain the natural habitat.

The negative effects of the karstic lands in terms of vegetation is to convert into bare rocky habitats after the natural vegetation has been completely destroyed. Once vegetation cover has been completely removed in karstic land, the stony and rocky surfaces emerge. In these areas reforestation activities are very hard or sometime impossible because of the fact that natural equilibrium is destroyed and it is very hard to find a suitable soil for the plants.

5. CONCLUSIONS

Soils are not found on the steep slopes of karstic lands, except along the cracks and bedding surfaces or between the layers.

Soil has been developed along thin cracks and between the layers. Thin cracks and bedding surfaces are favourable places for holding water. So weathering or soil forming processes take place where there is water. Clay illuviation and the transportation of the soil particles in a vertical direction only occur as a result of the widening of the lapiés. With the progres of karstification, vertical material transport occurs through the enlargement of cracks. Thus, in the karstic areas which are deeply dissected by the lapiés soil is not found on the surfaces but in the deeper sections.

Clay is the main impurity within the limestone and this is the reason why the soils in the karstic lands often are clay or of clayey texture. The cracks in the limestone provides a favourable conditions for oxidation so that Fe becomes oxidized and soils attain reddish colour, and at the same time roots of trees easily penetrate into the deeper part of the area through the cracks.

Rich and thick soils are common in places where thin bedded stratigraphic sequence are present. Because pure limestones contain many more cracks than the clayey limestones, soil forming process in karstic lands takes a long time and the depth of the soils is mostly thin.

Soil erosion activities generally do not occur on the surfaces of karstic lands because runoff is very low due to high infiltration capacity. In these areas chemical erosion is dominant.

Karstic areas provide a suitable habitat for the growth of some distinct shrubs and trees. Karstic canyon valleys and small depressions such as doline are the main refuge areas for some relic and endemic species. That is why karstic land is generally rich in terms of relic and endemic species showing past climatic conditions.

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REFERENCES

ATALAY, I. (1973): Karstification and soil formation in the Taurus mountains: Turkish, summmary in English). Bulettin of Geomorphology , 5: 135-143.

ATALAY, I. (1987): The ecological conditions of the natural occurrence areas of cedar (Cedrus libani A. Rich.) and regioning of seed transfer of cedar in Turkey: General Dir. of Forest Pub Nu.: 661/63, Ankara, 167 p.

ATALAY, I. (1987) : Introduction to Geomorphology of Turkey (in Turkish). Ege University, Faculty of Letters Pub. Nu: 9, 454 p, İzmir.

ATALAY, I. (1988): Karstification and the ecology of the karstic land in the Taurus mountains (Summary in english), Bulettin of Geomorphology, 16: 1-8.

ATALAY, I. (1989): Soil formation of the karstic lands of the Taurus Mountain (in Turkish). Papers of 10th of Soil Scientific Meeting, Soil Science Union, Pub Nu: 5, 18.1-13.

ATALAY, I. (1989): Soil Geography (in Turkish). Ege Univ. Faculty of Letters Pub. Nu: 8, 450 p., İzmir.

ATALAY, I. (1991): Soil formation in the karstic land in Turkey. Proceedings of the International First Regional Conference of Geomorphology, Special Issue, 19, Bulettin of Geomorphology, 19: 139-144.

ATALAY, I. (1992): The ecology of beech (Fagus orientalis Lipsky) forests and their regioning in terms of seed transfers. Pub. of the Directory of Forest Trees and Seeds Improvement, Nu. 5, 209p., Ankara.

ATALAY, I. (1993): Red Mediterranean soils in the karstic land of Turkey: 2nd International symposium on the Red Mediterranean Soils, May, 1993, Adana, Turkey.

ATALAY, I. (1994): Vegetation geography of Turkey,Ege Univ Press, ISBN: 975 95527 8 7, Izmir, 352 p.

GERRARD, A. S. (1981): Soils and Lardforms. George Allen and Unwin. ISBN 0045510492, 219 p.

JENNINGS, J. N. (1985) : Karst geomorphology. Basil Blackwell Ltd, ISBN: 0-631- 14032-8, 293 p.

SARI, M., DINÇ, U., SENOL, S., and KAPUR, S. (1986): Karstik topraklarin oluşu, önemli fiziksel, kimyasal ve mineralojik özellikleri ile siniflandirilmisi, The formation of karstic soils and their main physical, chemical and mineralogic properties and classification (in Turkish), Papers of 9th of Scientific Meeting, Turkish Soil Science Union Pub. Nu:4, 6.1-6.9, Ankara.

PEDOGENEZA IN EKOLOGIJA KRASA V TURČIJI

Povzetek

Z vidika pedogeneze in ekologije je kraški svet jugozahodne in zahodne Turčije posebno pomemben. Za to študijo so bile izbrane različne lokacije. Ker prsti nastajajo v kamninskih sistemih, so upoštevane tudi fizikalne in kemijske lastnosti apnencev.

Splošno pravilo je, da se na strmih kraških pobočjih prsti ne morejo ohraniti, pač pa so v razpokah in plastnih razpokah na krasu, tako na mediteranskem kot tudi na egejskem področju. Ko voda prenika v razpoke in dalje v sedimentne plasti, se prično procesi lokalnega razpadanja. Rezultat tega je nastajanje prsti in situ, vzdolž razpok ter plasti, in ni nujno vezano na transport delcev prsti iz višjih leg.

Fizikalne in kemijske lastnosti apnencev so tudi pomemben dejavnik, ki vpliva na lastnosti prsti. Prsti na masivnih in manj razpokanih apnencih so običajno plitve in kamnite, medtem ko so na gosto prepokanem apnencu, še posebej, če so vmes laporne in peščeno-meljaste plasti, bolj globoke.

Delci prsti potujejo proti globljim delom apnenca kot posledica večanja škrapelj, ki običajno nastajajo vzdolž razpok. Na takih področjih poteka transport delcev prsti v navpični smeri.

Procesi oksidacije oziroma barvanje prsti v rdeče potekajo na apnencih veliko hitreje, kot na drugih matičnih kamninah, saj prepokana struktura apnencev omogoča dobro kroženje vode in zraka. Prisotnost pirita v apnencih lahko ta proces močno pospeši. Večina rdečih prsti na krasu se je morda razvila tekom teciarja ter v vročih in vlažnih obdobjih kvartarja. Debele plasti prsti na apnencih jasno odsevajo paleoklimatske značilnosti. Za nastajanje prsti in razvoj koreninskega sistema so v gostih gozdnih združbah v Taurusu zelo dobri pogoji.