MICROMORPHOLOGICAL INVESTIGATIONS OF RELIC SOILS OF THE CORDILLERA CENTRAL (SPAIN)

by

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INTRODUCTION

This paper is based on studies of the soils of the Cordillera Central made during the last decade (RIEDEL, 1971, 1973). Granitic and gneissic rocks besides meta - morphic schists are the parent materials of the soils. There is no influence of calcareous rocks. From the first it has been the intention to look particularly for such si tes where the soils developed in situ meaning directly from outcropping rocks. Such sites predominantly are situated in higher areas.

In so far these investigations are in contrast to studies of several other authors concentrating their in- vestigations within lower areas to soils developed pre - ferably from sediments containing appreciable amounts of dislocated products of rock weathering and soil formation from higher parts of the landscape.

The most conspicious marks of the soil cover in the there investigated area are high degree and high depth or rock weathering, intense soil colours as well as distinct accumulations of free iron and aluminium oxides. These phenomena are well known predominantly from tropical re gions. It may be noted already here that the present clima tic conditions in Central Spain seem to be unsufficient for such formations. In any case, important soil features are indicating the paleogenic character of the soils.

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In the following it will be attempted to present important micromorphological features of products of weathering and soil formation within the higher areas of the Cordillera between 500 and 1600 m a. sl. The various micromorphological features are presented in 5 groups.

The knowledge of these characteristics could serve for some better understanding of soils developed within sediments of lower positions which have been decisivly influenced by eroded materials from higher areas.

More rencent studies in various parts of Spain and Portugal as well as in Greece seem to confirm that the presented characteristics are of high significance of tropical paleoclimatic influences on the soil cover of the mediterranean region.

1. - Ferralitic/kaolinitic yellow-coloured saprolites of high depth

Saprolites have been found in neraly all parts of the Cordillera, especially developed from granitic rocks. They are found at all levels of recent climate and vegetation. They are completely absent only in such high locations as above 1800 m. a. sl. beeing removed there in glacial periods.

The saprolitic material often has been dislocated totally or partially by processes of denudation and erosion. In the first case granite cores and domed inselbergs remained as a witness of tropical climates. Granite cores have been found e. g. in the vallley of the Rio Jerte in 600 m. a. sl.

The depth of the relic kaolinitic saprolites -mostly more or less decapitated - is varying. The depth reaches not seldom more than 20 meters. (In the geographical literature e. g. LAUTENSACH even higher figures are given). Within the saprolites granitic blocks and spheroidic boulders are developed characteristically e. g. 10 km from La Alberca/province of Salamanca/Sierra de Francia in 1160 m a. sl. Very similar formations in Galicia //NW - Spain have been investigated mineralogically and micromorphologically very detailed by BISDOM (1967).

According to several authors, 1 meter of granitic rock needs under the humid tropical conditions for kaolinitic weathering a time span of about 20.000 to 50.000 years. If one considers only the lowest figure, the deep saprolites of the Cordillera needed half a million of years or more for their formation. Hence, there should be no doubt that the time span of the quartary has been unsufficient for the development of such deeply and intensively weathered materials.

2. Homogenized products of saprolites, non-rubefied

They are especially found at locations of medium heigth in the Central Sierra de Gredos but also in other parts of the Cordillera. Near La Alberca/ province of Salamanca/Sierra de Francia in 1.200 m a. sl. the granitic saprolite contains - in contrast to the formerly demonstrated example - no boulders of unweathered rock. In the lower parts of the profile the material is only partly homogenized by pedoturbation. But in the upper parts which are more heavely weathered the material is intensively homogenized.

Above El Arenal /province of Avila/Sierra de Gredos in 1.600 m a. sl. a recent mountain-ranker is developed on homogenized material of kaolinitic saprolite from granite.

In thin sections one often observes compounds with pyrosilicates weathering to colloidal kaolinites which absorbed yellow-coloured, amorphous ferric hydroxides from iron-containing silicates as e.g. near Cuacos de Yuste/province of Caceres/Sierra de Gredos in 600 m a. sl. The relic rock structure is only partly preserved.

The clay illuviation gives some impression of the mechanical instability of kaolinitic saprolites of high weathering degree. Hence, this material shows a transition stage between the here demonstrated group 1 and 2.

3. Homogenized products of saprolites, rubefied.

They are found especially below 700 m a. sl. in the southern Sierra de Gata and Sierra de Gredos. Also till up to 1.500 m a. sl. they are found, but only seldom, in central valleys and at the northern side of the Cordillera which probably had been uplifted after rubefication of the soil material.

Near El Arenal/province of Avila/Sierra de Gredos in 700 m a. sl. a typical soil profile on schist is developed from heavely homogenized saprolitic material which became rubefied. In the lower parts being more yellowish coloured the relic rock structure is still partly preserved. The microstructure in a depth of 50 cm is characterized by strong weathering feldspars and less weathered micas within a reddish matrix besides a strong red clay illuviation.

A material of some higher degree of rubefication can be seen from another soil near El Arenal in 800 m a. sl.

At the end of this group number 3 the micromorphological aspects of a typical ferrallitic red soil material from W-Africa is presented, which may show the relationships to the rubefied materials from the Cordillera Central.

It is well known that rubefied materials in thin sections are reddish or red coloured under normal as under incident light. They usually show even at high magnification no distinct red particles, meaning the red phase as such is optically not disintegratable using the light microscope.

The so-called rubefication is a process of the in situ transformation of yellow-coloured amorphous ferric hydroxides into red-coloured oxides which are amorphous or crystalline. Rubefication occurs preferably - as is commonly assumed -under conditions of properly inner and outer drainage as well as under a pedoclimate of mar ked alternation of the humidity and pronounced dry sea sons. It proceeds downwards within the soil profile (see synopsis of rubefication in: SCHMIDT-LORENZ, 1971, p. 59-61).

4. Plinthitized saprolites and their derivates:

At several localitites of the cordillera central wea therin products are showing without doubt characteristic signs of plinthitization. E. g. the strong red coloured saprolite from granitic rock in the vicinity of Jarandilla in the province of Caceres/Sierra de Gredos in 600 m a. s. l. seems to be -on the base of the macroscopical as pects only- a product of rubefication as defined before hand. But as a matter of fact this is a plinthitized sapro lite.

Plinthitization (alias lateritization) recently has been defined as a special case of secondary ferrallitiza tion meaning ferrallitization of specific weathering products resulting in a relative oxide accumulation (. R. SCHMIDT-LORENZ, 1974, 1975). Hematite is the charac teristic iron mineral of plinthites. Hematite exists as spherical micro-aggregates of clay size or of fine silt si ze.

Hematite originated from the direct in-situ trans - formation of yellow coloured, amorphous ferric hydroxi de (syn. ferrihydrite) withn a matrix of kaolinitic clay minerals which had absorbed the hydroxide. Absorbing became ineffective when desilication of clay minerals and export of dissolved silicic acid started. At this time they yellow iron hydroxide had been transformed to hematite. If the destruction of the kaolinitic clay minerals continued the hematitic microaggregates coalesced into a more or less dense mass due to the disappearence of the kaolinitic substance between the hematitic particles. Dense hematitic masses needed for their formation besides silica export also an export of alumina from the dissolution of the clay minerals. This process is based on congruent kaolinitic dissolution which will occur at silica concentrations in the solution higher than about 1 ppm SiO_2.

In the course of plinthitization also gibbsite may appear if the kaolinite dissolution is incongruent. This happens only at very low concentrations of silicic acid in the solution and at a pH above 4,2. (See the next to the last example of group 5: gibbsite formation in a plinthitic cuirasse).

In every case yellow coloured kaolinite-ferric hydroxide complex has been the parent material in which plinyhitization started. This complex originated from saprolitizing of more or less acid rocks. The transformation of the yellowish material by plinthitization took place within such saprolites or within their homogeneized derivates. (1)

The micromorphology of the above mentioned plinthitized saprolite from Jarandilla demonstrates the contrast to rubefied materials quite well. Plinthitic saprolites -as well as their homogenized derivates - look in thin sections using normal light not red as rubefied mate

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(1) During the working meeting a poster with 140 colour micrographs and scanning photos besides a diagram demonstrating this concept of plinthitization is exhibited by the second author.

rials but non-transparent, dark grey or strong brown coloured within the plinthitized fabric compounds. (Plate I) This non-transparency under normal light is caused by hematitic micro-aggregates. Under incident light the plinthitic fabric elements look in thin sections deep red (Plate 2) similarly to rubefied materials.

The next example stems from Pinefranqueado/province of Caceres /Sierra de Gata in ca. 600 m a. sl.. In the lower part of the profile one may recognize the relic rock structure of the reddened saprolite which again is not rubefied in the traditional sense but plinthitized. In the upper part the saprolite is homogenized. The micromorphology of such solum shows particularly at lower magnifications the characteristic distinctness to rubefied soil materials. The dark brown colour under normal light might give the impression that fine organic particles have been intermixed. But this has to be rejected as the strong red colour is indicating incident light.

If soil material, which is brownish-yellow coloured through amorphous ferric hydroxide, increases in proportion e. g. by illuvation of clay from upper profile parts the /mixed material is increasing red in thin sections under normal light too. But at thigh magnifications the origin of the reddening particles from the plinthitized saprolite may be proved quite easily. (As new term for this process of reddening the term "Plinthrhodofication" has been recommended; R. SCHMIDT - LORENZ, 1977).

It is remarkable that unhardened plinthitic materials developed within quartziferous kaolinitic beds had been found in the humid parts of Spain, i. e. at Pechon near Santander in Northern Spain near see level. Here the plinthitic material is developed below a typical humus podzol. The purplish shining of the plinthitic substance is the most striking single criterion for macroscopical distinction form rubefied materials. Also under incident light in thin sections this colour not seldom is recognizable. Under normal light the hematitic masses are non-transparent.

5. Plinthitic Cuirasses.

Near El Negredo in the province of Segovia/Sierra de Ayllon in an altitude of 1100 m. a. sl. a very hard plinthitic cuirasse of more than 4 meters thickness exists above a deep bed of bauxitic materials, the last being developed from kaolinitic clays. The plinthithic cuirass is to a large extent of allochthonous nature. This is demonstrated by the help of a polished hand specimen under incident light at different angles: more or less rounded pieces of plinthitized material with relic schist structure verify the conglomeratic nature and the allochthonous origin. The reflecting parts consist of goethitic cortices from imported solutions containing iron which incrusted the plinthitized pieces jointly. Under the polarizing microscope the most important characteristics of plinthites are observable in this material from El Negredo: a) hematitic micro-aggregates within schist beeing moderately weathered regarding the relatively high proportion of only less weathered micas besides kaolinites; (Plate 3, normal light ; b) the macroscopically pinkish coloured parts of the plinthitic material consist of hematitic macro-aggregates within a gibbsitic matrix which had been formed in situ by destruction of fine-sized kaolinitic clay; large kaolinitic booklets had been preserved (Plate 4, crossed nicols); c) the darkest parts of the formerly demonstrated handspecimen exist of high concentrations of hematitic micro-aggregates also the mentioned goethitic cortex around the plinthitized pieces is conspicous.

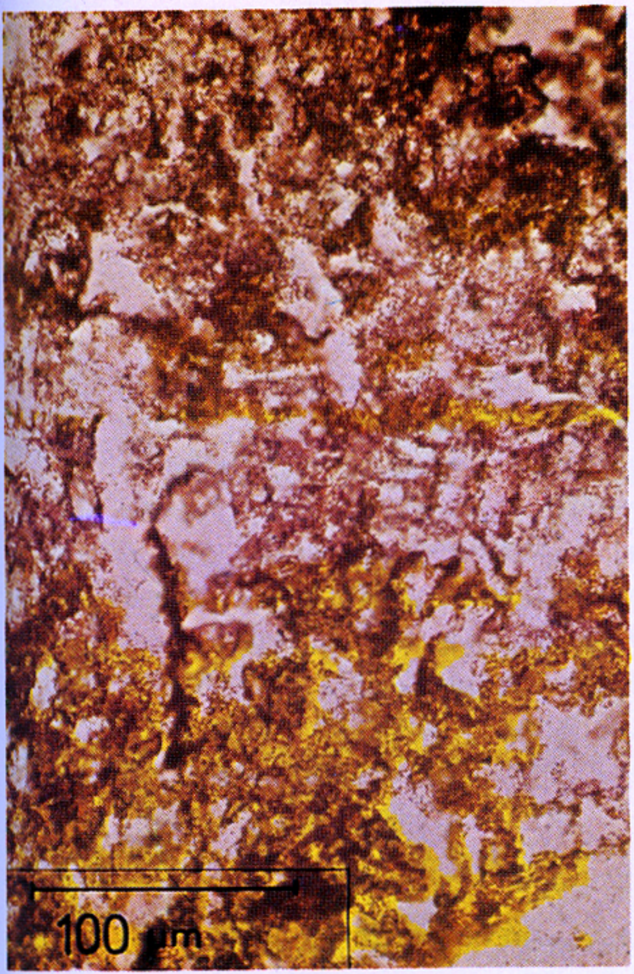

Plate 1

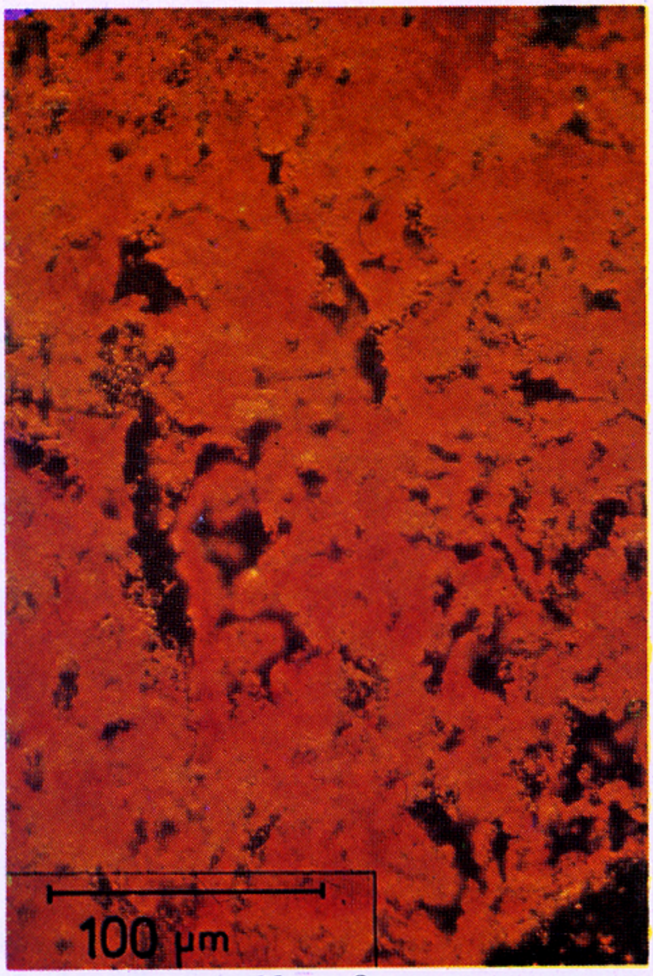

Plate 2

Plate 3

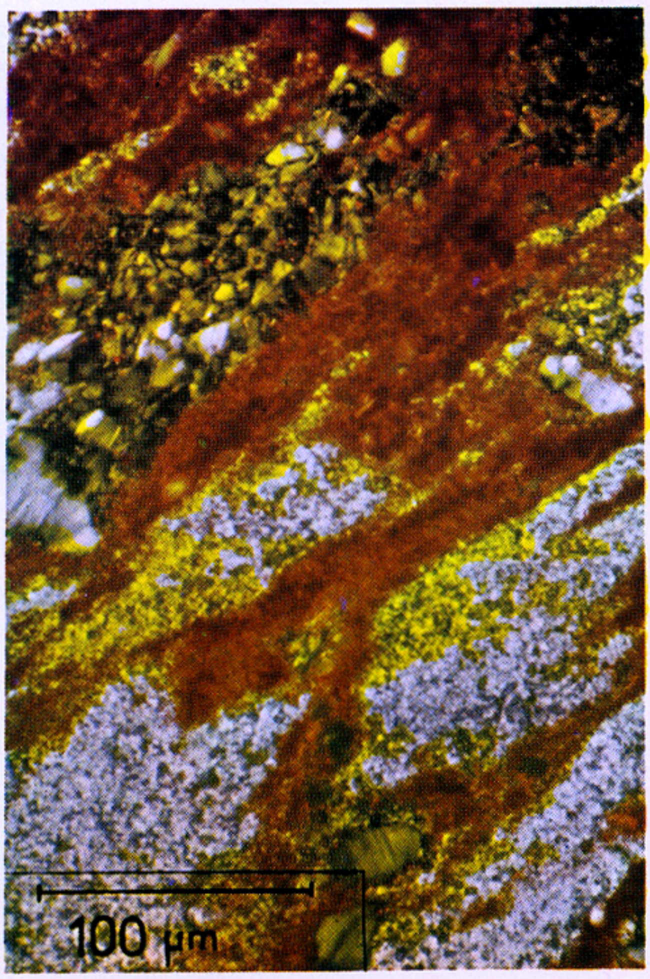

Plate 4

SUMMARY .-

The paper deals with important minero-micromorphological features of selected weathering and soil materials developed mainly directly from outcropping granitic and metamorphic rocks within the higher located areas of the cordillera between 500 and 1600 m a. s. l. The materials indicating marked influences of tropical paleoclimates are presented in the following order: kaolinitic yellowish coloured saprolites of high depth, homogenized products of saprolites (non-rubefied and rubefied), plinthitized saprolites and their derivates, plinthitic cuirasses.

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