MICROMORPHOLOGICAL STUDY OF INITIAL CLAY ILLUVIATION AND FORMATION OF A RED MEDITERRANEAN SOIL

by

A. R. MERMUT (1)

INTRODUCTION

During the formation of soils, especially from hard rocks, it is still interesting to see the morphological changes step by step as to how parent rocks, at last, become-mature soils. Micromorphological methods are the onliest tool of soil science to see directly what happens when a hard rock transforms to a soil. If a hard rock, that has, just started to weather is observed under the petrographic microscope, micro-crakc systems are found. It seems that the formation of microcracks is the first step of weathering of rocks. If a rock formed mainly from a single mineral , cleavage characteristic of that particular mineral must take an important role, when the micro crack, patterns are forming. There are publications (like Bisdom, 1.967), which given the role of micro crack systems during the rock weathering. Transformation of minerals starts from the crack surfaces. Mermut (1.973), has already observed number of thin sections showing the initial stages of soil formation. Complex chemical reactions occur which are controlled partly by climate and partly by chemical make up of the rock. When the new materials are formed on the rock surfaces they are released and moved downward as they come in touch with water.

There are number of studies which have yielded in -

(1) University of Ankara, soils Department, Faculty of Agriculture, Diskapl/Ankara (TURKEY)

formation on the sequence and the magnitude of eluviation and illuviation processes (Among others; McKeagne and Arnaud 1.969, Brewer 1.968, Buol and Hole 1.961, Manishina, 1.958). Initial stage of soil formation has not yet much been the subject of intense micromorphological studies. Such a study needs to have hard parent rocks and in situ formed soil.

Red Mediterranean soils, generally, are formed on the crystalline carbonatic rocks, like limestones and dolomites, especially of Mesozoic eras. Red Mediterranean soils are extensively found in the west and southwest of Turkey. It is the purpose of this study to examine a regolith starting from the hard crystalline rocks to the surface soil horizons enriched with organic matter. Within the period of human life no one can be able to see the changes in rock weathering however it is thought that in regolith one can see all the phases of the soil formation.

MATERIAL AND METHODS .

A Red Mediterranean soil profile, taken from the south of Marmara region (Turkey), about 200 m above the sea lavel, formed on crystalline dolomitic limestone which had been described and analysed by Hizalan et al., (1.975) was used. The soil was very thin due to erosion, whereas the parent material (C horizon) was thick enough to study (1-2 m).

The area in which the studied soil is situated is characterised by the following climatic data : Nean annual temperature 15ºC, mean annual rainfall about 700 mm, with a long dry period in the summer and rainy in the winter(Mediterranean type of climate).

Micromorphology of the soil is given below :

B 0-10 cms.

Skeleton grains generally are of the silt size and they are consisting of quartz, micas, feldispars and organic frag -

ments. Skew and craze planes, vughs and interconnected vughas and channels are the formas of the pores. Matrix is skel-vo-insepic and argillasepic. Neoferran, ferric nodules, papules, intercallary iron oxide crystals (silt sized), agrotubules, phytoliths, fecal pellets are the main pedological features.

C 10-200 cms.

Same skeleton grains as above. There are only vughs and interconnected vughs. Matrix generally shows crystic plasmic fabric. Few argillans, neoferrans and ferric nodules found, are the main pedological features.

INITIAL CLAY ILLUVIATION.

When the hard dolomitic limestones of the examined profile is observed with minute inclusions of other minerals, practically no porosity and cracks could have been observed in the thin section with normal microscope. Macromorphologically rocks has a milky color. The total amount of SiO_2, Al_2O_3, Fe_2O_3, Na_2O_3, K_2O and H_2O (above 105ºC) found about 9.76 % (table I), which shows the amount of minute inclusions in the crystalline rock. It is thought that the soil, in our case a Red Mediterranean soil, has been formed from these impurities, consisting of quartz, felds pars and micas.

Micromorphology of C horizon, having a thickness of about 2 m and very well preserved, was quite interesting to see. Vughs and interconnected vughs are found which had been formed due to leaching of carbonates. Total amount of SiO_2, Al_2O_3, Fe_2O_3, Na_2O, K_2O and H_2O (above 105ºC) was found around 59.33 %, which was 6 times more as compared with the parent rock.

Texture of soil is found to be light having about 52 % sand fraction, 14 % coarse particles bigger than 2 mm, in it. The skeleton grains consisting of calcites, sometimes as big as visible with necked eyes.

If a crack is observed, illuviated clays particles, sometimes with other coarser particles are seen on the wall of the cracks. The clay illuviation which takes place at the begining of weathering of lithified parent rocks is termed as "initial clay illuviation". When the carbonates are released and leached, cracks will be widened and illuviated material will get again free from to move to other places with the impurities left after leaching (fig. 1 and 2).

If the latter process works continuously, illuviated material will be disrupted, enrichment of soil materials takes place and Red Mediterranean soil forms from this dynamic material. When the original rock structure is changed to the extend of about 50 % the resulting material may be designated as soil.

FORMATION OF RED MEDITERRANEAN SOIL .

In the C horizon, ferriargillans were found on the surface of the vughs and interconnected vughs (fig. 3 and 4). This is a further step of secondary or tertiary illuviation, but still may be considered as initial clay illuviation. The chemistry of this process would require a discussion of rock chemistry, a subject which is beyond the scope of this work.

However considering the electrostatic charges and attraction froces between the dolomite or calcite and clay sized particles, is expected that particles in the suspension will not have much possibility to move downward to a long distance and they will be adsorbed. The illuviated clay sized materials have reddish brown color, because of free iron in them. These materials are also visible in the matrix forming bridges between the crystalline materials. Considerable amount of free iron oxides found in the C horizon (table I), is also showing that these illuviated materials are containing iron compounds in them. C horizon has a yellow, yellowish red color macromorphologica

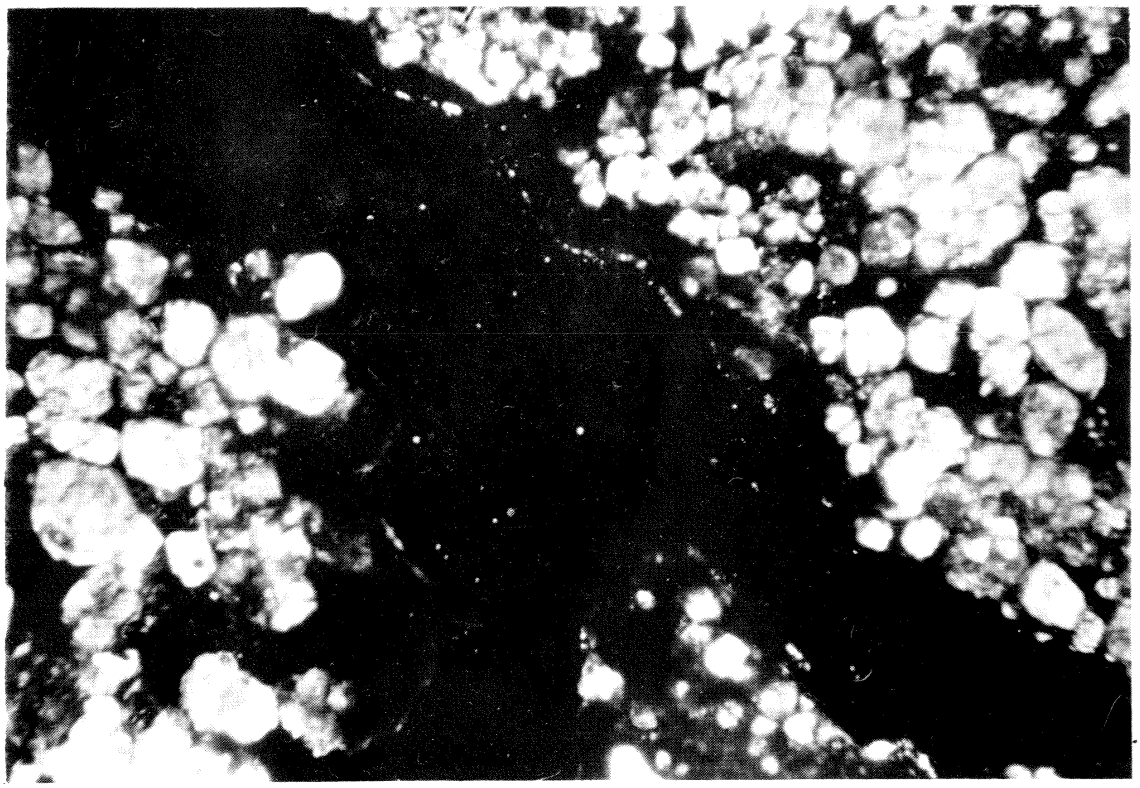

Fig. 1 - Photomicrographs of initial clay illuviation seen on the calcite crystals C horizon, magnification 350 x, polarized light.

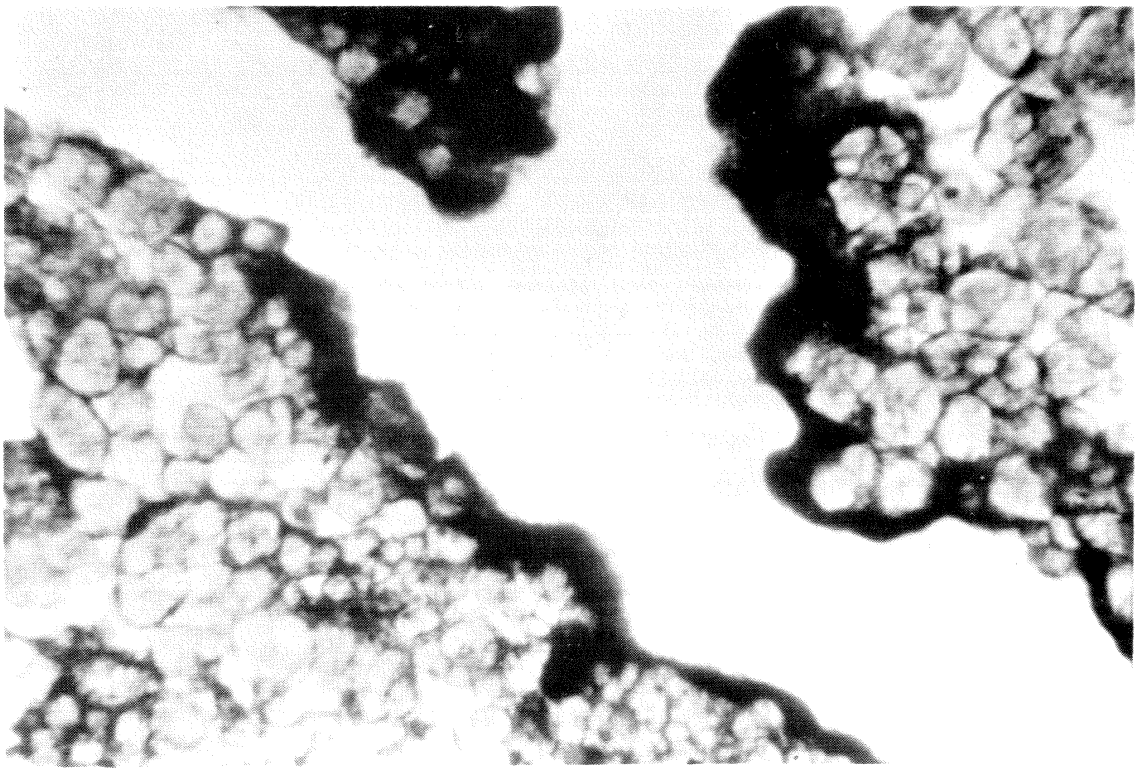

Fig. 2 - Same as fig 1, with plain light.

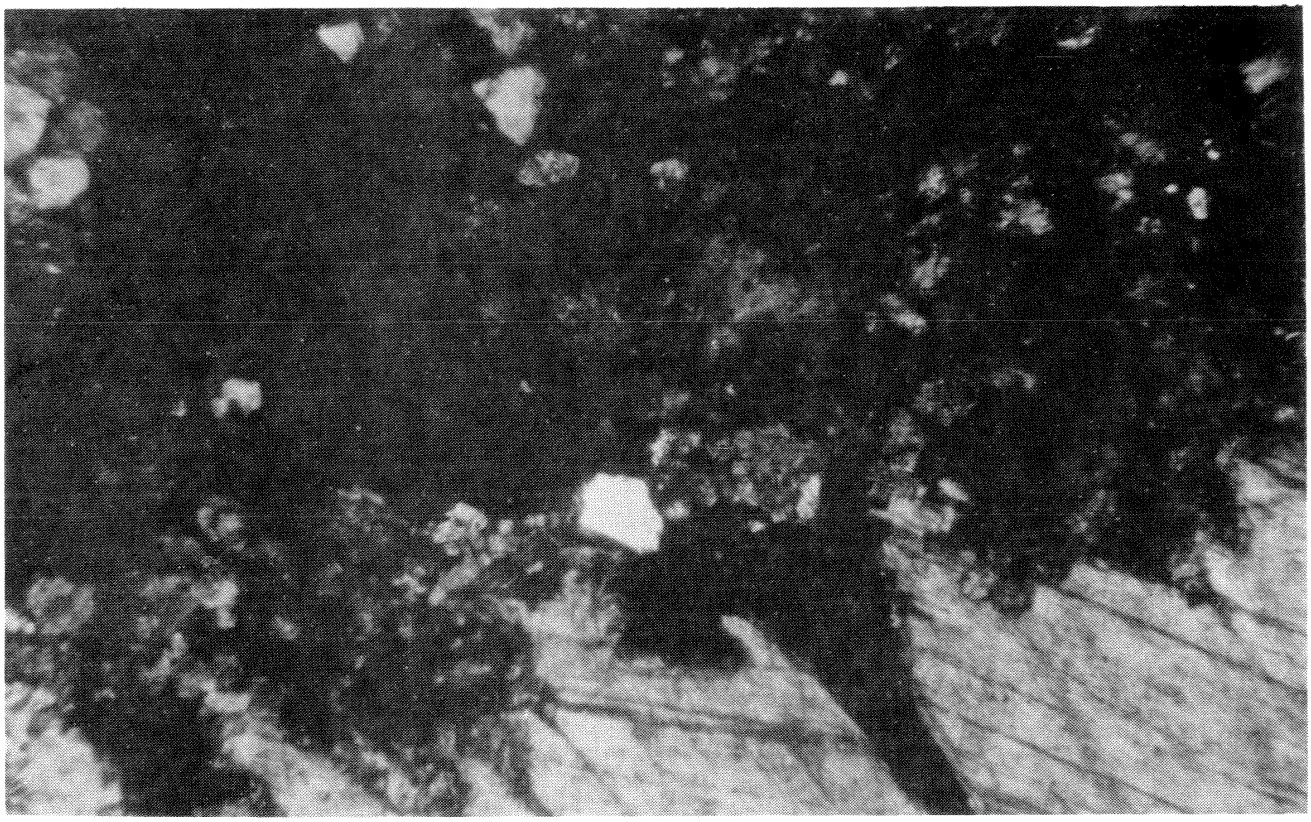

Fig. 3- Formation of soil matrix of Red Mediterranean soil. Note the original rock and soil metarial on it. Magnification 250 x, polarized light.

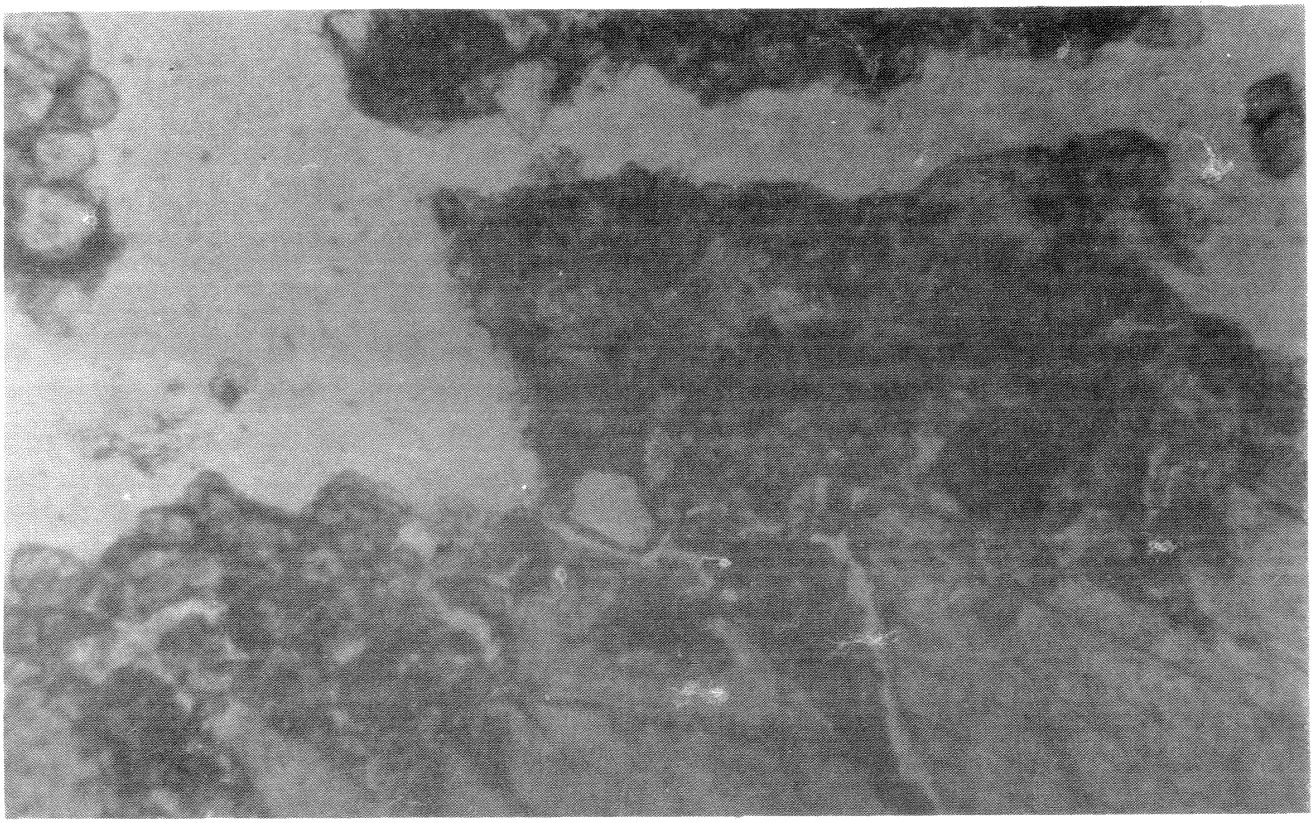

Fig. 4- Some as fig 3, with plain light.

lly. This is also an indication of enrichment of iron oxides and hydroxides in the C horizon. As matter of fact they are very important for the staining of the soil. Ferriargillans, which seem highly rich in iron oxides and hydroxides, are very thick, also attract attention. Chemical composition of these argillans could have been analysed by means of "x-ray microprobe analyser" which author could not have had in his hand.

Plasma of the C horizon still has crystic fabric in general, whereas the chemical composition shows the appearence of a soil. Micromorphologically the original rock structure has disappeared. However there are quite number of original pieces when observed under microscope. If the decalcification process works continuously, repeated illuviation processes are also continuing. Carbonates are leached out and the remaining materials enriching with the soil like material. Real soil forms after the end point of decalcification. Illuviation process must be still active in this stage, till the swelling and shrinking process becomes dominant.

B horizon has the typical color of Red medditerranean soil. This is because of the enrichment of iron oxides which was 82 times as compared with hard crystalline rock. SiO_2 increased 9 times, whereas Al_2O_3 increased about 6.5 times. Even Na_2O and especially K_2O also increased very much. Here it seems that K was used for the formation of illitic clay minerals. Instead of argillans much papules were found in the matrix of the B horizon. This shows the activity of swelling and shrinking process caused by succesive drying and wetting which is quite normal for this soil in the area studied. Skel-vo-insepic plasmic fabric and papules also whow the activity of swelling and shrinking.

Table 1. Some characteristics of the examined soil

Horizon	Depth cm	Organic matter %	Free Fe_2O_3 %	Particles >2 mm	Clay %	Silt %	Sand %	pH 1/2,5 water
B	0- 10	3.92	4.10	0.5	38.2	43.0	8.8	7.1
C	10-200	-	2.78	13.9	30.0	17.8	52.2	7.7
R	200 +	-	-	-	-	-	-	-

Horizon	Depth cm	SiO_2 %	Al_2O_3 %	Fe_2O_3 %	CaO %	MgO %	Na_2O %	K_2O %	CO_2 %	H_2O (above 105°C)
B	0- 10	59.61	12.50	8.22	1.65	1.67	0.63	2.17	nil	7.46
C	10-200	41.50	8.80	3.88	20.68	2.49	0.20	0.63	16.19	4.52
R	200 +	6.70	1.90	0.09	32.29	15.09	0.19	0.10	41.70	0.78

SUMMARY

The illuviation of clay sized inorganic materials, which takes place during the first stage of weathering of hard parent rocks is tentatively called "initial Clay Illuviation". It was found that during the progressive weathering of hard rocks, illuviated materials again get free to move to other places with the materials left from previous weathering.

A red mediterranean soil, formed on crystalline dolomitic rock, having a very thick (2m) C and a thin (10 m) B horizon was studied micromorphologically. Ferriargillans, found on top of pure calcite, show the evidence of the formation of Red Mediterranean soil from the materials which are present as impurities in hard crystalline dolomitic rock. An explanation is given as to how this process is undergoing during the formation of Red Mediterranean Soil.

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