MORPHOLOGY OF SOME SOILS IN THE ÇUMRA
AREA (TURKEY), IN PARTICULAR THE MICRO-
MORPHOLOGY OF THE CARBONATE FRACTION OF
AN USTOLLCAMBORID, A THAPTO
CALCIORTHIDIC USTOLLCAMBORID, AND
A TYPIC UDORTHENT.

W.P. LOCHER 1969
MORPHOLOGY OF SOME SOILS IN THE ÇUMRA AREA (TURKEY),
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FRACTION OF AN USTOLLC CAMBORTHID, A THAPTO CALCIORTHIDIC
USTOLLC CAMBORTHID, AND A TYPIC UDORTHENT.

Report by W.P. LOCHER

of field and laboratory investigations carried out in the
framework of the post-graduate study in Tropical Soil Science.

1969

Laboratory of Regional Soil Science, Wageningen, The Netherlands
Department of Tropical Soil Science
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SUMMARY

In the field (Turkey) at first the results of biological activity in some subsoils of soft lime in the Çumra Area were investigated. No connection could be determined between the occurrence of krotovinas and the flourishing of crops.

Secondly, the irrigated soils of the Alluvial May fan all appeared to show a homogenized upper layer. Probably a connection exists between landuse and rate of biological homogenization, but this could not be proved.

In the laboratory (Wageningen) micromorphological descriptions were made of two May fan profiles (an ustolic camborthid and a thapto calciorhidic ustolic camborthid) and one soft lime profile (a typic udorthent). The carbonate fraction of these profiles was studied in detail. Six forms of carbonate were distinguished: nodules; extremely fine crystalline "fields" (corresponding with soft lime-pockets in the field); crystallaria (corresponding with pseudomycelium in the field); calcitans (ditto); skeleton grains; and intercalary crystals. The genesis of these carbonate forms is treated. The micromorphological distinction between pedogenetic and geogenetic carbonate appeared to be difficult in some cases, which could be expected, because the precipitation of carbonate in the soil will follow the same chemical rules as in some limestones.

Finally several carbonate forms were counted in one profile. The difficulties and possibilities of counting on thin sections are evaluated.
1. INTRODUCTION

This report deals with the author's field and laboratory investigation, carried out in the framework of the post graduate study in Tropical Soil Science at the Agricultural University, Wageningen. The field work took place in Turkey in the summer of 1965, where I participated in the "Research and Training Project in the Great Konya Basin" of our department of Tropical Soil Science, guidance Ir. T. de Meester, supervisor Prof. Dr. ir. P. Buringh.

The laboratory investigation, carried out in November and December 1966, consisted of the study of thin sections of some profiles described in the field, and was guided by Ir. J. Bouma, Mr. Th. Pape, and Dr. S. Slager, of the department of micromorphology of the Laboratory of Regional Soil Science, Wageningen.

My investigation dealt initially with the influence of the soil (macro)fauna on some soils in the Çumra area). In short the instructions for the field work were as follows.

1. In 1964 some observations in profiles with a relatively thin loamy topsoil over a subsoil of soft lime), especially near Kaşinhani, seemed to indicate that there could be a positive correlation between the occurrence of many krotovinas in the subsoil and a good growth of the crops. My instruction was to test this hypothesis by profile and crop studies.

2. A second instruction was to investigate the influence of the land use (irrigated horticulture) on some of the May fan soils) by the study of profiles, by making soil peels and by collecting soil samples for thin sectioning. Especially the question whether these soils show a clear biological homogenization had to be studied.

) For the location of the Çumra area, and the explanation of the soil map units in this area, see DRIESSEN and DE MEESTER (1969).
At the laboratory in Wageningen it appeared to be better to change the subject of thin section analysis to a study of the morphology of the carbonate fraction in three of the sampled profiles.

From this report it will become clear that the results of my investigations were not quite satisfactory. Therefore, much attention will be paid to a critical evaluation of the question how one should go to work best in investigations like these. I preferred to spend some time to think this question over rather than to try to improve the work by extending the laboratory observations, considering that in the field already I did not design the investigation properly.
FIGURE 1 Location of the profiles W 54, 65-18 and 65-19.
The figure shows part of the soil map of the Çumra Area, compiled by DRIESEN and DE MEESTER (1969).
2. FIELDWORK

2.1 Krotovinas in subsoils of soft lime

At first an area south west of Kasinhani was investigated (cf. DRIESSEN and DE MEESTER 1969, pp. 42-46), where the soil series is Lo 2 = Kasinhani series, moderately well drained (L = land type of Lacustrine plain; Lo = association of Soft lime soils). Most of this series is used as a natural grazing area, but arable land also occurs, especially south of the beach ridge. The observations were concentrated on the arable land of a rather big farm (100 ha), named Rakimbeş Çiftiliği (location see fig. 1). On this farm a rather good crop of wheat and barley is cultivated in dry farming. I studied some profiles and had an interview with the farmer of Rakimbeş Çif. A field profile description and the results of salinity analyses of profile W 54, a typic udorthent, (location see fig. 1), are given in 2.3.

The profiles studied did not confirm the hypothesis that there could be a correlation between the occurrence of krotovinas') in the soft lime subsoil and the crop growth, simply because no krotovinas were observed in the soft lime subsoil. Few roots penetrate through the subsoil, so that the plants are nearly entirely dependent on the loamy top layer of the soil (which is very shallow to moderately deep, e.g. in W 54: 34 cm). Therefore, to solve the question whether a yield of cereals, rather good according to the standards of the Konya Basin, is harvested there, an interview was organised with the farmer (with the aid of Mr. A. Mermut as an interpreter).

') "Krotovinas are irregular tubular streaks within one horizon of material transported from another horizon. They are caused by the filling of tunnels made by burrowing animals in one horizon with material from outside the horizon." (SOIL SURVEY MANUAL, page 244).
The farmer told us (in 1965) that the farm had existed for fifteen years (after the drainage canals had been repaired). At first they suffered from much salt, but since a seven years the crops were good. In 1953 a (top?) soil sample was investigated in Ankara (Soil and Fertilizer Research Institute) with the following results: little potassium and very little phosphate and nitrogen; 18% "gravel" (>$2\text{ mm}$, probably hard carbonate concretions); 55% "lutum" (probably calculated from the saturation percentage); $\text{pH} = 7.5$; carbonate contents 65% (Scheibler).

In spite of the low N-, P- and K-contents they did not give fertilizers, but they did give stable-manure (5000 to 6000 kg. per ha). Because of the high water table (in summer at 80 cm depth) it may not be necessary to leave the land fallow every second year in order to spare water for the crop, but the farmer uses this dry farming system according to the habits in this area. Perhaps a result of this dry farming is the desalting of the topsoil in the fallow year, but on the other hand the growing of wheat on a small field in three successive years appeared to be successful. The farmer states that the salinity is not severe (this is confirmed by the analyses of W 54; see p. 10 ; apparently the groundwater is of a good quality). However, after growing sugar beets (10,000 to 15,000 kg per ha) he observed salinization. Then the salt was removed by sprinkling irrigation, and now he only grows wheat and barley. The yields are: 2,000 kg wheat per ha and 2,500 kg barley per ha. On the best soils he always grows wheat and on the less good ones barley (no rotation), wheat making the best price. He does not use special varieties, but buys current varieties in Konya or Ankara, or he uses his own sowing seed. He does not apply herbicides nor insecticides (which is not very necessary here according to him). The machinery consists of a tractor and a plow. Harvesting is done with a hired combine. The soil tillage consists of plowing and harrowing, and in the fallow year of rooting up to a depth of 7 cm with a cultivator. Conclusion. A tentative conclusion must be that a skilful farmer, though doing nothing special, (now) gets a good yield of cereals from these soils without (pumping) irrigation, because of the high groundwater table and the good quality of this water. Probably the soft lime subsoil provides water for the crop via capillary rise, as few roots can penetrate through the subsoil which has few or no krotovinas. May this be true,
more severe salinization is to be expected on the long run and then the farmer will have to irrigate in order to remove the salt from the top layer. A more decisive conclusion can only be drawn with the aid of experimental fields (exact data of yields on the soils of unit Lc-2) and more chemical soil analyses.

Secondly, a small area lying 5 km south west of Çumra was studied. This area is now mapped as Te 1.4 (T = landtype of Terraces; Te = association of Flat terrace soils; Te 1 = Beylerce series, 1010 m - level; Te 1.4 = Beylerce loamy soil, deep), but at the time of my fieldwork it was thought to be "Ürûnlû marl", a soil series now called "Ürûnlû series" (Lc 1; Lc = association of soft lime soils). Surely this area does not belong to the Ürûnlû series, and the present name may be correct. However, from the agricultural point of view there is, in my opinion, little difference between the profiles I described in the surrounding area of Ac 1.4 (A = landtype of Alluvial plain; Ac = association of Çarşamba fan soils; Ac 1.4 = Çumra clayey soil, deep, over soft lime). Both units (Te 1.4 and Ac 1.4) show in the upper meter a surface layer of brown clay loam, lying over an AC-horizon, consisting partly of clay loam and partly of soft lime. Both units have also hard carbonate concretions (also in the clay loam) and a platy structure of the soft lime, probably stratification by sedimentation. Indeed, the terrace soils, too, can have soft lime in the subsoil. Anyhow, Te 1.4 or Ac 1.4, my object was to study the krotovinas in the soft lime. In contrast with the Kaşinhani area I found here many open and half or totally filled-up wormholes (of a size between 2 and 10 mm) in the soft lime. Krotovinas made by Citellus or Spalax) (of a size between 50 and 100 mm) were also observed. Roots clearly grow only through the holes and krotovinas, not through the soft lime itself. I did not find indications of a connection between plant growth and the occurrence of krotovinas. First, all profiles studied showed common or many animal holes and krotovinas. For a comparison one needs two things: Secondly, other factors dominate the plant growth, such as (probably) salinity and a very important one as the farmer’s management, especially the water

\textsuperscript{1} of W.F. LOCHER and A.F. GRONEMAN (1968), pp. 28-29.
supply by irrigation which causes great differences in crop growth even on the same field. Thus the method of varying one factor holding the other factors constant, could not be applied. At the same time the question may rise whether the problem has been correctly stated. It seems logical, that there should be an indirect connection between plant growth and krotovinas rather than a direct connection. Both the plants and the animals are influenced by the same factors, such as moisture condition of the soil and salinity. Where the circumstances are favourable, both the plants and the animals will flourish and we cannot simply say that the plants prosper because there are more holes and krotovinas (left aside the case that the krotovinas are fossil).

These considerations led to the decision not to extend the field work on this subject to more profile and more detailed crop observations (e.g. the counting of wormholes on horizontal surfaces; interviews with farmers).

2.2 Biological homogenization of May fan soils

The problem was: do the soils of the May fan, used in irrigated horticulture, show a clear biological homogenization as a result of the landuse? In other words, were they not homogenized after the sedimentation and can we find May soils with a different history of landuse and showing perhaps a more or less original, stratified profile?

Surely the upper layer (at any rate till 1 m depth) of the May fan soils shows much biological activity where the soils are irrigated, regardless whether they are used as market gardens or as arable land. I studied profiles of all the four phases of the Alibey series (Am 1) and they always had many worm holes and worm krotovinas and mostly also some krotovinas made by Citellus or Spalax. If these soils were not homogenized during the sedimentation, they are homogenized now as a result of irrigated agriculture. There is no stratification in the upper layer.
An example is profile 65-18 (description on pp. 11 - 13), showing a homogene texture (loam) and structure till 75 cm depth, where a transitional layer of homogene and stratified parts starts. Below 110 cm the stratification is clear, but spottishly disturbed by krotovinas.

A profile of the Alibey series with a not-homogenized upper layer I could not find, but maybe I did not look for them at the right places. To solve the question of the influence of the landuse, a proper planning of the field work should have been to study profiles of the same unit with a different (history of) landuse, as SLAGER (1966) did in his thesis. Now my fieldwork only leads to the conclusion that the Alibey series generally have a homogene upper layer. About the causes I cannot say anything for certain. At any rate, the structure and texture of most of the soils of the Alibey series look very favourable for agriculture and horticulture.

For micromorphological investigation I chose the profiles 65-19 (mapping unit Am 1.4; description on pp. 14-16) and 65-18 (mapping unit Am 1.3). These profiles are indeed different in rate of biological activity (see the following chapter) and in landuse, but they are also geologically different: 65-19 being an Alibey loamy soil, moderately deep over terrace soil (class. 1967: thapto calcifloridic ustollc camborthid), and 65-18 being an Alibey loamy soil, deep, stratified subsoil (class. 1967: ustollc camborthid). This means that also the laboratory work cannot go much further than the descriptive stage, because an unbiased comparison of the two profiles is not possible. Why I chose just these two profiles, is not quite clear to me now.

2.3 The field descriptions of the profiles

On the next pages the profile descriptions of the profiles W 54, 65-18, and 65-19 are given, made according to the instructions of the SOIL SURVEY MANUAL (1951, suppl. 1962). Salinity analyses of W 54, and results of some countings of worm holes in 65-19 are added.
Profile no.: W 54 (= field and report number)

Mapping unit: Lc 2.2 = Kaşinhani soft lime over limestone, shallow loamy surface soil (DRIESEN and DE MEESTER 1969)

Physiography (land type): Lacustrine plain

Soil association: soft lime soils

Soil series: Kaşinhani series, moderately well drained

Area: Çumra area, Turkey

Location: near Rakimbey Çifçiliği, Turkey, a farm 5 km SE of Kaşinhani

Elevation: 1010 m

Relief position: flat

Slope: level

Parent material: calcareous (carbonatic?) loam over soft lime

Landuse: arable land

Vegetation: fallow

Drainage condition: moderately well drained

Groundwater depth: 80 cm

Salinity: see results of analyses on next page

Root distribution: 0-34 cm, common roots; 34-80 cm, few roots

Biological activity: 0-34 cm, small animal holes, mostly < 2 mm

Human activity: ploughing

Irrigation: none

Ap 0-20 cm, calcareous clay loam, grayish brown (10 YR 5/2) when moist and light gray (10 YR 7/1) when dry; moderate fine and medium granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many macro- and mesobiopores; common hard carbonate concretions of a size of 0.5 to 3 cm; abrupt, smooth boundary.

A1 20-34 cm, grayish brown (10 YR 5/2) calcareous clay loam, light gray (10 YR 7/1) when dry; weak fine and medium granular structure; slightly hard, very friable, slightly sticky, slightly plastic; many macro- and mesobiopores; common hard lime concretions with a size of 0.5 to 3 cm; abrupt, wavy boundary.
profile W 54 continued

C 34-80 cm, white (10 YR 8/2) soft lime, very white when dry; moderate medium platy structure; hard, very friable, slightly sticky, slightly plastic; common macrobiopores (mostly < 0.5 mm) and few mesobiopores; many hard lime concretions with a size of 0.5 to 10 cm.

Described by: W.P. Locher, A. Mermut and C. Winkelmolen
Date: 1.9.1965, sun
Diagnostic horizons: ochric epipedon
Classification 7th Appr. 1967: typic udorthent

Bulk soil samples
0-20 cm
20-34 cm
34-70 cm

TABLE no. 1: Salinity analyses of profile W 54

<table>
<thead>
<tr>
<th>depth in cm</th>
<th>sat. perc.</th>
<th>pH</th>
<th>( E_{Ce} ) ( \text{mmho/cm} )</th>
<th>( Na^+ ) me/1</th>
<th>( Ca^{++}+Mg^{++} ) me/1</th>
<th>( Cl^- ) me/1</th>
<th>( SO_4^{2-} ) me/1</th>
<th>( Cl/SO_4 )</th>
<th>SAR ( \sqrt{\text{mmol} / l} )</th>
<th>ESP estimated from the SAR ( \sqrt{\text{mmol} / l} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>50.5</td>
<td>7.80</td>
<td>6.50</td>
<td>16.2</td>
<td>52.0</td>
<td>25.0</td>
<td>35.5</td>
<td>0.70</td>
<td>3.18</td>
<td>5.09</td>
</tr>
<tr>
<td>20-40</td>
<td>55.9</td>
<td>7.85</td>
<td>4.06</td>
<td>17.7</td>
<td>24.1</td>
<td>14.6</td>
<td>25.8</td>
<td>4.07</td>
<td>3.02</td>
<td>4.07</td>
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<tr>
<td>40-60</td>
<td>55.9</td>
<td>8.00</td>
<td>2.70</td>
<td>11.6</td>
<td>16.3</td>
<td>5.25</td>
<td>17.9</td>
<td>3.33</td>
<td>2.33</td>
<td>2.33</td>
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<tr>
<td>60-80</td>
<td>47.5</td>
<td>8.12</td>
<td>1.87</td>
<td>7.30</td>
<td>11.7</td>
<td>2.50</td>
<td>11.5</td>
<td>1.27</td>
<td>1.27</td>
<td>1.27</td>
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<tr>
<td>80-100</td>
<td>40.3</td>
<td>8.12</td>
<td>1.36</td>
<td>4.83</td>
<td>8.58</td>
<td>1.35</td>
<td>9.25</td>
<td>0.81</td>
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<tr>
<td>100-120</td>
<td>41.1</td>
<td>7.95</td>
<td>2.16</td>
<td>5.25</td>
<td>17.0</td>
<td>2.45</td>
<td>16.2</td>
<td>0.15</td>
<td>0.15</td>
<td>0.15</td>
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</tbody>
</table>

These results are quoted from WINKELMOLEN (1966). The sampling took place in September 1965. The laboratory methods were according to HANDBOOK 60 (1954). From the \( E_{Ce} \)-values it can be seen that only the upper 40 cm of the profile is slightly saline. The low Exchangeable Sodium Percentages indicate that there is not an alkalinity problem.

\( \sqrt{\text{mmol} / l} \) cf. LOCHER and GRONEMAN (1968), pp. 22-23a.
Photo 1: Soil peel of profile 65-18.
Depth is given in cm.
Profile no.: 65-18 (= number of soil peel)

Field no.: W 66
Mapping unit: Am 1.3, Alibey loamy soil, deep, stratified subsoil (DRIESEN and DE MEESTER, 1969)

Physiography (land type): Alluvial plain
Soil association: May fan soils
Soil series: Alibey series
Area: Çumra Area, Turkey
Location: 1.5 km north of the centre of Igergumra
Elevation: 1015 m
Relief position: flat
Slope: level
Parent material: loamy deposits of the river May
Landuse: irrigated arable land
Vegetation: fallow
Drainage condition: well drained
Groundwater depth: appr. 5 m

Moisture condition: 0-35 cm dry; 35-70 cm moderately dry; 70-170 cm moist
Salinity: on profile surface salt efflorescence 70-185 cm

Root distribution: plentiful 0-182 cm
Human activity: ploughing and irrigation
Gravel: 0-182 cm, very few rounded lime gravel < 1 cm
Secondary carbonates: 17-182 cm, fine "pseudomycelium" (in the clay loam mainly in the bigger pores) and very small soft powdery spots

Biological activity: 17-182 cm, few worm holes; some root holes filled up with moder.

Apl 0-15 cm, brown (10 YR 4/2.5) calcareous loam, light brownish gray to pale brown (10 YR 6/2.5) when dry; clods and loose structure; non to slightly sticky, non plastic, very friable, slightly hard; abrupt, smooth boundary.
profile 65-18 continued

Ap2 15-17 cm, brown (10 YR 4/2.5) calcareous loam, light brownish gray to pale brown (10 YR 6/2.5) when dry and brown (10 YR 5/3) when moderately dry; moderate medium platy structure; slightly sticky, slightly plastic, very friable, slightly hard; common macro- and mesobiopores; abrupt, smooth boundary.

A1 17-75 cm, brown (10 YR 4/2.5) calcareous loam, light brownish gray to pale brown (10 YR 6/2.5) when dry and brown (10 YR 5/3) when moderately dry; (very) weak coarse subangular blocky; slightly sticky, slightly plastic, very friable, slightly hard; many macro- and many mesobiopores; abrupt, wavy boundary.

C1 75-110 cm, calcareous stratified loam and clay loam with the same colour and consistence as in A1; 79-88 cm, moderate medium platy clay loam; 88-90 cm, massive or very weak medium subangular blocky loam, 90-94 cm, moderate thin platy clay loam; 94-101 cm, moderate medium platy clay loam; 101-110 cm, layers and lenses of clay loam and loam (0.5 to 2 cm thick), platy and weak subangular blocky; common macro- and few mesobiopores, more horizontal than vertical pores; abrupt, wavy boundary.

C2 110-134 cm, calcareous (sandy) loam; very weak coarse subangular blocky; colour and consistence as in A1; common macro- and mesobiopores; abrupt, wavy boundary.

C3 134-164 cm, calcareous clay loam to silty clay loam; colour and consistence as in A1; 134-145 cm, weak medium subangular blocky; 145-164 cm, moderate medium platy; common macro- and mesobiopores; abrupt, wavy boundary.

C4 164-182 (bottom pit) cm, calcareous (sandy) loam; very weak coarse subangular blocky; colour and consistence as in A1; many to common macro- and few to common mesobiopores.
profile 65-18 continued

Described by: W.P. Locher
Date: 14.9.1965, sun
Diagnostic horizons: ochric epipedon, cambic horizon
Classification 7th Appr. 1967: ustolic camborthid

Soil samples:

Bulk samples:

<table>
<thead>
<tr>
<th>Depth Range</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0- 15 cm</td>
<td></td>
</tr>
<tr>
<td>15- 17</td>
<td></td>
</tr>
<tr>
<td>17- 75</td>
<td></td>
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<tr>
<td>75-110</td>
<td></td>
</tr>
<tr>
<td>110-135</td>
<td></td>
</tr>
<tr>
<td>135-163</td>
<td></td>
</tr>
<tr>
<td>163-185</td>
<td></td>
</tr>
</tbody>
</table>
Photo 2: Soil peel of profile 65-19.
Depth is given in cm.
Profile no.: 65-19 (number of soil peel)

Field no: W 62

Mapping unit: Am 1.4, Alibey loamy soil, moderately deep over terrace soil (DRIESEN and DE MEESTER 1969)

Physiography (Land type): Alluvial plain

Soil association: May fan soils

Soil series: Alibey series

Area: Çumra area, Turkey

Location: 4 km east of Alibeyhüyük

Elevation: 1016 m

Relief position: flat

Slope: level

Parent material: loamy deposits (of the river May?), lying over (residual?) calcareous to carbonatic material of a structural terrace

Land use: irrigated market gardening

Vegetation: tomatoes, corn, sunflowers, beans

Groundwater depth: depending on irrigation

Drainage condition: moderately well drained

Irrigation: one time a week in the growing season

Root distribution: 0-20 cm, abundant; 20-40 cm, plentiful; 40-147 cm, few

Moisture condition: 0-147 cm, moist

Human activity: ploughing; manuring

Biological activity: see page 16

Ap 0-25 cm, (dark) brown (10 YR 4.5/3) calcareous loam to clay loam, (pale) brown (10 YR 5.5/3) when dry; weak very fine to fine granular; slightly sticky, slightly plastic, very friable, soft; many macro- and mesobiopores; many worm holes; some salt efflorescence on the peds; abrupt, wavy boundary.

A1 25-44 cm, (dark) brown (10 YR 4.5/3) calcareous loam to clay loam, pale brown (10 YR 6/3) when dry; weak fine subangular blocky (and appr. 10% fine granular); slightly sticky, slightly plastic, very friable, slightly hard; many macro- and common mesobiopores; many wormholes; 10 wormholes in filled-up hole Ø 6 cm; salt efflorescence on peds; clear, wavy boundary.
profile 65-19 continued

IIAC<sub>ca</sub> b 44-61 cm, (dark) brown (10 YR 4.5/3) calcareous clay loam; weak medium subangular blocky; slightly sticky, slightly plastic, very friable, slightly hard; many macro- and many mesobiopores; common wormholes; salt efflorescence on peds; common distinct medium segregations of lime: very pale brown (10 YR 8/3) when moist and very white when dry, slightly sticky, slightly plastic, very friable, slightly hard, common macro- and many mesobiopores; clear, wavy boundary.

IIIC<sub>ca</sub> b 61-120 cm, (very) pale brown (10 YR 6.5/3) calcareous loam, alternating with 0.5 to 10 cm large spots of very pale brown (10 YR 8/3) lime (clay loam) that is white when dry; the lime occupies 50 to 80% of the horizon; both the lime and the calcareous loam have a very weak medium angular blocky to massive structure, and are slightly sticky, slightly plastic, very friable, slightly hard; the loam has many macro- and few mesobiopores; (dark) brown (10 YR 4.5/3) krotovinas of diameter 5 to 10 cm; common wormholes, sometimes filled-up; abrupt, wavy boundary.

II C<sub>2</sub> 120-147 (bottom pit) cm, (pale) brown (10 YR 5.5/3) calcareous (carbonatic?) loam; massive, slightly sticky, slightly plastic, very friable, slightly hard; many macro- and many mesobiopores; few distinct medium soft lime segregations.

Described by: W.P. Locher
Date: 4.8.1965, sun
Diagnostic horizons: ochric epipedon
cambic horizon
calciic horizon (buried)
Classification 7th Appr. 1967: thapto calciorthidic ustolic camborthid
profile 65-19 continued

Bulk samples:

- 0-20 cm
- 20-40 cm
- 40-70 cm
- 40-70 (A-mat.)
- 40-70 (lime)
- 70-120 cm
- 80-90 (animal holes)
- 120-140 cm

<table>
<thead>
<tr>
<th>TABLE no. 2</th>
<th>Number of (open) wormholes per m² in profile 65-19</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(counted on horizontal surfaces of 40 to 40 cm).</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>depth</th>
<th>horizon</th>
<th>2 - 4 mm</th>
<th>8 - 10 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 cm</td>
<td>Ap</td>
<td>600</td>
<td>60</td>
</tr>
<tr>
<td>20 cm</td>
<td>Ap</td>
<td>606</td>
<td>30</td>
</tr>
<tr>
<td>30 cm</td>
<td>A1</td>
<td>174</td>
<td>12</td>
</tr>
<tr>
<td>45 cm</td>
<td>AC_{ca b}</td>
<td>600</td>
<td>12</td>
</tr>
<tr>
<td>55 cm</td>
<td>AC_{ca b}</td>
<td>78</td>
<td>12</td>
</tr>
</tbody>
</table>

Three worms were caught from this profile and determined by Dr. ir. J. Doeksen as Lumbricus-terrestris-like.

The laboratory work consisted of several parts:

1. Training in the micromorphological description techniques according to the system of BREWER (1964).
2. Making thin section descriptions of some profiles.
3. The study of the micromorphology of the carbonate fraction of these profiles.
4. The counting of different kinds of carbonate particles.
5. The evaluating of the results.

Point 1 is treated in: 3.1
Point 2 is treated in: 3.2
Point 3 is treated in: 4.1 4.2
Point 4 is treated in: 5.4
Point 5 is treated in: 3.3 3.4 3.5 4.3 5.1 5.2 5.3.

3.1 Micromorphological terminology

The terminology used in the micromorphological descriptions is according to BREWER (1964). The definitions are not repeated here. The few terms, deviating from or added to Brewer's terminology, are explained in the descriptions, except the terms for the secondary structure which are according to the Soil Survey Manual (1951), with the addition: "Spongey" = met sponsstructuur, gangen in iedere richting door de grond lopend en onderling verbonden (JONGERIUS, 1957, page 48).

The following conventions were applied in the descriptions:

a. The most important feature is mentioned first. For example "crystic and argillasepic" means that the greater part of the plasma has a crystic plasmic fabric and less than half of the plasma has an argillasepic plasmic fabric. When "or" is used instead of "and", the sequence has no meaning, because the proportion of the two (or more) components is estimated to be fifty-fifty. In the same way the most important kind of skeleton grain or void is mentioned first.
b. In order to shorten the descriptions, some more or less self-evident things are omitted. Examples: when no distribution pattern is mentioned it means that the pattern is "at random"; no sharpness of boundary mentioned: "with a sharp boundary" is omitted. "Channel" means "regular metachannel", "vugh" means "orthovugh", but "mammillated vugh" means "mammillated metavugh". When no basic fabric is mentioned (e.g. with glaeules) the basic structure is "porphyroskelic". With the plasmic structure mostly no size is mentioned because the size of plasma (e.g. carbonate crystals) is by definition extremely fine and sometimes partly very fine (smaller than appr. 8 micrometer). A "skelsepic plasmic fabric" means an "argillasepic and skelsepic plasmic fabric", because only a minor part of the plasma can be grouped as argillans around grains.

The definitions of Brewer are generally well-thought out and well formulated. However, Brewer's definition of subcutanic feature (p. 293) is not correct: "A subcutanic feature is a pedological feature (recognized by a difference in texture, structure, or fabric as compared with the enclosing S-matrix) that has a consistent relationship with natural surfaces in the soil material, but does not occur immediately at the surfaces." Then he makes a subdivision in neocutans and quasicutans. "Neocutans: these occur subcutanically immediately adjoining the natural surfaces with which they are associated." This definition is in contradiction with the last part of the definition of subcutanic feature. Therefore, I propose to define "subcutanic feature" as follows:

"A subcutanic feature is a pedological feature (recognized by a difference in texture, structure, or fabric as compared with the enclosing S-matrix) that has a consistent relationship with natural surfaces in the soil material, and does not occur on the surfaces but subcutanically either immediately or not immediately adjoining them." (that part of the definition that is underlined deviates from Brewer's definition).

Brewer himself states that his terminology is not complete. Additional terms will be necessary as knowledge is increasing. In my opinion new terms must only be coined when the terminology of Brewer is absolutely insufficient. Otherwise a confusion of tongues threatens to arise in the still relatively virginal field of the micromorphological terminology (a confusion which already exists in other fields of soil science, alas).
Obviously MULDERS (1969) does not share this opinion. He states (p. 163): "The micromorphological description was done after Brewer (1964) although in some cases completion was necessary." Then he gives a list of definitions, but does not mention which definition is Brewer's and which is not. It appears that two new terms are used by Mulders: "calciasepic" and "allotriomorphic" (p. 165), while he uses "crystic plasmic fabric" in a stricter sense than Brewer. "Calciasepic fabric: the plasma of this fabric exhibits a flecked orientation and has an important proportion of carbonates e.g. 15-40 percent being of definite importance for the physical constitution of the soil material." (Mulders, p. 164). Now the question is, why Mulders uses "calciasepic" instead of "crystic". The definition of "crystic" by Brewer is sufficient to describe a plasma which has many calcite crystals: "Crystic) plasmic fabric: the plasma is usually anisotropic and consists of recognizable crystals, usually of the more soluble plasma fractions." (Brewer, p. 317). Then, with the plasmic structure the chemical composition of the crystals can be mentioned. Completion of Brewer's terminology was not necessary in this case. Perhaps Mulders has an other conception of "crystals": he speaks of "calcite microlites" instead of calcite crystals: "The plasma grains are of 3-10 μ size or smaller, are closely packed together and the plasma is composed of clay and highly irregular calcite microlites." (p. 167, Micromorphology of a Typic Calcic Orthid, profile 38). The term "microlite" is not defined and no reason is given for the use of this term.

3.2 The descriptions of the thin sections

The thin sections were made in our Laboratory of samples taken with Kopecki rings (some with copper boxes), according to the method described by JONGERIUS and HEINZBERGER (1963).

Most of the descriptions were made in November and December 1966 and some of them in June 1969. All of them were corrected in June 1969.

"Mulders' definition (p. 165): "Crystic plasmic fabrics: the plasma is usually anisotropic and consists of recognizable crystals of the more soluble plasma fractions, being soluble in water e.g. gypsum and halite."
For the conventions applied in the descriptions be referred to 3.1. One point must be mentioned here. Recently (when this report was nearly finished) Mr. E.C. Tjoe-Awie drew my attention to the fact that most of the acicular skeleton grains which are now described as micas probably are not micas but aragonite (these acicular grains often show a slightly rhombic crystal form). If they would be all micas, the question should arise why they are all cut normal to the plane of the plates. However, the presence of micas in profile 65-18 was established by microscopical determination of a crystal derived from a clod sample (biotite). It is possible that it is difficult to recognize e.g. muscovite in thin sections because of its transparent nature. It is recommended to give special attention to the possible occurrence of aragonite (being a carbonate!) in further studies on the micromorphology of Turkish profiles.

On the next pages the descriptions of the thin sections are given. The sequence is: at first profile W 54, then 65-18, 65-19, and finally 64-2. Within each profile the descriptions are arranged according to increasing depth of the sample (see Table no. 3 ). An index to the thin section numbers can be found on page 86.
<table>
<thead>
<tr>
<th>Profile number</th>
<th>Depth (cm)</th>
<th>Horizon</th>
<th>Thin section number</th>
<th>Size of the thin section (cm)</th>
<th>Description on page(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>W 54</td>
<td>20-25</td>
<td>A1</td>
<td>65091</td>
<td>4 to 4</td>
<td>22</td>
</tr>
<tr>
<td>W 54</td>
<td>50-55</td>
<td>C</td>
<td>65092</td>
<td>4 to 4</td>
<td>23</td>
</tr>
<tr>
<td>65-18</td>
<td>15-20</td>
<td>A1</td>
<td>65079</td>
<td>3 to 2</td>
<td>24</td>
</tr>
<tr>
<td>65-18</td>
<td>30-40</td>
<td>A1</td>
<td>65104</td>
<td>14 to 7</td>
<td>25-27</td>
</tr>
<tr>
<td>65-18</td>
<td>63-68</td>
<td>A1</td>
<td>65080</td>
<td>4 to 4</td>
<td>28-29</td>
</tr>
<tr>
<td>65-18</td>
<td>95-100</td>
<td>C1</td>
<td>65082</td>
<td>4 to 4</td>
<td>30</td>
</tr>
<tr>
<td>65-18</td>
<td>118-123</td>
<td>C2</td>
<td>65083</td>
<td>4 to 4</td>
<td>31-32</td>
</tr>
<tr>
<td>65-18</td>
<td>147-152</td>
<td>C3</td>
<td>65084</td>
<td>3 to 2</td>
<td>33</td>
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<tr>
<td>65-18</td>
<td>170-175</td>
<td>C4</td>
<td>65085</td>
<td>3 to 2</td>
<td>34-37</td>
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<tr>
<td>65-19</td>
<td>5-10</td>
<td>Ap</td>
<td>65072</td>
<td>4 to 4</td>
<td>38-39</td>
</tr>
<tr>
<td>65-19</td>
<td>15-30</td>
<td>A1</td>
<td>65097</td>
<td>14 to 7</td>
<td>40-42</td>
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<tr>
<td>65-19</td>
<td>25-30</td>
<td>A1</td>
<td>65071</td>
<td>4 to 4</td>
<td>43</td>
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<tr>
<td>65-19</td>
<td>45-50</td>
<td>II ACa b</td>
<td>65070</td>
<td>4 to 4</td>
<td>44-45</td>
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<tr>
<td>65-19</td>
<td>60-65</td>
<td>II ClCa b</td>
<td>65073</td>
<td>4 to 4</td>
<td>46-48</td>
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<tr>
<td>65-19</td>
<td>75-80</td>
<td>II ClCa b</td>
<td>65075</td>
<td>4 to 4</td>
<td>49</td>
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<tr>
<td>65-19</td>
<td>90-95</td>
<td>II ClCa b</td>
<td>65076</td>
<td>4 to 4</td>
<td>50-52</td>
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<tr>
<td>65-19</td>
<td>110-115</td>
<td>II ClCa b</td>
<td>65077</td>
<td>4 to 4</td>
<td>53</td>
</tr>
<tr>
<td>65-19</td>
<td>130-135</td>
<td>II C2</td>
<td>65078</td>
<td>3 to 2</td>
<td>54-55</td>
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<tr>
<td>64-2</td>
<td>5-15</td>
<td>B 21Ca b</td>
<td>64101</td>
<td>3 to 2</td>
<td>56</td>
</tr>
</tbody>
</table>
Description of thin section no. 65091 (Çumra area, Turkey)

Profile: W 54    Depth: 20-25 cm.    Horizon: A1

Field description: W.P. Locher, A. Mermut and C. Winkelmolen (1-9-'65)
Mapping unit: Lacustrine plain, Kaşinhani soft lime over limestone, shallow loamy surface soil (Lo 2.2; cf. DRIESSEN and DE MEESTER, 1969).
Thin section description: W.P. Locher (31-7-’69).

Plasmic structure: crystic (oblate carbonatic) and argillasepic.

Basic structure:
- skeleton grains: - calcite, fine and very fine, oblate or equant
  - quartz and felspar, fine and very fine, equant
  or oblate, sometimes prolate or triaxial;
  - few other minerals.
- voids: - very fine macro and meso and fine macro orthochannels;
  - very fine macro and meso irregular vughs;
  - very fine macro and meso craze planes.

Elementary structure:
- fabric: glaebular.
- main pedological feature: very many carbonate nodules with an oblate
  crystic plasmic structure, sometimes containing a single skeleton
  grain and few meso vughs, sometimes with crystal chambers or calcitans
  of very fine carbonate crystals, or few skew planes with or without
  crystal sheets. The nodules are ellipsoidal or spherical or prolate or
  triaxial and occur in all the size classes from very fine to very coarse.
  A distinction could be made between very dense (hard?) nodules with very
  few microscopical voids and dense (less hard?) nodules with few voids.
  The former are browner than the latter.

Secondary structure: fine and very fine granular and very fine subangular
blocky.
Description of thin section no.: 65092 (Çumra area, Turkey)

Profile: W 54  
Depth: 50-55 cm  
Horizon: C

Fields description: W.P. Locher, A. Mermut and C. Winkelmolen (1-9-'65)
Mapping unit: Lacustrine plain, Kapinhani soft lime over limestone, shallow loamy surface soil (Lo 2.2; cf. DRIESSEN and DE MEESTER, 1969).

Thin section description: W.P. Locher (31-7-'69).

Plasmic structure: crystic (oblate carbonatic).

Note: the plasma resembles the plasma of the less dense carbonate glaebules of 65091 (A1-horizon).

Basic structure:
- skeleton grains: - few calcite, fine and very fine, oblate and triaxial;
  - very few quartz and felspar, very fine;
  - a single other mineral.
- voids: - micro, meso and very fine macro joint planes (parallel to the soil surface);
  - meso and very fine macro irregular vughs;
  - meso and very fine macro orthochannels.

Elementary structure:
- fabric: glaebular.
- main pedological feature: many carbonate nodules as described in 65091, but now also with rather sharp to very diffuse boundaries, and one nodule of an extremely coarse size (2.5 cm).
Description of thin section no. 65079 (Cumra area, Turkey)

Profile no.: 65-18 (no. of soil peel) Depth: 15-20 cm Horizon: A1
Field description: W.P. Locher (Sept. '65)
Mapping unit: Alluvial fan of May river, Alibey loamy soil, deep, stratified subsoil (Am 1.3; cf. DRIESEN and DE MEESTER, 1969).


No. 65079 is a small thin section.

Description of 65079 as that of 65104 (depth 30-40 cm) with the following differences:

No. 65079 has:
- argillasepic plasmic fabric.
- no craze planes (because of the smallness of the thin section?).
- no lubline needles (and fewer oblate intercalary carbonate crystals).
- no pedorelicts ("clay-balls").
- no secondary structure.
Description of thin section no. 65104 (Cumra area, Turkey)

Profile no.: 65-18 (= no. of soil peel) Depth: 30-40 cm Horizon: A1

Field description: W.P. Locher (Sept. '65)
Mapping unit: Alluvial fan of May river, Alibey loamy soil, deep, stratified subsoil (Am 1.3; cf. DRIESSEN and DE MEESTER, 1969)

Plasmic fabric: skelsepic and glaessepic).

Basic structure:
- skeleton grains: - felspar and quartz, fine and medium and very fine, very angular and angular, with a low sphericity;
  - fine calcite, oblate and triaxial;
  - micas and other well weatherable minerals.
- voids: - very fine macro and meso mammilated interconnected orthovughs;
  - very fine macro channels;
  - very fine macro craze planes.

Elementary structure:
- fabric: crystallaric
- main pedological feature: intercalary crystals of carbonate: 1) very and extremely fine, oblate, random or clustered, either unrelated or in voids parallel to their walls (seldom real calctans); 2) needles of lublinite, clustered or random, cutanic to the walls of voids (seldom real cutans).

Primary structure: - other pedological features:

continued

') Plasmaseparations as which skelsepic, but now occurring around glaebules (term coined by our Laboratory).
Description of thin section no. 65104 continued

- compound embedded grain stress argillans, slightly separated, sharp to diffuse boundaries, extremely thin.
- carbonate nodules with an extr. and very fine oblate crystic plasmic structure, rather sharp boundaries, prolate and equant, subangular, medium and fine.
- opaque organic nodules reflecting with incident light, prolate, subangular, fine and medium.
- pedorelicts: coarse prolate nodules with an argillasepic plasmic fabric, and with few silt grains and many random intercalary crystals of carbonate, and a porphyroskelic basic fabric.

REMARK: These could be the so-called "clay-balls", which often occur in the May fan soils (cf. DRIESEN and DE MEESTER, 1969, page 30). These authors state: "Presumably these clay balls have been translocated from elsewhere." In the terms of Brewer this would mean, that these pedorelicts are para-pedorelicts. From a thin section observation only I cannot conclude whether this may be true. The other possibilities cannot be excluded: 1 ortho-pedorelicts, which means derived from the soil material of the horizon in which they occur (i.e. rests of stratification in this homogenized A-horizon); or 2 meta-pedorelicts, which means derived from the soil material of another soil horizon (i.e. transported by animals from the stratified subsoil).
- sedimentary relicts: coarse and medium "inherited" lithorelicts, oblate, with an asepic plasmic fabric, and a basic structure of concentric fine acicular skeleton grains and fine subangular opaque organic nodules.
- pedotubules: ortho-aggrtubules.

Other features:
- many sections of roots, medium;
- few fine circular shells.

Secondary structure: coarse subangular blocky.
65104  pol. light  3lx
65-18  30-40 cm  Al

Photo 3: Primary structure of 65104 voids
Description of thin section no. 65080 (Çumra area, Turkey)

Profile no.: 65-18 (= no. of soil peel) Depth: 63-68 cm. Horizon: A1

Field description: W.P. Locher (Sept.' 65).
Mapping unit: Alluvial fan of May river, Alibey loamy soil, deep, stratified subsoil (Am 1.3; cf. DRIESEN and DE MEESTER, 1969).

PART I (appr. 87% of the thin section)

Plasmic fabric: argillasepic (slightly skelsepic)

Basic structure:
- skeleton grains: - medium and coarse and fine felspar or quartz, oblate and triaxial;
  - fine and medium calcite, oblate;
  - micas and many other well-weatherable minerals.
- voids: - very fine macro and meso and fine macro regular orthochannels;
  - very fine macro and meso and micro irregular and regular vughs, sometimes interconnected;
  - very fine macro craze planes.

Elementary structure:
- main pedological feature: intercalary crystals of carbonate: 1) very and extremely fine, oblate, random and clustered, either unrelated or in voids parallel to their walls (some real calcitans occur, thin and very thin); 2) needles of lublinite, clustered and random, cutanic in voids.

continued
Description of thin section no. 65080 continued

Primary structure: the same as that described in thin section no. 65104 (depth 30-40 cm), with the following differences:
- here also occur some spherical medium ferric and manganiferous nodules;
- for the "pedorelicts" see Part II of the description.

PART II (appr. 13% of the thin section)

The surface ratio of Part I and Part II was estimated by counting 400 points in a systematical grid all over the thin section. I experienced difficulties, because the mutual exclusive classes could not be established with enough certainty.

Part II consists of clayey and/or denser spots, and could be pedorelicts, either ortho-, meta-, or parapedorelicts (cf. the description of 65104). Part II occurs in Part I as prolate and equant, medium to very coarse, subangular nodules, with sharp to rather diffuse boundaries.

Plasmic fabric: argillasepic.

Basic structure:
- skeleton grains: as described in Part I, but here they are mostly fine and very fine and often much less in number.
- voids: very fine macro regular orthochannels;
  - few meso and micro vughs.

Elementary structure: as that of Part I (crystallaric).

Primary structure: few carbonate nodules, opaque organic nodules and "lithorelicts" as described in Part I.
Description of thin section no. 65082 (Çumra area, Turkey)

Profile no.: 65-18 (=no. of soil peel). Depth: 95-100 cm. Horizon: C1

Field description: W.P. Locher (Sept. '65).

Mapping unit: Alluvial fan of May river, Alibey loamy soil, deep, stratified subsoil (Am 1.3; cf. DRIESSEN and DE MEESTER, 1969).


Description of 65082 as that of 65080 (depth 63-68 cm) with the following differences:

PART I (appr. 25% of the thin section)
- skeleton grains: now fine and medium and few coarse (so the S-matrix is finer textured);
- more calcite.
- elementary structure: now many crystallaria of carbonate crystals are present, being either thin channel and normal void calcitans or neocalcitans, or crystal chambers and crystal sheets; the lublinite needles are still present.

PART II (appr. 75% of the thin section)

The really clayey parts are now estimated to occupy appr. 25% of the thin section. Mostly they have sharp boundaries. Now not only equant to prolate spots of these clayey parts occur, but spottishly they have a very thin platy secondary structure within Part I. Besides spots occur which can also be reckoned to Part II, with diffuse boundaries with Part I, and having a texture' coarser than the really clayey parts but finer than Part I, and occupying appr. 50% of the thin section.

') texture in the sense of grain size distribution (unlike Brewer).
Description of thin section no. 65083 (Cumra area, Turkey)

Profile: 65-18 (= no. of soil peel) Depth: 118-123 cm. Horizon: C2

Field description: W.P. Locher (Sept. '65).
Mapping unit: Alluvial fan of May river, Alibey loamy soil, deep, stratified subsoil (Am 1.3; cf. DRIESEN and DE MEESTER, 1969).

Plasmic fabric: skelsepic.

Basic structure:
- skeleton grains: - medium and fine and coarse felspar and quartz, oblate and triaxial;
  - medium and fine calcite, oblate and triaxial;
  - flintstone, micas, well-weatherable minerals.
- voids: - very fine and fine macro regular and irregular orthochannels;
  - very fine and fine macro irregular interconnected vughs;
  - very fine macro craze planes.

Elementary structure:
- main pedological feature: intercalary crystals of carbonate:
  1) very and extremely fine, oblate, clustered and random, often being thin and very thin channel and normal void calcitans and neocalcitans;
  2) needles of lublinite, clustered and random, cutanic to the walls of voids (seldom real cutans).

Primary structure: - other pedological features:
- pedorelicts (cf. no. 65104): many coarse and very coarse equant and prolate nodules with a crystic or argillasepic plasmic fabric, and with a porphyroeskelic basic structure, having some silt grains and seldom medium skeleton grains, no voids other than micro vughs, and having sharp boundaries.
- carbonate nodules with an extremely and very fine oblate crystic plasmic structure, sharp boundaries, spherical and ellipsoidal, medium (one is very coarse).

REMARK: Probably these nodules are sedimentary relicts.
- opaque organic nodules and "inherited lithorelicts" as described in 65104.

continued
Description of thin section no. 65083 continued

REMARK: This thin section shows a coarser texture than other horizons of this profile, which corresponds with the field description.
Description of thin section no. 65084 (Çumra area, Turkey)

Profile: 65-18 (= no. of soil peel). Depth: 147-152 cm. Horizon: C3

Field description: W.P. Locher (Sept. '65).
Mapping unit: Alluvial fan of May river, Alibey loamy soil, deep, stratified subsoil (Am 1.3; cf. DRIESSEN and DE MEESTER, 1969).

No. 65084 is a small thin section.

Plasmic fabric: argillasepic and slightly skelsepic.

Basic structure:
- skeleton grains: - micas and other platy minerals, with a medium and fine length, sometimes weakly oriented parallel to each other;
  - very fine or fine and medium felspar and quartz, oblate and triaxal;
  - very fine or fine calcite, oblate and triaxal;
  - other minerals.
- voids: - very fine and fine macro regular orthochannels;
  - meso or very fine macro or micro simple packing voids.

Elementary structure:
- main pedological feature: intercalary crystals of carbonate, mainly as thin channel calcitans and neocalcitans, sometimes as crystal chambers; few lublinite needles.

Primary structure: - other pedological features:
- pedorelicts as described in 65083 (depth 118-123 cm);
- few carbonates nodules as described in 65083.

REMARK: This thin section shows a slight stratification in texture.
Description of thin section no. 65085 (Çumra area, Turkey)

Profile: 65-18 (= no. of soil peel) Depth: 170-175 cm. Horizon: C4
Field description: W.P. Locher (Sept. '65).
Mapping unit: Alluvial fan of May river, Alibey loamy soil, deep, stratified subsoil (Am 1.3; cf. DRIESEN and DE MEESTER, 1969).
Thin section description: W.P. Locher (Nov. 1966),

No. 65085 is a small thin section. This thin section shows a clear stratification of sandy and clayey layers, 2 to 10 mm thick. This stratification is not mentioned in the field description of this horizon, but can also be observed on the soil peel.

PART I (coarsest textured layer; sandy loam ?)

Plasmic fabric: argillaseptic.

Basic structure:
- skeleton grains: medium and fine and coarse felspar and quartz, triaxial and oblate;
- medium and fine calcite, oblate;
- micas and other well-weatherable minerals.
- voids: very fine macro interconnected vughs (simple packing voids);
- very fine macro orthochannels.

Elementary structure:
- main pedological feature: intercalary crystals of carbonate, mainly clustered in vughs, extremely fine and fine, oblate.

Primary structure: other pedological features:
- fine and medium carbonate nodules with an extremely fine crystic plasmic structure, sharp boundaries, ellipsoidal;
- fine and very fine opaque organic nodules;
- sedimentary relicts as described in 65104;
- sections of roots.

continued
Description of thin section no. 65085 continued

PART II (finer textured than Part I, coarser than Part III; silt loam ?)

**Plasmic fabric:** argillasepic.

**Basic structure:**
- skeleton grains: - fine calcite, oblate and triaxial;
  - fine felspar and quartz, triaxial and oblate;
  - micas, weakly oriented parallel to the stratification (soil surface);
  - other well-weatherable minerals.
- voids: - meso and very fine macro interconnected vughs (simple packing voids);
  - very fine macro orthochannels.

**Elementary structure:**
- main pedological feature: channel neocalcitans, rather sharp boundaries thin and medium, with an extremely fine crystic plasmic structure, seldom lublinite needles.

**Primary structure:** other pedological features:
- fine carbonate nodules with an extremely fine crystic plasmic structure, sharp boundaries, ellipsoidal or subangular;
- fine and very fine opaque organic nodules;
- some sections of roots.

PART III (finest textured layers; clay loam ?)

**Plasmic fabric:** argillasepic.

**Basic structure:**
- skeleton grains: - very fine and fine calcite, oblate and triaxial;
  - very fine and fine felspar and quartz, oblate and triaxial;
  - micas and other platy minerals, moderately oriented parallel to the stratification (soil surface).
Description of thin section no. 65085 continued

- voids: very fine and medium macro channels;
  - meso and very fine macro craze planes;
  - meso and very fine macro vughs.

**Elementary structure:**
- main pedological feature: channel neocalcitans, rather sharp to rather diffuse boundaries, medium, with an extremely and very fine crystic plasmic structure.

**Primary structure:** few fine pedological features as described under Part I, and ortho-aggrotubules.
Photo 4: Stratification in 65065. The thin section itself used as a negative (10x). The voids are black on the photo; the smaller angular black spots are mostly skeleton grains. Part I is the coarsest textured layer, Part III the finest textured layer.
Description of thin section no. 65072 (Çumra area, Turkey)

Profile no.: 65-19 (= no. of soil peel) Depth: 5-10 cm. Horizon: Ap

Field description: W.P. Locher (Aug. 1965)
Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1.4; cf. DRIESEN and DE MEESTER, 1969).

Plasmic structure: crystic (oblate carbonate crystals) and argillasepic.

Basic structure:
- skeleton grains: - angular medium quartz and felspar with a low sphericity;
  - fine calcite with a very fine crystic plasmic structure, oblate and triaxial;
  - some medium micas and other well weatherable minerals.
- voids: - irregular very fine macro vughs, often interconnected, and irregular meso and micro vughs;
  - intrapedal and transpedal very fine and medium macro channels.

Elementary structure:
- fabric: glaebular;
- main pedological feature: carbonate nodules with an oblate crystic plasmic structure, sharp and rather sharp boundaries, spherical and ellipsoidal but sometimes subrounded, coarse and medium and fine.

Primary structure:
- other pedological features:
  - carbonate nodules as described under elementary structure but with some brown ferric impregnation, either spottish, dendritic) or total.
  - ditto but having a neoferromanmangan, very thin and thin.
  - manganiferous concretions, spherical, medium and fine.

continued

"dendritic = repeatedly branched (cf. BLOKHUIS et al., 1969)."
Description thin section no. 65072 continued

- manganiferous nodules, spherical, medium.
- opaque organic nodules reflecting with incident light, prolate, subangular, medium.
- sedimentary relicts: some coarse inherited lithorelicts.

Secondary structure: very fine and fine granular, and spongey, and very fine subangular blocky (many granules can be conceived as matrix') fecal pellets, welded and single, spherical and ellipsoidal to lobate, medium).
Description of thin section no. 65097 (Çumra area, Turkey)

Profile no.: 65-19 (= no. of soil peel). Depth: 15-30 cm. Horizon: A1

Field description: W.P. Locher (Aug. '65)
Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1.4; cf. DRIESENN and DE MEESTER, 1969).

Thin section description: W.P. Locher (Nov. '66).

PART I (nearly the whole thin section)

Plasmic structure: crystic (oblate carbonate crystals) and argillasepic.

Basic structure:
- skeleton grains: - angular medium and fine quartz and felspar with a low sphericity;
  - fine calcite with a very fine crystic structure, oblate and triaxial;
  - some micas and other well weatherable minerals.
- voids: - macro regular and irregular orthochannels;
  - macro and meso irregular and regular vughs, sometimes interconnected.

Elementary structure:
- fabric: glaebular.
- main pedological feature: carbonate nodules with an oblate crystic plasmic structure, sharp and rather sharp boundaries, spherical and ellipsoidal but sometimes subrounded, medium and fine, sometimes having some ferric impregnation.

Primary structure: - other pedological features:
- carbonate nodules with an oblate crystic plasmic structure, sharp boundaries, equant and prolate (mostly subangular), coarse and very coarse, and having a basic structure of few skeleton grains and voids as described above;

continued
Description of thin section no. 65097 continued

- manganiferous concretions and nodules, spherical, medium (mostly being an impregnated S-matrix or carbonate nodule);
- opaque organic nodules reflecting with incident light, prolate, medium;
- sedimentary relicts: inherited lithorelicts, coarse, with an orgillasemitic plasmic fabric and an elementary structure of very fine acicular and medium triaxial skeleton grains and fine organic nodules.

Secondary structure: very fine and fine and medium subangular blocky, spongey and fine granular.

PART II (a spot of appr. 0.5 cm²; see, however, the description of thin section no. 65071)

Plasmic fabric: argillasepic (slightly lattisepic)

Basic structure:
- skeleton grains: few fine and very fine felspar, quartz, calcite, mica, etc., oblate or triaxial.
- voids: - very fine macro and meso irregular and regular orthochannels;
  - meso and very fine macro regular and irregular vughs, sometimes interconnected.

Elementary structure:
- main pedological feature: intercalary crystals of carbonate, very and extr. fine, oblate, clustered, often cutanic to the walls of the voids (sometimes real calcitans).
Photo 5: The primary structure of 65097. The thin section itself used as a negative (15x). Voids are black, carbonate nodules light-grayish. Most of the skeleton grains can be seen as small angular black spots.
void carbonate nodules opaque organic nodule skeleton grain manganiferous concretion

1 mm
Description of thin section no. 65071 (Cumra area, Turkey)

Profile no.: 65-19 (= no. of soil peel). Depth: 25-30 cm. Horizon: A1

Field description: W.P. Locher (Aug. '65)
Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1.4; cf. DRIESEN and DE MEESTER, 1969).
Thin section description: W.P. Locher (Nov. '66)

This thin section can be divided in two parts, which show a different microstructure. Part II occurs within Part I in a clustered and dendritic distribution pattern, and the ratio of the surfaces of the two parts is estimated to be fifty-fifty. Thin section no. 65071 is sampled from the same depth in the profile as no. 65097 and indeed shows much resemblance with no. 65097, except for the ratio of the two parts (no. 65097 having a very small part II).

PART I: as the description of Part I in thin section no. 65097.
PART II: as the description of Part II in thin section no. 65097 but with the following addition:

Primary structure: - other pedological features:
- carbonate nodules with an oblate crustic plasmic structure, sharp boundaries, spherical and ellipsoidal but sometimes subrounded, medium and fine;
- few manganese concretions as described in Part I of 65097.

REMARK: The plasma of Part II is non-crystic, but many crystallaria occur. This leads to the conclusion that the carbonate of the plasma has been dissolved and has been nearby recrystallized as crystallaria.
Description of thin section no. 65070 (Çumra area, Turkey)

Profile no.: 65-19 (= no. of soil peel)  Depth: 45-50 cm.  Horizon: (II)ACca b

Field description: W.P. Locher (Aug. '65)
Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1.4; cf. DRIESSEN and DE MEESTER, 1969).

Thin section description: W.P. Locher (Nov. '66)

PART I (appr. 30% of the thin section)

Plasmic structure: crystic (oblate carbonate crystals) and argillasepic.

Basic structure:
- fabric: vughy and channelled porphyroplastic to agglomeroplastic S-matrix.
- skeleton grains: - angular fine and medium quartz and felspars with a high and low sphericity;
  - fine angular calcite, equant to prolate, with a very fine crystic plasmic structure;
  - some micas and other well weatherable minerals.
- voids: - meso and very fine macro irregular vughs, sometimes interconnected;
  - very fine macro regular channels.

Elementary structure:
- fabric: glaebular;
- main pedological feature: carbonate nodules with an oblate crystic plasmic structure, sharp and rather sharp boundaries, spherical and ellipsoidal but sometimes subangular, medium and fine, sometimes some ferric impregnation.

Primary structure: - other pedological features:
- manganiferous concretions, spherical, medium;
- opaque organic nodules reflecting with incident light, prolate, medium;

continued
Description of thin section no. 65070 continued

- intercalary crystals of carbonate, very and extr. fine, oblate, clustered and random, sometimes cutanic to the walls of voids; mostly in a spot as described in Part II of thin section 65097.

- sedimentary relicts: inherited lithorelicts, coarse, with an argillasepic plasmic fabric, and a basic structure of lattisepic very fine acicular and medium triaxial skeleton grains, and fine organic nodules.

Secondary structure: spongey and very fine granular (the granules could be matric fecal pellets).

PART II (appr. 20% of the thin section)

Part II occurs mainly as an irregular united area, but also as very coarse spherical carbonate nodules.

Plasmic fabric: crystic.

Basic structure:
- fabric: vughy and channelled and crazed porphyroeskelic S-matrix;
- skeleton grains: few skeleton grains as described in part I;
- voids: - meso and very fine macro irregular vughs, sometimes inter-connected;
  - very fine macro regular channels;
  - meso craze planes.

REMARK: Part II contains less vughs and channels than Part I.

Primary structure:
- fabric: glaebular pedotubulic.
- pedological features: - carbonate nodules as described in part I under elementary structure, but now mostly with ferric impregnation;
  - pedotubules: ortho-aggrotubules (with matrix of Part I).
Description of thin section no. 65073 (Cumhra area, Turkey)

Profile no.: 65-19 (= no. of soil peel). Depth: 60-65 cm. Horizon: (II)C1ca

Field description: W.P. Locher (Aug. '65)
Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1.4; cf. DRIESEN and DE MEESTER, 1969).
Thin section description: W.P. Locher (Nov. '66).

PART I (appr. 70% of the thin section).

Plasmic structure: crystic (oblate carbonate crystals) and argillasepic.

Basic structure:
- skeleton grains: - medium and fine quartz and felspar, triaxial and oblate; few fine calcite, oblate and triaxial;
- few micas, coarse flintstone, heavy minerals.
- voids: - meso or very fine macro interconnected mammillated orthovughs;
- macro regular and irregular orthochannels;
- very fine macro craze planes.

Elementary structure:
- fabric: glaebular.
- main pedological feature: many carbonate nodules with an oblate cristi plasmic structure, sharp and rather sharp boundaries, subangular, with a high and low sphericity, medium, having sometimes some skeleton grains and meso vughs.

REMARK: It is something of a dilemma whether these features must be conceived as glaebules or as lithorelicts or as S-matrix. Surely they have a higher carbonate content than the surrounding S-matrix, but the contrast is much less than e.g. in thin section no. 65070. The difference between 65070 and 65073 is: 1) the carbonate content of the S-matrix in 65073 is higher; 2) in 65073 there are more "glaebules" than "S-matrix". When Part II is conceived as a lithorelict, the glaebules could be lithorelicts of this lithorelict.

continued
Description of thin section no. 65073 continued

Primary structure: - other pedological features:
- manganiferous concretions, spherical, medium (impregnated S-matrix);
- organic nodules and sedimentary relicts as described in thin section 65097.
- pedotubules: meta-aggrotubules of Ap-material (cf. thin section 65072).

Secondary structure: spongey and very fine granular.

PART II (appr. 30% of the thin section)

Part II occurs in Part I as extremely and very coarse subangular spots, dominantly with a high sphericity. A question is whether Part II must be conceived as glaebules of Part I or as a lithorelict. In the latter case Part I could be ortho-aggrotubules of Part II.

Plasmic structure: crystic (oblate carbonate crystals).

Basic structure:
- skeleton grains: few medium and fine quartz, felspar, calcite and mica, oblate and triaxial; few coarse other minerals.
- voids: - micro, meso or very fine macro irregular vughs;
  - very fine macro regular orthochannels.

Primary structure:
- fabric: pedotubulic and crystallaric.
- pedological features: few meta-aggrotubules and crystal tubes of carbonate.
Description of thin section no. 65075 (Çumra area, Turkey)

Profile no: 65-19 (= no of soil peel). Depth: 75-80 cm. Horizon: (II)C1ca b

Field description: W.P. Locher (Aug. '65).

Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1.4; cf. DRIESSEN and DE MEESTER, 1969).

Thin section description: W.F. Locher (Nov. '66).

Description of no. 65075 as that of no. 65073 with the following differences:

Related distribution pattern of Part I and Part II: spottishly Part I and Part II are more intensively mixed than in thin section 65073.

Secondary structure: fine subangular blocky and very fine granular.
Description of thin section no. 65076 (Gumra area, Turkey)

Profile no.: 65-19 (=no. of soil peel). Depth: 90-95 cm. Horizon: (II)C₁ca b

Field description: W.P. Locher (Aug. '65).
Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1,4; cf. DRIESEN and DE MEESTER, 1969).
Thin section description: W.P. Locher (Nov. '66).

Plasmic structure: crystic (oblate carbonatic).

Basic structure:
- fabric: crazed and vugby and channelled porphyroskelic S-matrix (some spots are agglomeroplastic).
- skeleton grains: - medium and fine and very fine felspar and quartz, triaxial and oblate;
  - fine and very fine calcite, oblate;
  - micas and medium other minerals.
REMARK: less skeleton grains than e.g. in thin section no. 65072.
- voids: - very fine macro parallel craze planes (= joint planes);
  1) meso, micro and very fine macro irregular vughs in the porphyroskelic Part;
  2) very fine macro and meso interconected mammillated vughs in the agglomeroplastic Part;
  - very fine macro regular orthochannels.

Elementary structure:
- fabric: glaebular.
- main pedological feature: coarse and very coarse carbonate nodules with an oblate crystic plasmic structure, browner and denser than the S-matrix (having few micro vughs), sharp boundaries, spherical, seldom having some skeleton grains.

continued
Description of thin section no. 65076 continued

Primary structure: other pedological features:
- few cutanic carbonate crystallaria;
- few manganiferous concretions and opaque organic nodules;
- lithorelicts, medium, equant, containing fine skeleton grains;
- pedotubules; meta-isotubules of Al-material, coarse, equant.

Secondary structure: The agglomeroplastic Part is spongy and very fine granular.
Photo 7: Review of an agglomeroplasmic and a porphyroskelic spot in 65076 with the same cryptic plasma. Thin section itself used as a negative (15x). Voids are black on the photo; some of the smaller black spots are skeleton grains. The limestone pebble is an incidental feature in profile 65-19. The carbonatic "nodules" could also be conceived as peds (grams).
porphyro skeletal part

agglomeroplastic part

void

carbonate nodules

skeleton grain

manganiferous concretion

very coarse calcitic skeleton grain with an extremely fine cryptic plasmic structure (limestone pebble)
Description of thin section no. 65077 (Cumra area, Turkey)

Profile no.: 65-19 (= no. of soil peel) Depth: 110-115 cm. Horizon: IIc1a b

Field description: W.P. Locher (Aug. '65).
Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1.4; cf. DRIESSEN and DE MEESTER, 1969).
Thin section description: W.P. Locher (Nov. '66).

Description as that of no. 65076 with the following differences:

- the elementary structure of 65077 is pedotubulic with coarse and very coarse ortho-aggrotubules;
- the carbonate nodules are medium and coarse;
- in addition the secondary structure is medium subangular blocky.

REMARK:
No. 65077 has more skeleton grains, more channels and vughs, more agglomeroplasmic spots and less carbonate nodules than no. 65076.
Description of thin section no. 65078 (Çumra area, Turkey)

Profile no.: 65-19 (= no. of soil peel) Depth: 130-135 cm Horizon: (II)C2

Field description: W.P. Locher (Aug. '65)
Mapping unit: Alluvial fan of May river, Alibey loamy soil, moderately deep over terrace soil (Am 1.4; cf. DRIESEN and DE MEESTER, 1969).
Thin section description: W.P. Locher (Nov. '66).

No. 65078 is a small thin section.

Plasmic structure: crystic (oblate carbonatic).

Basic structure:
- skeleton grains: - medium to very fine felspar and quartz, triaxial and oblate;
  - fine and medium well-weatherable minerals;
  - fine calcite, oblate.
- voids: - micro or meso mammillated orthovughs, sometimes interconnected;
  - very fine macro regular and irregular orthochannels.

Elementary structure:
- fabric: glaebular.
- main pedological feature: carbonate nodules, with an oblate crystic plasmic structure, browner and denser than the S-matrix (seldom having micro vughs and/or fine skeleton grains), sharp to diffuse boundaries, spherical and ellipsoidal, sometimes subrounded, medium and fine.

Primary structure: - other pedological features:
- few manganiferous concretions and opaque organic nodules;
- medium equant lithorelicts;
- pedotubules: - meta-isotubules of Al-material, coarse, equant.
Photo 8: The primary structure of 65078. The thin section itself used as a negative (15x). The black spots are voids or skeleton grains. The light grayish, more orless circular spots are carbonate "nodules".
Description of thin section no. 64101 (Çumra area, Turkey)

Field description: T. de Meester and C.C. Bannink (3-9-’64) (see Preliminary Report no. 1 of the Konya Project: T. DE MEESTER, 1964, A semi-detailed soil survey of the Çumra Area. In this report one can find the description of profile 64-2 under the head "Profile no. 1).

Mapping unit: Flat terrace soils, Okpu clayey soil, deep (Te 2.1) (cf. DRIESSEN and DE MEESTER, 1969).

Thin section description: W.F. Locher (31-7-1969).
No. 64101 is a small thin section.

Plasmic structure: skelsepic, crystic (oblate carbonatic) and argillasepic.

Basic structure:
- skeleton grains: - felspar and quartz, medium and fine, with all the four kinds of shape;
  - fine calcite, oblate and triaxial;
  - micas and many other minerals.
- voids: highly biogeneous structure with many kinds of channels, vughs and craze planes.

Elementary structure:
- fabric: glaebular
- main pedological feature: carbonate nodules with an oblate crystic plasmic structure, sharp and rather sharp boundaries, spherical and ellipsoidal but sometimes subrounded, fine to extremely coarse, sometimes containing few skeleton grains and meso vughs.

Primary structure: other pedological features:
- intercalary crystals of carbonate, mainly lublinite needles, but also oblate crystals especially in small parts (\(\frac{1}{3}\) mm\(^2\)) with a microstructure as described in Part II of the thin sections 65097 and 6571 (profile 65-19, 15-30 cm);
- manganiferous concretions, medium;
- fine opaque organic nodules.

Secondary structure: very fine and fine and medium crumb.
3.3 Micromorphology of Profile W 54

W 54 is a profile with a loamy topsoil of 34 cm lying over a subsoil of lacustrine soft lime (cf. 2.1). The field description is given on pp. 9-10. Classification according to the 7th Approximation 1967: typic udorthent. Two thin sections were made of undisturbed samples taken by Kopecki rings (20-25 cm and 50-55 cm). The observed microstructure confirms the field observations (see descriptions of thin sections no. 65091 and 65092 on pp. 22, 23). The topsoil has both carbonatic and argillic plasma ("argillasepic and crystic"), the subsoil has very much lime ("crystic"). Only biopores smaller than 1 mm are observed ("very fine macro ortho-channels"), no bigger holes or krotovinas. The "hard carbonate concretions" which were described in the field, are found back in the thin sections as "carbonate nodules", the most striking pedological feature. The subdivision between very dense and dense nodules, mentioned in the description of thin section 65091, has no parallel in the field description. Left aside the question how the presence of the nodules in the soft lime subsoil must be explained (sedimentation versus redistribution in the soil), the presence of the glaebules in the topsoil could be explained by postulating that this topsoil should be a residual soil, originated from the soft lime after solution of a part of the carbonates. The study of the microstructure gave no objections to this hypothesis. Confirmation could be got e.g. by the analysis of the clay mineralogy.

3.4 Micromorphology of Profile 65-18

No. 65-18 is an alluvial profile with a loamy topsoil and a stratified subsoil. Classification according to the 7th Approximation 1967: ustollic camborthid. Confer the field description (pp. 11 - 12) and the thin section descriptions (pp. 24-37).

Thin section no. 65104 (depth 30-40 cm): The result of alternating drying and moistening of the profile can be seen from the "skelseyepic and glaesepic" plasmic fabric, which means that part of the plasma lies oriented around skeleton grains and glaebules. (cf. photo 21).
These cutans are described under the head Primary structure as "extremely thin embedded grain stress argillans". In descriptions of other thin sections which also show a skelsepic fabric the description of these argillans is omitted because the term skelsepic already implies their presence.

The soil material cannot have been transported over a long distance because the skeleton grains are "very angular and angular with a low sphericity". This fact corresponds with the description of the physiographic unit as an alluvial fan (local river's sediments).

The profile has a reserve of mineral nutritious substances because many "well weatherable" minerals (e.g. pyroxene, hornblende, epidote, biotite, plagioclases) occur. Slower-weathering minerals such as other felspars, zircon and quartz are also observed.

The description of the voids shows that a rather high biological activity is present (mammillated vughs; channels), but not so high that the secondary structure is granular. However, locally krotovinas filled up with granules ("ortho-aggrotubules") occur.

In the field "pseudomycelium of lime" is described, which we find back in the thin section as crystallaria and "calcitans" (= cutans of calcite); lublinite needles occur in the crystallaria. Perhaps these crystallaria and calcitans are the only pedogenetic form of carbonate in the profile. The fine-crystalline carbonate glaebules ("carbonate nodules with an extremely and very fine oblate cristic plasmic structure") may be sedimentated (cf. chapter 4); thin section study does not give a definite answer.

The "clay balls" (see the remark with the description) form an interesting feature. If they should be rests of stratification one should expect to find also less rounded clayey spots in the thin section. This is not the case, so I can agree with the statement of DRIESSEN and DE MEESTER (1969, p. 30): "Presumably these clay balls have been translocated from elsewhere." However, deeper in the profile (e.g. thin section 65080, 63-68 cm) the clayey parts have somewhat less regular forms, and thin section 65085 (170-175 cm) shows a clear stratification. Thus a combined
hypothesis is proposed: the clayey parts of profile 65-18 originate partly from sedimentation as an entity (especially higher in the profile) and partly from rests of stratification (especially deeper in the profile).

Review of the thin sections of the whole profile:
With increasing depth the only striking difference with thin section 65104 is the stratification. Generally speaking the thin sections show an increasing heterogeneity in texture.
The thin section study adds little really new to the conclusions already drawn in the field concerning the geogenesis of the soil material and the biological homogenization (cf. 2.2).

3.5 Micromorphology of profile 65-19

No. 65-19 is a profile with an alluvial loamy topsoil lying over a terrace subsoil with a calcic horizon. Classification according to the 7th Approximation 1967: thapto calciorthic ustolic camborthid. Confer the field description (pp. 14 - 16 ) and the thin section descriptions (pp. 38 - 55 ).

Thin section no. 65072 (depth 5-10 cm):
The most striking feature of 65072 is the high carbonate content of the plasma: "crystic (oblate carbonate crystals)". "Argillasepic" is added, which means that the other part of the plasma consists of clay minerals (e.g. clay-humus) which do not occur in clearly oriented groups (asepic = without plasma separations).
The basic fabric is described as "porphyroskellic": within the primary peds (here many granules) a relatively high proportion of the voids is ultramicroscopic.
The skeleton grains are described as being "angular with a low sphericity" (= "triaxial") or "oblate" (= angular with a high sphericity). In case the topsoil of 65-19 be alluvial the soil material cannot have been transported over long distances (which would have resulted in rounded grains), which fact corresponds with the physiographic unit (alluvial fan).
Photo 9: A meta-isotubule (krotovina) in the II C2-horizon of profile 65-19. The pedotubule can be seen as a darker, rounded spot right on the photo (having more white spots = skeleton grains). Most of the black spots are voids. The rest of the photo shows the crystic soil plasma.
The high biological activity in this profile can be deduced from the voids directly made by animals (channels), and indirectly (vughs) as a result of the granulation, but also from the secondary structure which is mainly granular.

The carbonate nodules from another striking feature. They can be distinguished from the calcite skeleton grains by a finer crystalline structure. The description cannot give a definite answer to the question of the origin of these carbonate nodules. Several hypotheses are possible (see chapter 4).

Review of the thin sections of the whole profile:

With increasing depth the following trend is observed. The secondary structure becomes more subangular and spongey than granular, but the occurrence of pedotubules (krotovinas) shows important animal activity also deeper in the profile (see photo 9). So the biological activity changes from granulation to perforation. The carbonate content increases: in thin section 65070 (45-50 cm) spots of relatively pure carbonate are observed (distinguished as "Part II"). From 90-95 cm (no. 65076) the plasma is described as crystic only, which means that the argillic part of the plasma is nearly totally masked by the abundance of carbonates (HCl-treatment of the thin sections could produce an image of the argillic plasmic fabric if not too much of the carbonates occur as dolomite; cf. SLOTHOUWER 1968). Crystallaria occur less frequent than in profile 65-18, but are a striking feature in no. 65071 (25-30 cm), see the description of Part II. Of the other carbonates cannot be said whether they are pedogenetic or geogenetic (cf. chapter 4 and the remark in the description of 65073). The typical stratification in the subsoil of 65-18 is not observed in profile 65-19, which corresponds with the classification as mapping unit: 65-19 has a "terrace" subsoil. This leads to the question whether the material of the topsoil of 65-19 is alluvial (according to the mapping unit; horizon symbols and classification are adapted to this concept, see the profile description); or that the whole
profile must be conceived as a highly biogeneous terrace soil. A thin section description (no. 64101, see p. 56) of the topsoil of a typical terrace soil (profile 64-2) shows more resemblance with 65-19 than with 65-18, especially concerning the cryptic plasma (cf. the photos 3, 10 and 11). But this is no proof that the topsoil of 65-19 is "terrace". Clay mineral analysis could perhaps give a more definite answer.

Photo 10: The primary structure of the topsoil of profile 65-19.
Voids are black. The finely flecked whitish spots are carbonate nodules. The carbonate nodule in the centre of the photo is shown in detail on photo 12 (see 4.1).

Photo 11: The primary structure of the topsoil of profile 64-2.
Voids are black. The two finely flecked grayish large spots are carbonate nodules.

As has been mentioned in chapter 2 the sampling in the field appeared to be inadequate for studying the biological homogenization in the laboratory satisfactorily. At the time of my laboratory work the study of the carbonate fraction of the soil was a topic at our Department of Micromorphology. For these reasons it was decided to emphasize the carbonates in my laboratory work.

4.1 The description of the distinguished carbonate forms

The following carbonate forms could be distinguished:

A. "Nodules" (see photos 12 and 13): Nodules with a mostly extremely fine oblate crystic plasmic structure, mostly having sharp or rather sharp boundaries, and a spherical or ellipsoidal form, which implies that the angularity is rounded (however, sometimes subangular nodules occur). Generally the nodules vary in size between appr. 20 and 500 μm, and are seldom coarser. Sometimes they have some brown ferric impregnation. Inclusions can occur, e.g. of fine skeleton grains. Sometimes some meso or micro vughs are observed.

B. "Fields" (see photos 14-16): Spots ("fields" in the thin section) of various forms and sizes (mostly coarser than 1 mm), largely consisting of the same extremely fine (≤ 5 μm) oblate crystals as the nodules. Inclusions of skeleton grains and some voids occur.

C. "Crystallaria" (see photos 17-20): Crystallaria, i.e. groups and rows of crystals of various sizes (mostly smaller than 20 μm) lying in voids either clustered or somewhat apart from each other. They can be crystal chambers or crystal sheets. Mostly the crystals have an oblate form, but needles can occur.

D. "Calcitans" (see photo 21): Calcitans and neocalcitans, i.e. crystallaria that form cutans and neocutans to the walls of voids.
E. "Skeleton grains" (see photos 22 and 23): Calcite skeleton grains, either with an undifferentiated rock fabric or consisting of very fine (5-20 μ) crystals.

F. "Crystals": Solitary crystals, smaller than appr. 20 μ, lying in the S-matrix (intercalary crystals).

Below and on the next pages the photos nos. 12 to 23 inclusive can be found.

Photo 12: An ellipsoidal medium carbonate nodule with an extremely fine oblate crystic plasmic structure, and (rather) sharp boundaries.

The white spot in the corner on the right to the bottom is a calcite skeleton grain; ditto on the left: a part of a quartz grain.

Photo 13: A subrounded coarse carbonate nodule with partly an extremely fine and partly a fine oblate crystic plasmic structure, and with a high sphericity and a sharp boundary.

The two angular dark-gray spots in the nodule are skeleton grains (size appr. 100 μ). This nodule may be a lithorelict (limestone particle).
Photo 14: A carbonate "field" (Part II in the description of 65073) in polarised light.

The S-matrix consists largely of crystic plasma. Most of the black spots are voids. White spots are skeleton grains.

Photo 15: Like photo 14, but now in normal light.

The white spots are voids or skeleton grains. The spherical and ellipsoidal darker spots may be conceived as carbonate nodules with some ferric impregnation.

Photo 16: Review of Part I and Part II in 65073 (cf. photo 4).

Voids are black. In the corner to the left at the bottom a part of a carbonate "field" (described as Part II in 65073) can be seen, which has a rather dense primary structure. The rest of the photo shows the agglomeroplastic fabric of Part I.
Photo 17: **Cryallaria**

(polarised light).

The carbonate has been dissolved in the (dark) spots of argillasepic plasma and nearby recrystallized as groups and rows of crystals (white on the photo).

Photo 18: **Cryallaria**

(normal light).

Like photo 17, but now in normal light.
Photo 19: Crystallaria
(detail of photo 17)

Around the argillasepic (slightly lattisepic) plasma the carbonate is recrystallized as crystallaria (crystals with a size between 4 and appr. 50 μm).

The drawing belongs to photo 19.

Photo 20: Lublinite needles.
The fine white lines on the photo are crystallaria of lublinite needles. Voids are black. Crystallaria of oblate crystals can also be seen.
Photo 21: Crystallaria and calcitans.

The crystallaria, consisting of extremely fine to fine oblate carbonate crystals, sometimes lie as a cutan along the walls of the voids and can then be named calcitans.
Photo 22: **Calcite skeleton grains.**
To the left: a medium prolate calcite skeleton grain with a very fine and fine crystic structure.
To the right: a fine prolate calcite skeleton grain with an undifferentiated rock fabric. Voids are black.

Photo 23: **Desintegrating carbonate particles.**
To the left: a desintegrating carbonate nodule with a (mostly) extremely fine crystic structure.
To the right: a desintegrating calcite skeleton grain with a fine crystic structure. Voids are black.
4.2 The occurrence of the carbonate forms

The forms, A, C, D, E, and F occur both in profile 65-18 and profile 65-19. Form B (the fields) occurs only in profile 65-19. The forms C and D (crystallaria and calcitans) are an exception in 65-19, but are very common in 65-18. Accordingly the field description of 65-18 mentions pseudomycelium at all depths, and that of 65-19 does not mention pseudomycelium.

Table no. 4 gives a review of some literature where one or more of these carbonate forms are recorded, and of some thin sections of our Laboratory collection which show these forms.

N.B. It is not suggested that the morphology of the carbonates described in the recorded literature is quite the same as in my profiles: the table must be read in a general sense, e.g. "in profile 37 of Mulders carbonate nodules occur"; these nodules may have another size and another plasmic structure than described above under heading A.
TABLE no. 4  The occurrence of the six distinguished carbonate forms in some Turkish and non-Turkish profiles

<table>
<thead>
<tr>
<th>Reference</th>
<th>Country</th>
<th>Soil</th>
<th>Prof.no. (or thin section no.)</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<tr>
<td>this report</td>
<td>Turkey</td>
<td>camborthid (alluvial fan)</td>
<td>prof. 65-13</td>
<td>x</td>
<td>x</td>
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<tr>
<td>this report</td>
<td>Turkey</td>
<td>calciorthidic camborthid (alluvial over str. terrace)</td>
<td>prof. 65-13</td>
<td>x</td>
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<tr>
<td>this report</td>
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<td>calciorthid (structural terrace)</td>
<td>prof. 64-2</td>
<td>x</td>
<td>x</td>
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<tr>
<td>this report</td>
<td>Turkey</td>
<td>udorthent (lacustrine)</td>
<td>prof. W 54</td>
<td>x</td>
<td>x</td>
<td>x</td>
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<td></td>
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</tr>
<tr>
<td>MULDERS (1969)</td>
<td>Syria</td>
<td>calciorthids (alluvial)</td>
<td>e.g.</td>
<td>x</td>
<td>x</td>
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<tr>
<td>AL RAWI et al. (1968)</td>
<td>Iraq</td>
<td>entisols, vertisols (alluvial)</td>
<td>prof. 37</td>
<td>x</td>
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<tr>
<td>BLOKHUIS et al. (1969)</td>
<td>Sudan</td>
<td>vertisols (alluvial)</td>
<td>thin sect. 66091</td>
<td>x</td>
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<td>Our lab.collect. Czechoslovakia rendzina</td>
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<td>thin sect. 67227</td>
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</table>

| J. RÖDER (1967) Netherlands (Tholen) | entisols (marine) | thin sect. 66091 | x | x |   |   |   |   |
| H.G. LEFERS (1966) Netherlands (Zeeland) | inceptisols (marine) | thin sect. 66076 and others | x | x | x |   |   |   |
| H.L. SLOTHOUWER (1968) Turkey | calciorthids (lacustrine) | soil peels 66-C 3.1 | x | x | x | x | x | x | x | x |
4.3 The carbonate forms: pedogenesis versus geogenesis

A. "Nodules"

The origin of form A is generally thought to be pedogenetic (cf. e.g. SLOTHOUWER 1968; BLOKHUIS, PAPE and SLAGER 1969). Slothouwer (p. 28) states this opinion without giving a satisfying proof. Blokhuis gives reasonable arguments for his vertisols. In my case, I cannot be quite sure whether the observed nodules are pedogenetic or geogenetic (in the latter case they should be classified as skeleton grains, c.q. para-pedorelicts). The possibility that the nodules are skeleton grains cannot be excluded because e.g. thin section no. 67227 of a rendzina in Czechoslovakia shows that the plasmic fabric of limestone particles is sometimes the same as the plasmic fabric of the nodules described in this report. The nodules could thus be skeleton grains rounded by transport in river water. The other possibility is that the nodules were formed pedogenetically in a residual soil on limestone (e.g. a rendzina) and that later on they were transported by water (then they are para-pedorelicts in the terminology of Brewer).

My countings of carbonate in profile 65-18 (see table on page 83) do not show a clear trend concerning the size and number of the nodules in three horizons. In spite of the restrictions in drawing conclusions from these countings (see chapter 5) it can be said that very clear differences in size and number should have been observed by the countings if they would have been present. Now we see in profile 65-18 that:

a) there is no very clear connection between the size of the nodules and the texture of the horizon as a whole (170-175 cm contains fine-textured layers). If the nodules would be purely geogenetic one would expect that in finer-textured layers the glaebules are also finer-textured on the average; and

b) there is no particular horizon with many more nodules than the other horizons have (conclusion from counting on three thin sections, and "impression" from the field and other thin sections observations). This fact slightly indicates that the nodules should be geogenetic, unless the (pedogenetic) processes should be the same in all the horizons of this profile. The conclusion for profile 65-18 is that the nodules are either pedogenetic or geogenetic, but probably they are both.
Concerning profile 65-19 the same conclusion can be drawn, but an additional hypothesis is possible. The subsoil of 65-19, thought to be a structural terrace subsoil, contains form B ("fields"). The nodules here can have the same basic structure as the fields of carbonate; then they differ only in form. Many of these nodules were probably formed by granulation of the fields (then they are peds), and some of these glaebules may also have been transported to the (alluvial) topsoil by the high animal activity. Whether the granulation must be conceived as a result of external disruption by animals or as a result of passage in intestinal canals, is not quite sure (in the latter case the nodules could be called fecal pellets). I prefer the first hypothesis because probably the material would have been altered more if they were fecal pellets. An interesting investigation would be to test this hypothesis by taking worms (geophages) and have them burrow in a carbonatic soil sample, after which the results of the burrowing could be observed in thin sections.

B. "Fields"
The study of thin sections alone cannot give a definite answer to the question whether the irregular spots of carbonate-rich material (having mostly an extremely fine crystic plasmic structure) in profile 65-19 are lithorelicts (remnants of a soft limestone layer) or pedogenetic (recrystallized) carbonates. The ca-horizon consists partly of "fields" (Part II in thin section 65073, see pp. 46-48) and partly of spots with a lower carbonate content and a more porous structure (Part I in 65073). The fields contain some skeleton grains, but much less than in Part I; their mineralogical composition is about the same. So there are three important differences between Part I and Part II (cf. photos 6 and 14-16): Part I contains less carbonate in the plasma, has a higher number of (the same kind of) skeleton grains, and has a much higher porosity (more interpedal and intrapedal voids; the secondary structure of Part I is spongey and very fine granular where Part II has no secondary structure). These facts lead to the conclusion that the two above mentioned hypotheses are both equally probable:
1. If the fields (Part II) would be conceived as pedogenetic glaebules one has to suppose that during their growing these glaebules pushed aside most of the S-matrix, in order to explain the fact that their skeleton grain content is much lower than that of Part I. It is known that growing crystal groups can push aside soil material (cf. the origin of puffed solonchaks).

2. If the fields would be conceived as lithorelicts one has to suppose that soft limestone may contain some felspar, quartz and other skeleton grains, and moreover that Part I is a meta-pedorelict (i.e. material brought from another horizon by animals), in order to explain the higher number of skeleton grains in Part I. In thin section 65092 (see p. 23) of the C-horizon of Profile W 54 was observed that soft lime can contain some felspar and quartz grains indeed. And the secondary structure of Part I is a demonstration of the high animal activity.

In summary, the difficulty is that the results of the biological activity mask the results of the other processes. If there would have been carbonate concentration only or carbonate dissolution only, thin section study could have given an answer to the question which of the two processes had taken place.

C. "Crystallaria"
The crystallaria are undoubtedly pedogenetic carbonates, being recrystallized in voids, and having various crystal sizes. This can nicely be seen in thin section 65071 (prof. 65-19, 25-30 cm., where spottishly (Part II) the carbonate of the plasma has been dissolved and nearby recrystallized as crystallaria. Photos 17-19 show an identical spot in thin section 65097.

D. "Calcitana"
Sometimes the crystallaria form rather closed cutans of walls of voids. When the crystallaria lie on the walls Brewer speaks of calcitans, and when they lie subcutanically adjoining the walls their name is neocalcitans. Perhaps calcitans are formed via water movement from the voids into the S-matrix, and inversely neocalcitans by evaporation of the soil solution into the larger voids. But it is also possible that the local CO₂-pressure (related with the microbiological and plant root activity) plays the most important part whether a calcitan or neocalcitain is formed.
E. and F. "Skeleton grains" and "Crystals"

The name skeleton grains implies that the origin of this carbonate form is geogenetic. However, AL RAWI et al. (1968) state (p. 70): "The occurrence of calcite crystals in the thin sections often evidences a complicated pattern, both from the purely morphological and still more from the interpretative viewpoint. The difficulty arises when distinguishing between primary crystals, i.e. as part of the soil's skeleton particles and secondary formations, as they are both to be found in the same range of sand and silt size." Then they cite Kubiena who distinguished primary and secondary crystals on account of the crystal morphology (the intercalary crystals having rather well developed crystal faces). "However, it may be troublesome to distinguish these two kinds of calcite crystals in the case of fine, calcareous soil materials, the more when these are characterized by an ever dominating crystic plasmic fabric (calcite) which soaks both the skeleton and the plasma."

I experienced the same difficulties. Therefore, I often mentioned in the thin section descriptions the presence of both calcite skeleton grains and intercalary crystals without knowing exactly whether a certain particle is surely a skeleton grain or surely an intercalary crystal. But I do be sure that both are occurring, especially in the alluvial material that originates from a limestone mountain area (interrupted by volcanic rocks) and thus must contain calcite skeleton grains: it would be most unlikely that the geogenetic carbonate should only occur in the soil plasma. Finally, some of the "skeleton grains" could be small parts of shells ("biorelicts"; this term is suggested by Blokhuis et al. 1969).

For the investigation of the genesis of carbonate forms thin section studies are necessary, and they are very helpful in formulating hypotheses. However, drawing definite conclusions is often impossible. This requires application of other research techniques. A good example of such an investigation is that of Blokhuis et al. (1969). Next to micromorphology they applied stereomicroscopy, micro-techniques, X-ray diffraction, and chemical analyses. Additionally they reach to the conclusion (p. 198) "that good results can only be obtained when field studies support microscopic studies and vice versa." (spacing of me).
5. Some countings of carbonate particles on thin sections of profile 65-18

Although it was originally my intention to get a statistically justified quantification of the carbonate particles in profile 65-18, it will appear from the following that my results can only be used as an illustration of the occurrence of the different types of particles. Rather than completing my countings in a different way, I preferred to spend some time in evaluating the problems of counting on thin sections. The results of the investigation of literature on this subject will be given in a separate report. Some essentials will be mentioned here in order to explain my results.

The objects of the counting were:

A. to determine the total volume percentage of carbonates;
B. to determine the grain size distribution of the different types of carbonate particles;
C. to determine the trend of A and B in the profile.

The counting method was as follows. To select the particles which entered the sample, the thin section was traversed by a number of straight lines parallel to one side of the thin section, at equal intervals. The microscope table was moved while a line in the ocular "ran" over the thin section. Each carbonate particle that was crossed by the line was measured. So far the method was identical with the "continuous line integrator" method (cf. CHAYES, 1956), i.e. concerning the way of sampling. In measuring the particles I followed another method. With the continuous line integrator method the length of the segments of the line cut by the boundaries of the particles to be measured are added. I used the lines only as indicators of particles to be included in the sample. Hereafter I estimated with the eye the "equivalent diameter" of the particle and noted down this length. This equivalent diameter is twice the radius of a circle with the same area as the particle.

When I followed this method I did not realize that not all the above-mentioned objects could be attained by it. An evaluation will be given now.
5.1 Object A: determination of the volume percentage of a component

The soundness of the estimation of volume proportions by measuring areas (on thin sections) was already mentioned by DELESSE (1848). After him this equivalence of areal and volumetric proportions was called the Delesse relation. CHAYES (1956) gave a mathematical proof of the consistency of the Delesse relation; a proof can also be found in ANDERSON and BINNIE (1961).

A second problem is the method of measuring relative areas in thin sections ("modal analysis"). I cite Chayes (p. 2): "Thus, although any procedure which estimates the actual mineral composition of a rock is, strictly speaking, a modal analysis, nearly all modes are estimated by areal measurement performed on thin sections under the microscope. The instruments used for this purpose are now fairly numerous and quite varied in design and construction." And on page 31: "Although Delesse first proposed the basic relation to which we have assigned his name he developed no instrument specifically designed for modal analysis. His only "practical" contribution was a technique so impractical as to discourage imitation for nearly half a century." Nowadays the most important methods are point counting and continuous line integrator. "Estimates of areal ratios based on the counting of randomly located points are both consistent" and unbiased. Those based on parallel continuous lines are consistent but may be biased. (.....) it is reasonable to argue that the bias is ordinarily much smaller than the random error of the process and is therefore of little or no practical importance. (.....) In practice modal analyses are nearly always based on systematic rather than random

1) "consistent" kan het beste vertaald worden door "asymptotisch raak": "Een asymptotisch rake schatter is een schatter die, behoudens een willekeurig klein gekozen kans, ten hoogste een willekeurig klein gekozen verschil met de te schatten parameter vertoont, indien men de omvang van de steekproef voldoende groot neemt." Statistische termen, Normblad NEN 3117 (1968).

2) "unbiased = zuiver. "Een zuivere schatter is een schatter waarvan de verwachting gelijk is aan de te schatten parameter, wat ook de waarde daarvan is." (NEN 3117).
sampling. (.....) on the whole, biases introduced by systematization will be trifling except in the event of linear or periodic trends." (Chayes, pp. 9, 11 and 12). From this review of the conclusions of Chayes' argumentation we see that modal analysis on thin sections can give results which can be statistically evaluated (with confidence intervals, etc.). Naturally a precondition is to follow exactly the method for which is proved that it is consistent.

Now my interpretation of "line counting" appears to deviate from the continuous line integrator method as already mentioned above. As a result my method does not give a consistent estimator of the volume percentage of some kinds of carbonate particles (which was object A).

5.2 Object B: determination of grain size distribution

The determination of the grain size distribution of a rock or soil by means of thin sections is a very complicated matter. About this subject interesting papers are e.g. Münzner and Schneiderhöhn (1953), and Van der Plas (1962). Münzner and Schneiderhöhn used the continuous line integrator method in a variant called "Das Sehnenschnittverfahren": "Legen wir durch einen Dünnschliff eine Gerade, so stellen die Strecken, die innerhalb der getroffenen Kornflächenschritte abgeschnitten werden, die zu messende Sehnen dar. Ihre mikroskopische Ausmessung wird besonders einfach, weil es zur Ermittlung der Korngrößenverteilung nicht unbedingt erforderlich ist, die Sehnenlängen genau zu bestimmen. Es genügt vielmehr, nach Wahl einer Klasseneinteilung festzustellen, welcher Größenklasse jede beobachtete Sehne angehört." (p. 457). The authors gave a "Vergleichende Betrachtung von Sehnenlängenverteilung und Siebkorngrößenverteilung. Zur Untersuchung, ob und in welchen Ausmass die..."

') The total carbonate content can never be measured on thin sections because the fraction smaller than appr. 30 μm cannot be seen adequately as the thickness of the thin section is 15 μm. This must be done chemically (which is also much easier!).
gemessenen Sehnenlängenverteilungen sich von den entsprechenden Siebkorngrößenvverteilungen unterscheiden, wurden einige leicht aufbereitbare Sandsteine sowohl der Siebung als auch dem Sehnen­schnittverfahren unterworfen. Die gewonnenen Sehnenlängenverteilungen wurden (nach Umrechnung in Gewicht) mit den gefundenen Siebkorn­größenvverteilungen verglichen. Da das Sehnenschnittverfahren für grosse Körner oft nur kleine Sehnen liefert, lag die Vermutung nahe, dass bei den gemessenen Sehnenlängenverteilungen die Klassen mit feineren Korngrössen stärker besetzt seien als bei den Ergebnissen der Siebanalyse. Die tatsächlichen Befunde gaben jedoch ein anderes Bild: Die beiden Verteilungen wiesen zwar Unterschiede auf (sie waren in einigen Fällen allerdings bemerkenswert gering); in gar keiner Weise zeigte aber die Sehnenlängenverteilung das erwartete stärkere Auftreten feinere Korngrössen. (p. 458-459). For explaining this fact the authors distinguish three effects: Verkleinerungseffekt, Erfassungseffekt, and Formeffekt (p. 459). The "Verkleinerungseffekt" has been described in the quotation above. Among others it is caused by the "cutting effect": the area of a grain on the thin section mostly does not correspond with the largest section possible, so the Verkleinerungseffekt gives an underestimation of the larger grains. The "Erfassungseffekt" gives an overestimation of the larger grains, because the probability of hitting a grain by a line is directly proportional to the diameter of the visible grain area normal to this line. Finally the "Formeffekt" gives an overestimation of the larger grains in comparison with the sieve analysis, because long and narrow grains can pass relatively small sieve openings while they can give larger chords on the thin section. So the Formeffekt is caused by the deviation from the sphere-form.

When the grains are spheres, correction formulas can be calculated for the Verkleinerungseffekt and the Erfassungseffekt. Münzner and Schneiderhöhn state optimistically in their introduction: "In der vorliegenden Arbeit wird (....) eine Methode angegeben, die mit hinreichender Genauigkeit die Ermittlung der wahren Korngrössenverteilung in der gleichen Form ergibt wie die mit Hilfe der Siebanalyse gewonnene
Korngrössenverteilung." (p. 457). However, at the end of the paper they give an example of an analysis of a Buntsandstein and state: "Der Vergleich der Spalten (4) und (5) dieser Tabelle" zeigt in einigen Klassen eine gute Übereinstimmung, in anderen dagegen sind grössere Abweichungen vorhanden. Dieser Befund ist nicht verwunderlich, da die Körner des verwendeten Sandsteins keineswegs eine genau kugelige, sondern eine etwas längliche Form besitzen." Indeed, without the application of correction factors, the deviations are much larger (see column 6 of their tabel 7), but the authors admit that the deviations still present after the correction cannot be owed entirely to the "Formeffekt": the correction factors are calculated for grains of a sphere-form so that for a real sandstone the Verkleinerungseffekt and the Erfassungseffekt cannot be entirely eliminated. I may conclude that the "Sehnenschnittverfahren" gives only a consistent estimator of the grain size distribution in exceptional cases; herewith "grain size" is conceived as "the grain size measured with the sieve analysis". This addition is necessary. When Münzner and Schneiderhöhn speak of "der waren Korngrössenverteilung" (see the quotation above) we must ask: what is the real grain size distribution? It would have been better if they had omitted the work "wahren". Each granulometric method measures a different kind of "grain size". VAN DER PIAS (1962) remarks (p. 146): "Granulometric analysis in general is expected to give the same kind of information as is given by the volume frequency distribution. It is, however, impossible to arrive at a true volume frequency distribution in practical work. The best estimates of this type of variable are given by sampling methods based on resedimentation. These methods are only valuable for the small fractions of unconsolidated samples. However, the numerical results from resedimentation analysis are arrived at by calculations based on the assumption that the available particles are spheres with an arbitrarily fixed specific gravity." Thus we see that in this case not the particles with a size

Column (4) gives the weight percentages of the size classes, calculated from the "Sehnenschnittverfahren" (with the application of correction factors), and column (5) gives the weight percentages of the sieve analysis.
below a certain (fixed) value are measured, but just those particles which are still present in the suspension after a certain sedimentation time. Herewith the (e.g. pipette) method is not sentenced, but one must be careful to compare the results of a resedimentation method with a principally different method (e.g. estimation of the lutum percentage from the saturation percentage). If the volume frequency distribution is judged to be the best available information for a special purpose (e.g. the sedimentological circumstances of a quartz sand), one should bear in mind that a sieve does not only sort according to size, but also according to shape (cf. the "Formeffekt"). It may be possible that a granulometric analysis of two different sediments A and B, performed by the Sehnenschnittverfahren, gives more information about the differences between A and B than a sieve analysis of A and B, especially when the grain shapes in A and B differ from each other. Therefore, it is a pity that Münzner and Schneiderhöhn concentrated on the comparison with sieve analysis. They treated the reproducibility of the Sehnenschnittverfahren only when applied on a thin section of "Schrotkugeln" with a known size distribution, and not when applied on rocks (perhaps such a treatment is published in more recent literature?).

Resuming can be stated that the choice of the method of granulometric analysis must depend on two things:
1) The kind of information to be obtained determines whether we want to measure the size frequency distribution, the volume frequency distribution, or the number frequency distribution.
2) Comparison of two different samples succeeds best when the same method is applied. When this is not possible, that method must be chosen which gives the best approximation.

This leads us back to the question which sampling technique on thin sections gives the best estimator for the volume frequency distribution. With the aid of a theoretical experiment Van der Plas (1962) reaches to the conclusion that neither (uncorrected) line counting nor point counting gives a consistent estimator of the volume frequency distribution. FRIEDMAN (1965) attacked Van der Plas' conclusion about
point counting, but in my opinion it appears from their discussion that Friedman investigated a rock that just satisfied the exceptional conditions in which point counting of the grain size distribution gives good results.

Van der Plas (1962) recommends ribbon sampling as the best sampling technique for granulometric analysis: the bands within which all the (e.g. quartz, or carbonate) particles are to be counted should be laid systematically across the whole section. Thus there is no "Erfassungseffekt", but the cutting effect still exists.

In my case I used lines for the way of sampling. So I have to reckon both with the Erfassungseffekt and the cutting effect. The "Formeffekt" is avoided because I measured the "equivalent diameter" instead of the line segments, but this method of the equivalent diameter is subjective: no theoretical-statistical evaluation can be given. Whether the equivalent diameter method is useful when applied by a trained analyst, could be investigated empirically by comparison with another method of measuring areas (e.g. with a planimeter) on the same thin section.

The conclusion must be that also my object B, the determination of the grain size distribution of different kinds of carbonate particles in profile 65-18, could not be attained by the method I followed (let alone that not enough particles were counted). However, the figures (see table no. 5 on page 83) can be used as an illustration; bad figures are always better than no figures.

5.3 Object C: the trend of the carbonate content and size distribution in profile 65-18 with increasing depth

The countings were performed on three thin sections, the nos. 65104 (30-40 cm), 65082 (95-100 cm), and 65085 (170-175 cm), in order to get insight into questions such as the influence of weathering on the different kinds of carbonate particles. However, the distance between
these three samples is too large. Geogenetic differences of the horizons (stratification !) obscure the results of pedogenetic processes. Even counting of the available thin sections may be unsatisfactorily. A continuous sampling of the profile should have been the best method.

Thus a graphical representation of my figures (with profile depth as an ordinate) should be misleading.
5.4 Results of the counting

Four kinds of carbonate particles were distinguished:
1. nodules with an extremely fine crystic plasmic structure (abbr.: "nodules").
2. calcite skeleton grains with a very fine crystic structure (abbr.: "crystic calcite")
3. calcite skeleton grains with an undifferentiated rock fabric (abbr.: "calcite").
4. solitary crystals with a size of appr. 10 μ (abbr.: "crystals").

The carbonate was recognized on the thin section by the typical white-yellow-blue interference colours, after a training by comparing them with some thin sections (present in the collection of our laboratory) on which the carbonate is stained while of the same sample also a not-stained thin section exists.

The results of the counting are given in Table 5.

<table>
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<th>Profile depth (cm)</th>
<th>Number of counted particles</th>
<th>Sum of equivalent diameters (μ)</th>
<th>Mean diameter (μ)</th>
<th>Total line length (cm)</th>
<th>Number of particles per cm</th>
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<td>47</td>
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<td>892</td>
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</table>

For a discussion of these results see 5.1, 5.2, 5.3, and chapter 4.
6. REFERENCES


G.M. FRIEDMAN (1965), In defence of point counting analysis, a discussion (Grain-size determination and chemical analysis with the petrographic microscope). Sedimentology 4, 247-249.

L. van der PIAS (1965), In defence of point counting analysis, a reply. Sedimentology 4, 249-251.

G.M. FRIEDMAN (1965), In defence of point counting analysis: hypothetical experiments versus real rocks. Sedimentology 4, 252-253.


UNITED STATES DEPARTMENT of AGRICULTURE (1951; suppl. 1962), SOIL SURVEY MANUAL. Handbook 18.

USDA (1954), Saline and alkali soils. HANDBOOK 60.

USDA (1960; suppl. till September 1968), Soil classification, A comprehensive system, 7th APPROXIMATION.

C.J.G. WINKELMOLEN (1966), Salinisation and alkalisation patterns in some irrigated and non-irrigated areas of the Konya Plain, Turkey. Student’s report no. 135, Lab. of Reg. Soil Science, Wageningen.
## Index to the numbers of thin sections

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