# MICROMORPHOLOGY OF A TOPOSEQUENCE OF LATE-PLEISTOCENE FLUVIATILE SOILS IN THE EASTERN-PART OF THE NETHERLANDS.

by

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## Introduction .-

Late Pleistocene (Late Weichselian) fluviatile deposits occur at the surface in the Eastern part of the Netherlands (Koenigs, 1.949; Schelling, 1.951; Pons, 1.957; Poelman 1.965) and in larger areas in West-Germany between the Rhine and the border with the Netherlands (Fig. 1, Schelling, 1.951; Poelman, 1.965; Soil Survey Institute;1.975).

The geology (vertical stratigraphy) and physiography (soil map) enable the recognition of a toposequence of well drained sandy loam soils, imperfectly drained clay loam soils and poorly drained clay soils similar to the division of Schelling (1.951) and Pons (1.957).

Soil formation in this toposequence has been inferred from a detailed micromorphological study on 24 large thin sections. In literature detailed information about soil formation in these soils is lacking.

## Methods .-

The cross section has been made by augerings 5 to 30 meters apart and 220 cm deep. The soil map (1:10,000) is based on augerings 5 to 30 meters apart and 120 cm deep.

The profile descriptions are made according to the Soil Survey Manual (1.951, 1.962). Horizon designation A an (anthropic A horizon) is according to De Bakker and Schelling (1.966). The macromorphology is given as struc

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ture sketches following the suggestions and terminology of Jongerius (1.957) and profile sketches picturing important observations. Soil colors are Munsell colors of moist material. Soil classification according to the Soil Taxonomy (U.S.D.A., 1.975). Soil analyses comprise grain size distribution according to sieving and pipet method, the relative sand fraction (50-2000μμ) characterized by the median (Md 50) above and below which 50 % (w/w) of the sand fraction occurs. pH-KCl is determined potentiometrically in a 1:5 suspension of soil and 1N KCl by means of a glass electrode. Organic matter is determined by loss on ignition corrected for clay and calcium carbonate (Hofstee and Fien, 1.971). $P_2O_5$ is determined by X-ray fluorescence on $Li_2B_4O_7$ glass discs according to Halma (1.973). Impregnation for thin section preparation according to Fitz Patrick (1.970) and micromorphological description mainly according to Brewer (1.964). Counting results are obtained by point counting of 800 points (grid 3x3 mm). Clay fraction has been pretreated with hot 10 % $H_2O_2$ buffered at pH = 5 with Na acetate-acetic acid. Then centrifuging and decantation of the clear supernatant takes place. Dispersion is produced by NaOH addition to pH = 7 followed by two decantations of fraction $< 2 \mu m$ Suspensions with about 10 mg Na-clay are brought on porous tiles for X-ray diffraction by a suction technique according to van Reeuwijk (1.976).

Geology and physiography .-

A representative area of 12 ha near Heumen (Fig. 1) has been surveyed in detail resulting in a cross section (Fig. 2) and a soil map 1:10,000 (Fig. 3). The location of the cross section is indicated on the soil map.

The cross section very clearly shows the undulating topography with light textured deposits at higher elevations (especially in the Southwestern part; about 10 meters above Ordnance Datum). In the depressions (former gullies) heavier textured deposits are found, whilst in the major gully in the Northeast Holocene peat and clay overlies the Late Weichselian deposits (elevation about 8.5 meters above Ordnance Datum). Summarizing, the vertical stratigraphy can be divided into an undulating gravelly coarse sandy layer in the subsoil which can be correlated with the Fluviatile Low Terrace ("Niederterrasse") (Schelling, 1.951; Pons, 1.957, Steeger, 1.958; Braun und Quitzow, 1.961). Gradually the impact of the glacial era diminished and the sediment load of the river became sandier. This stratified sand deposit is apparent from the cross section. Sedimentation was not continuous and this sandy material could be blown out of periodically dry beddings thus forming local river dunes. When also the vegetation was gradually restored after disappearance of periglacial circumstances, the deposited material became progressively finer creating a layered complex consisting of sandy and clayey layers. Sedimentation became more continuous and sandy loam was deposited on the higher parts. The influence of the smaller gullies diminished and they silted up with clay loam. Gradually only major gullies remained active. Pons (1.957) dates the sedimentation of the sandy loam and clay loam between Pleni/glacial B and the Allerød When the Rhine deserted this floodplain and took its present course, peat grwth occurred in these major gullies from the Allerød into the Holocene (Pons, 1.957). Often a layer of Holocene clayey material covers this peat like in the gully in the Northeast.

The high ridge in the Southwest presumably has a plaggen epipedon because locally potsherd remnants have been found at a depth of 70 cm below the surface (see also micromorphology and analyses). The presumed original surface is indicated by a broken line in Fig. 2.

The soil map (Fig. 3) is based on some 140 augerings. The correlation of the legend units with topography can be seen on Fig. 2. The description of the legend units is given together with Fig. 3.

The soil map shows very clearly the major gully in the Northeast (unit Kv) bordered by heavy Pleistocene soils (units KLL2, LL2 and ML3) of which KLL2 has a thin Holocene cover. To the Southwest of this gully with associated heavy soils, a slightly elevated narrow ridge (unit ML1) occurs with associated sandy flankings (unit ML2). Another gully (units ML3 and ML4 in the centre) divides this narrow ridge from an elevated part with islands of well drained soils (unit HL1, HL2 and HL3) and associated sandy flankings (units ML1 and MI2). This relatively elevated part is separated from a very high rather broad ridge along the Looistraat (units HL1 and HL2) with sandy flankings (ML1) by yet another gully (units LL1 and ML4) broadening towards the Northwest with heavy flankings (unit ML3).

The investigated soils (location of pits indicated on Fig. 3) are representative for the units HL1 (Heumen I, altitude 10 meters; well drained sandy loam; Plaggept (U.S. D.A., 1.975); ML3 (Heumen II; altitude 9 meters; imperfectly drained sandy (clay) loam; Ochraqualf (U.S.D.A. 1.975) and KLL2 (Heumen III; altitude about 8.5 meters; poorly drained clay (loam); Haplaquept (U.S.D.A. 1.975). These soils form a toposequence representative for the surveyed area.

Macromorphology and data .-

The macromorphology of the investigated soils is presented schematically in Fig. 4. The moist colors have been mentioned in the description of their respective legend units. The structure changes from very weak subangular blocky tending to sponge structure, with many fine and common large biopores (Heumen I) to angular blocky and compound rough prismatic with common fine and many large biopores (Heumen II) to smooth prismatic with common fine and many large biopores (Heumen III). Slight mottling starts below 75 cm in Heumen I; strong mottling directly below the Ap and permanent reduction around 100 cm occurs in Heumen II and mottling in the top soil and around large biopores below the topsoil and permanent reduction around 50 cm occurs in Heumen III.

Some analytical data are given in Fig. 5. Heumen I has about 10 % clay in the top 95 cm, changing to about 20 % clay below that depth; Heumen II has 20–30 % clay abruptly changing to 6 % clay below 115 cm and HeumenIII has 35–40 % clay abruptly changing to 4 % clay below 90 cm. Correspondingly silt content increases and sand content decreases. The relative sand fraction shows a well expressed maximun in the 150–210 μm fraction in all three soils; Heumen I having a Md 50 of about 200 and HeumenII and III a Md .50 of about 160 .

Organic matter content is very high (8.1 %) in the topsoil of Heumen III remaining comparatively high (1.7 %) to about 50 cm but abruptly dropping to zero below that depth. The Ap horizon of Heumen II has 4.1 % organic matter abruptly dropping to negligible amounts below the tilled topsoil and Heumen I has 3.1 % organic matter in the Aanp, rather abruptly dropping to low values (0.5–0.3 %) in the remainder of the Aan.

pH-KC1 values are slightly above 4 (Heumen I) or slightly below 4 (Heumen II and III) indicating the very acid character of the soils. Due to fertilisation, the pH in the topsoils of all three soils is around 5.

The presence of the Aan horizon in Heumen I, apart from the potsherd fragments found during augering can also be appreciated from the $P_2O_5$ content which remains at a relatively high level to great depths in Heumen I (Pape, 1.970) in contrast to Heumen II and III where comparable figures are only found in the topsoils.

Micromorphology .-

The three soils show angular to subrounded skeleton grains and lithorelicts with a low sphericity of strongly va rying size and amount in accordance with the mechanical composition (Fig. 5). The composition of grains is similar in all three soils viz predominantly quartz with regularly mi cas and few feldspars, glauconite and other, unidentified minerals. Micas decrease in amount and size and they become more strongly weathered towards the topsoil. Felds pars show the same tendency but less clearly expressed. The distribution pattern of the skeleton grains changes from random to clustered and sometimes banded in the deeper subsoil.

The plasma consists of clay minerals, iron compounds and organic matter depending on the position in the soils. The amount of plasma becomes progressively higher from Heumen I to Heumen III. In Heumen I the groundmass has and asepic plasmic fabric and an agglomeroplasmic basic fabric and the plasma occurs in a slightly clustered distri bution pattern. In the IIB2tg horizon, the basic fabric is porous porphyroskelic. In Heumen II the plasma has mainly an asepic but locally an insepic plasmic fabric. To 35 cm depth the plasma is cloudy (possibly secondary silica). Reorientations (vosepic and skelsepic) occur regularly. The plasma occurs in a clustered distribution pattern and the groundmass has a porphyroskelic basic fabric, locally ve ry dense. In Heumen III the plasma has also mainly an ase pic plasmic fabric but insepic areas become more common. Reorientations (vosepic and skelsepic) occur frequently. The plasma occurs in a clustered distribution pattern and the groundmass has a porphyroskelic basic fabric, very dense below 60 cm.

The voids in Heumen I consist of many vughs and in terconnected vughs and common channels and compound packing voids of sizes up to some mm. Below 35 cm spora dically craze planes are found. In Heumen II many craze planes and common channels and vughs are found of sizes up to some mm. Below 115 cm the voids consist of simple packing voids. Below 85 cm the voids sometimes contain root remnants. In Heumen III craze and skew planes dominate and common channels and vughs occur with sizes up to some mm. Below 60 cm the voids often contain root remnants. Below 90 cm simple packing voids occur.

Special features .-

Welded and single matric fecal pellets (ϕ100-300 μm) are found in Heumen I in the upper 70 cm together with common pedotubules (aggro- and isotubules) whilst from 110-125 cm depth also striotubules are encountered. In Heumen II welded and single matric fecal pellets (ϕ100- 300 μm) are found especially in the upper 35 cm. Pedotubules (aggro and isotubules) to some mm are commonly found to 95 cm depth. Granotubules are occasionally found in the top 10cm. In Heumen III few welded and single matric fecal pellets (ϕ50-100 μm) are found in the top 15 cm and only occasionally in the deeper layers to 60 cm depth. Pedotubules (aggrotubules but especially isotubules) up to some cm are commonly found throughout the soil, sometimes within root remains.

Channels, normal void and free grain ferri-argillans (50-100 μm thick) occur in layers below 80 cm depth in Heumen I (photo 1), whilst also many ferri-argillaceous papules are found. Part of these features have a characteristic grainy morphology (photo 2 and 3; Brinkman et al, 1.973) and sometimes occur covered by neoferrans. Thin (10-30 μm) channel, normal void and free grain matri-ferri-argillans (van Schuylenborgh et al, 1.970) are found from 35 to 95cm depth becoming thicker (to 500 μm) below (photo 4). Quantification of ferri-argillans and derived papules by means of a point counting results in about 4 % (v/v) whilst matri-ferri-argillans occupy 0.5-1 % (v/v). In Heumen II channel and normal void (ferri)-argillans occur principally below

50 cm depth with many derived ferri-argillaceous papules. Below 100 cm also free grain ferri-argillans are found. The distribution of these features is not random. Between 50 and 95 cn they occur predominantly in the oxidized parts of the groundmass (photo 5) frequently covered by neoferrans (photo 6). In the reduced parts of the groundmass, the argillans and derived papules have a characteristic grainy morphology. With depth alternating layers with more and less ferriargillans occur. Thin (10-30 ) matri-ferri-argillans occur from 25-35 cm becoming thicker (to 1 mm) below that depth. Quantification (Fig. 6) shows 3-5% (v/v) (ferri)-argillans and derived papules below 50 cm and 1-2 % (v/v) matri-ferri-argillans below 25 cm. In Heumen III no (ferri)-argillans have been found. Sometimes weathered micas form cutans which have been observed in all three soils (Mermut and Pape, 1.971). Matri-ferri-argillans (10-50µm thick) are found below 15 cm and (organo)-matrans (50-300µm thick) also are present. Quantitatively (Fig. 6) these features occupy 1-2 % (v/v).

Below 65 cm and increasing with depth in Heumen I distinct neo-and quasi ferrans (10-50µm thick) with diffuse boundaries occur, sometimes covering ferri-argillans, together with distinct round to irregular ferri-manganiferous nodules (ø50µm to some mm). Only sporadically ferric nodules are found above 65 cm. Below 110 cm differences in iron content in the groundmass can be noticed. In Heumen II distinct irregular neo-ferrans (20- 100µm thick) lining channels and planes are found from 25-100 cm. Between 50 and 80 cm also many quasi-ferrans and neo-and quasi-mangans are found. Ferri-manganiferous nodules (50µm to some mm) are found frequently to 100 cm. However, the iron distribution cannot be adequately described in these terms. The groundmass below 25 cm is built up of ironrich (oxidized) parts and ironpoor (reduced) parts. From 25-50 cm these parts occur randomly distributed in the groundmass; from 50-80 cm the reduced areas occur along planes and channels, whilst the interiors of the peds are oxidized (photo 5.). From 80-100 cm randomly distributed oxidized parts occur in a reduced groundmass and below 100 cm the groundmass is completely reduced. In Heumen III many neo-and quasi-ferrans (photo 7) with diffuse boundaries occur as linings along planes and channels. They may be up to some cm thick but normally they are 20 µm-1 mm. Fe - rric nodules (20 µm-1 mm) are regularly present to 90 cm. Essentially the groundmass between 30 and 50 cm is predominantly reduced but with some randomly distributed oxidized parts. Below 50 cm the mentioned features occur around large voids (with only partly decomposed plant remains) in a reduced groundmass.

Plant remains occur in the topsoil of all three soils and in the reduced subsoils of Heumen II and III. Charcoal fragments are encountered regularly in Heumen I and occasionally in Heumen II and III. Baked loam fragments (1-4 mm) are found in the upper 70 cn of Heumen I (photo 8.). The top 30 cm of Heumen III consists of an irregular mixture of various composition. Sporadically in the A1g horizon biogenic carbonate has been found.

Clay mineralogy .-

X- ray diffractograms of Heumen I show strong peaks at d-spacings of 7 Å (Kaolinite), 10 Å (Illite) and 14 Å (chlorite, vermiculite, smectite) none of which is clearly dominant. Kaolinite is relatively constant with depth but decreases in the II B2tg, whilst illite shows the opposte. Soil chlorite is predominantly responsible for the 14 Å peak with some vermiculite. Only in the II B2tg part of the 14 Å peak is caused by smectite. In Heumen II the 14Å peak clearly dominates. Kaolinite stays relatively constant with depth but illite increases with depth. The 14 Å peak consists of some soil chlorite but predominantly vermiculite which decreases with depth and smectite which increases with depth. In Heumen III the same results as in Heu -

men II are found. In all three soils a shoulder between 10 Å and 14 Å indicates interstratifications of clay minerals and small quantities of quartz and minute quantities of feldspars complete the picture.

Discussion and interpretation .-

The soils of this toposequence from a landscape with an undulating topography. This topography is caused by an intricate pattern of shallow former gullies and slightly elevated ridges. In the cross section the correlation of elevation and texture of the deposit is clearly illustrated, as well as the stratified character of the deposits. The depositional environment is characteristic for braided river sediments. Micromorphologically the original stratification is appreciated from the clustered occurrence of plasma and the change from random to clustered and banded distribution of the skeleton grains with depth. Presumably the material has been deposited with little or no organic matter in view of the very low contents of organic matter below the A horizons. The very clear maximum in the 150-210 fraction in the relative sandfraction is explained by blowing out of finer sand particles during sedimentation (Pons, 1.957) or mixing with coarser sand also deposited by the braided river (Schelling, 1.951). The material dates from the Late Weichselian period (Pons, 1.957) and has not been covered by younger sediments except in the major gully in the Southwest. Hence soil formation has taken place over a period of about 10,000 years. It is assumed that the deposits have been originally calcareous and have been completely decalcified since. This assumption, however, cannot be proved by analytical or micromorphological data. Weathering has proceeded further in the topsoil than in the subsoil as is evident from the clay mineralogical data and the micromorphological observations concerning amount and weathering stage of micas and feldspars. This long continued weathering has produced very acid soils, (pH-KCl around 4).

The investigated soils strongly vary in texture which is also apparent from the structure, becoming more pris - matic from Heumen I to III. The amount of clay plasma, moreover, and the occurrence of plasma reorientations increases and the voids change from vughs and interconnected vughs to craze and skew planes. The biological activity decreases as is evident from the micromorphological description (compound packing voids, fecal pellets, pedotubules, papules) although many large channels remain present (earthworm activity). In view of the occurrence of ferri - argillans in biogenic voids, it can be concluded that biological activity must have been active before the start of clay illuviation, presumably biological activity has been present since deposition up till now.

Illuviation of mineral material has taken place in all three soils. Illuviation of fine clay, resulting in ferri-argillans and derived papules has been moderate to strong (Miedema and Slager, 1.972) in Heumen I and II (argillic horizon) but is absent in Heumen III. Bases on field observations Pons (1.975) already suggested the presence of an argillic horizon in such soils. The fact that the majority of these features occurs translocated (papules) points to the fossil character of the clay illuviation, which can also be appreciated from the covering of these features by neoferrans and neomangans. The predominant occurrence in Heumen II of clay illuviation features in the oxidized interiors of peds suggests that the clay illuviation has taken place under circumstances of better drainage. Illuviation of matri-ferri-argillaceous material has taken place in all three soils, although in Heumen I to a lesser extent than in Heumen II and III. If matri-ferri-argillans occur together with ferri-argillans, the former cover the latter suggestiong that the process resulting in matri-ferri-argillans succeeds the clay illuviation. Illuviation of matri-ferri-argillaceous is presumably correlated with agricultural use and is therefore a relatively young process. In situ weathering cutans of micas (Mermut and Pape, 1.971) have been occasionally observed in all three soils.

In this toposequence the drainage of the soils ranges from well drained to poorly drained. Heumen I shows micromorphologically features associated with (pseudo)gley below 65 cm (neoferrans, ferri-manganiferous nodules), whilst below 110 cm also differences in iron content of the groundmass have been noticed. These features of iron segregation cover clay illuviation features suggesting that (pseudo)gleying is a more recent process than clay illuviation. The grainy cutans due to clay decomposition (Brinkman et al, 1.973) point to pseudogley. In Heumen II it is possible to distinguish between gley and pseudogley (Bouma et al, 1.968; Bouma and Van Schuylenborgh, 1.969). Especially the layer between 50 and 80 cm shows oxidized interiors of peds with bleached areas in between. These bleached areas contain grainy cutans due to clay decomposition and also the cloudy character of the plasma in the A2g horizon (possibly secondary silica) points to pseudogley. Below 80 cm gleying is the most important with permanent reduction at 100 cm depth. As previously stated we consider clay illuviation to be a fossil process which has taken place under well drained conditions leading to an argillic horizon which promoted pseudogley. A rising groundwatertable (gley phenomena) has influenced the subsoil of Heumen II. In Heumen III only gleying has taken place.

The drainage condition of this soil, bordering a major gully, has always been bad, which prohibited clay illuviation. Illustrative for this poorly drained soil are the partly decomposed root remains present in large pores below 50 cm and the associated neoferrans around voids in a reduced groundmass.

The presence of a plaggen epipedon of about 70 cm in Heumen I is based on the potsherd fragments found during augering at 70 cm depth, the content of $P_2O_5$ and the presence of rather much charcoal and especially baked loam found micromorphologically.

The top 30 cm of Heumen III consists of a mixture of strongly varying composition. Presumably Holocene and Pleistocene material has been mixed by human activity.

Based on the presented data, Heumen I has a plaggen epipedon and a buried argillic horizon and is classified as Plaggept (U.S.D.A. 1.975). Heumen II has an ochric epipedon, an argillic horizon and hydromorphic features and is classified as an Ochraqualf (U.S.D.A., 1.975). Heumen III has an ochric epipedon, a cambic horizon and hydromorphic features and is classified as a Haplaquept (U.S.D.A. 1.975).

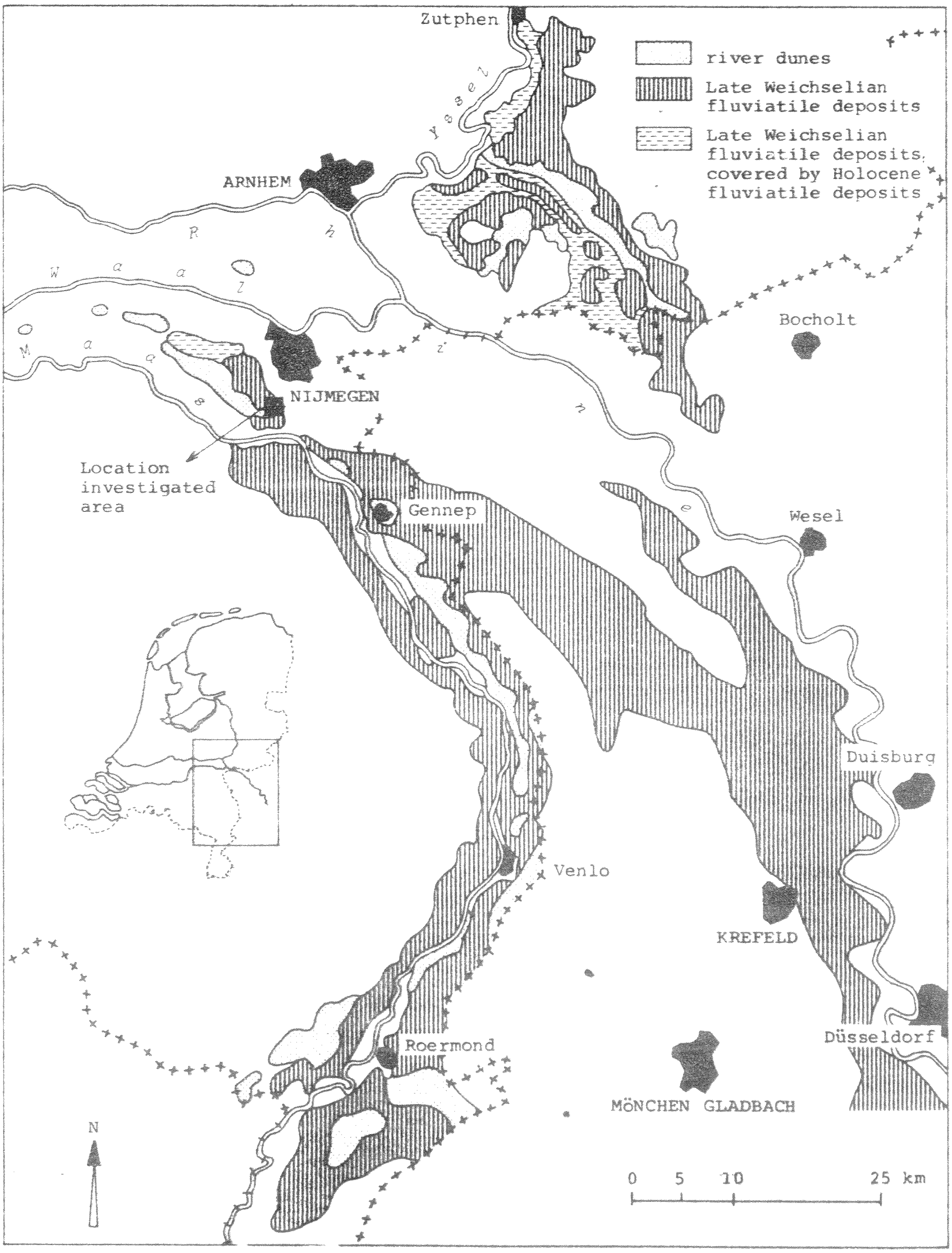
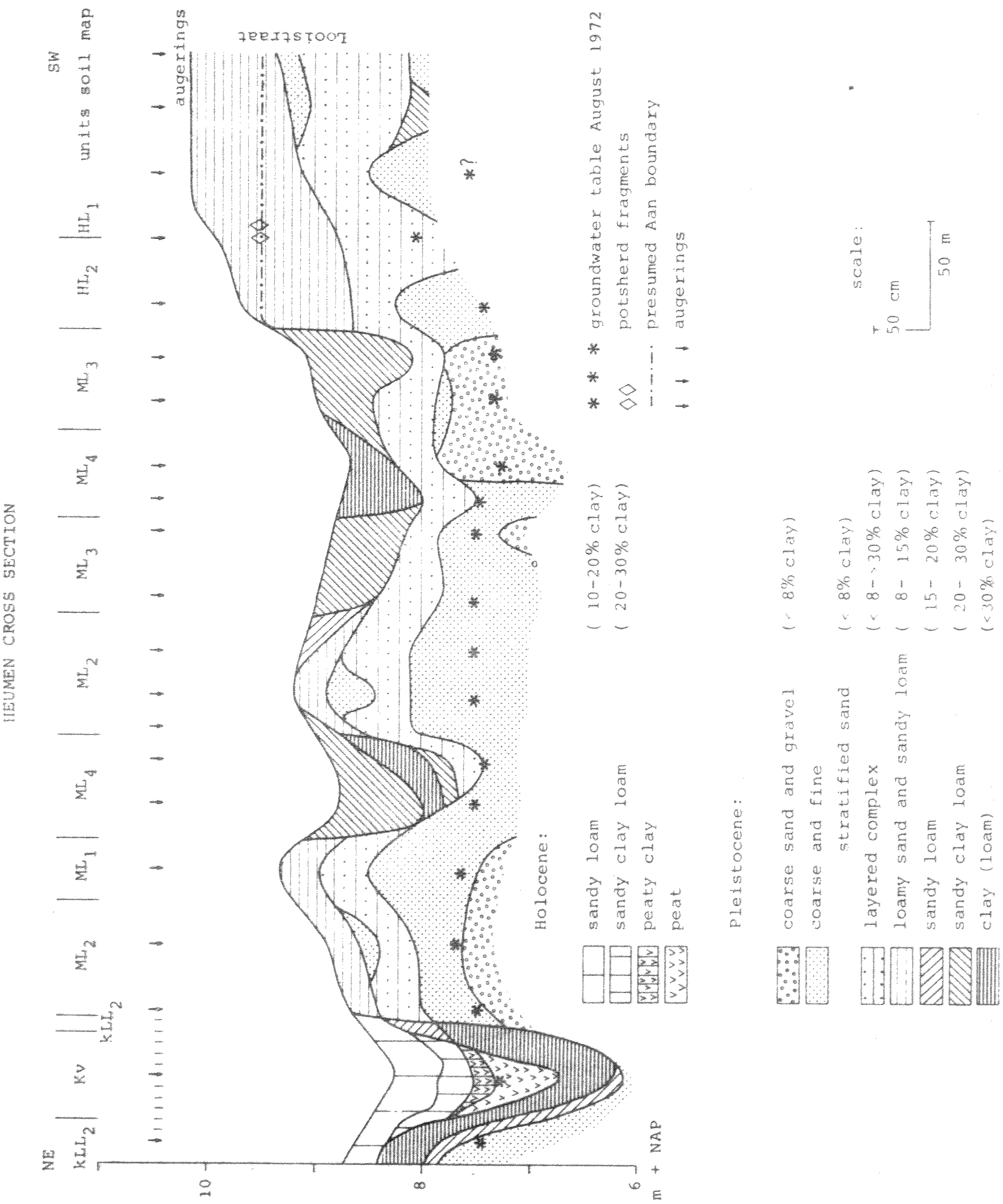



Fig. 1 : Distribution of Late Weichselian deposits in the Eastern part of the Netherlands and adjoining of West-Germany (after Schelling, 1.951 and Poelman, 1.965) and location of the investigated area.

Fig. 2: Representative cross section of the surveyed area:



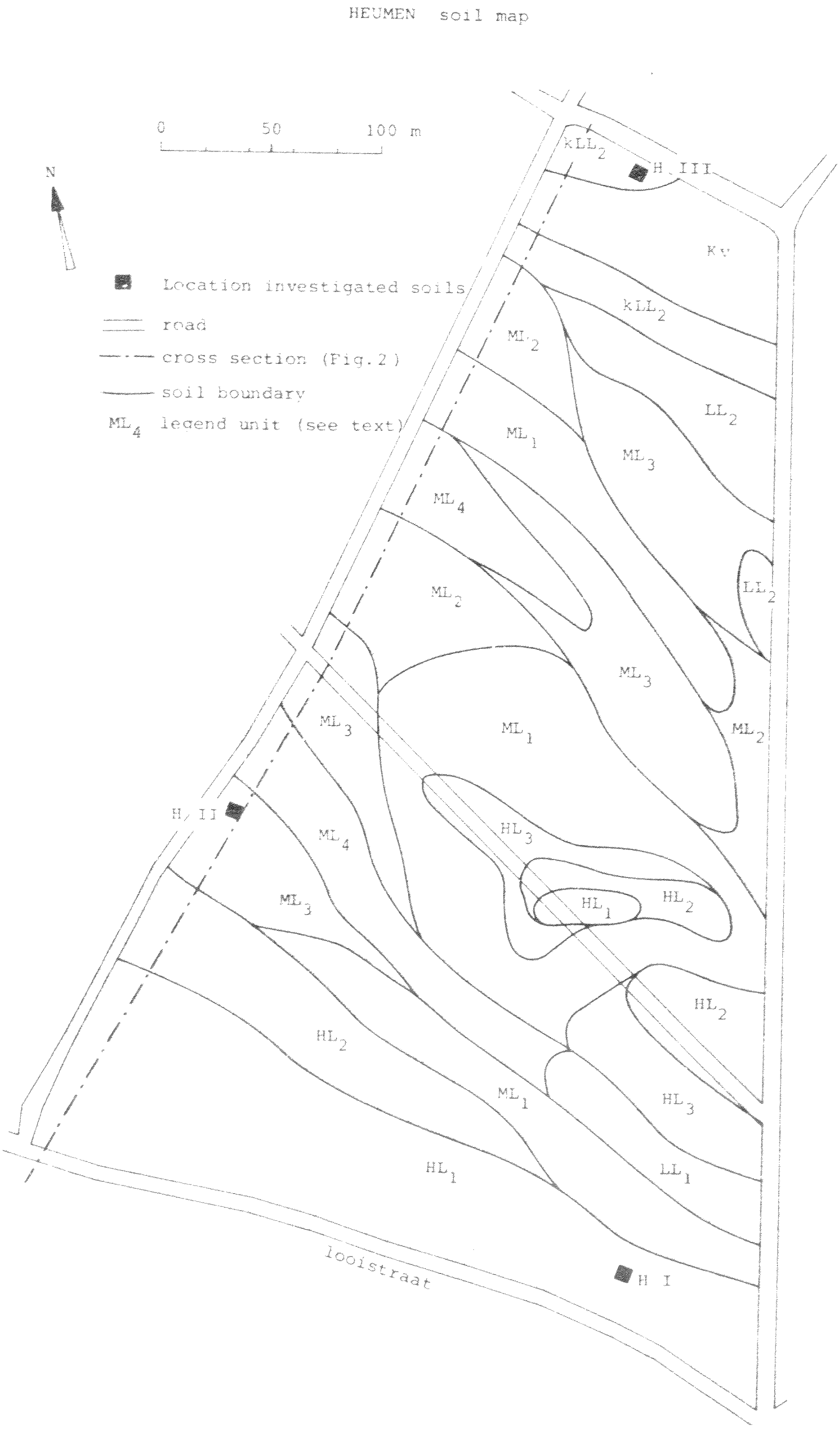



Fig. 3 : Soil map (1: 10,000) of the surveyed area and location of investigated soils and cross section.

## DESCRIPTION OF LEGEND UNITS .-

HL 1: Well drained brown sandy loam soils (soil Heumen I)
The tilled topsoil is about 30-40 cm, dark brown (10 YR 3/3) and has 10-15 % clay, overlying dark yellowish brown (10 YR 4/4) material of the same texture to depths larger than 80 cm. Below 80 cm the material becomes slightly mottled and changes below 100 cm to (loamy) sand or the layered complex; occasionally a stratified heavier deposit occurs.

HL 2: Moderately well drained brown sandy loam soils.
As HL 1, but mottling starts between 40 and 80 cm usually around 60 cm depth.

HL 3: Moderately well drained mottled brown sandy loam soils.
The tilled topsoil is about 30 cm, (dark) brown and has about 20 % clay overlying a brown, weakly mottled sandy loam of 10-15 % clay on the layered complex starting around 80 cm depth.

ML 1: Imperfectly drained mottled gray brown sandy loam soils.
The tilled topsoil is about 30 cm, (dark) brown and has about 20 % clay overlying a pale brown weakly mottled sandy loam of 10-15 % clay becoming clearly mottled and heavier (15-20% clay) around 70 cm depth, changing into the permanently reduced layered complex around 100 cm depth.

ML 2: Imperfectly drained strongly mottled gray brown sandy loam soils.
As ML 1, but mottling is more expressed immediately below the tilled topsoil.

ML 3: Imperfectly drained strongly mottled (sandy) clay loam soils. (soil Heumen II).
The tilled topsoil is about 25 cm, brown (10 YR - 5/3) and has about 25 % clay overlying a strong-

ly mottled pale brown (10 YR 6/3) sandy clay loam (20 -25 % clay) on strongly mottled light gray and strong brown (10 YR 7/1 & 7.5 YR 5/6) clay loam with 30-35 % clay, around 100 cm depth abruptly changing into the (light) gray (10 YR 6/1) permanently reduced layered complex.

ML 4: Imperfectly to poorly drained strongly mottled (sandy) clay loam soils.
The tilled topsoil is about 25 cm, gray brown and slightly mottled and has about 25-35 % clay overlying a strongly mottled material of the same texture (often stratified), changing between 40 and 80 cm, depth into permanently reduced material often belonging to the layered complex. Within 120cm regularly gravelly coarse sand is found.

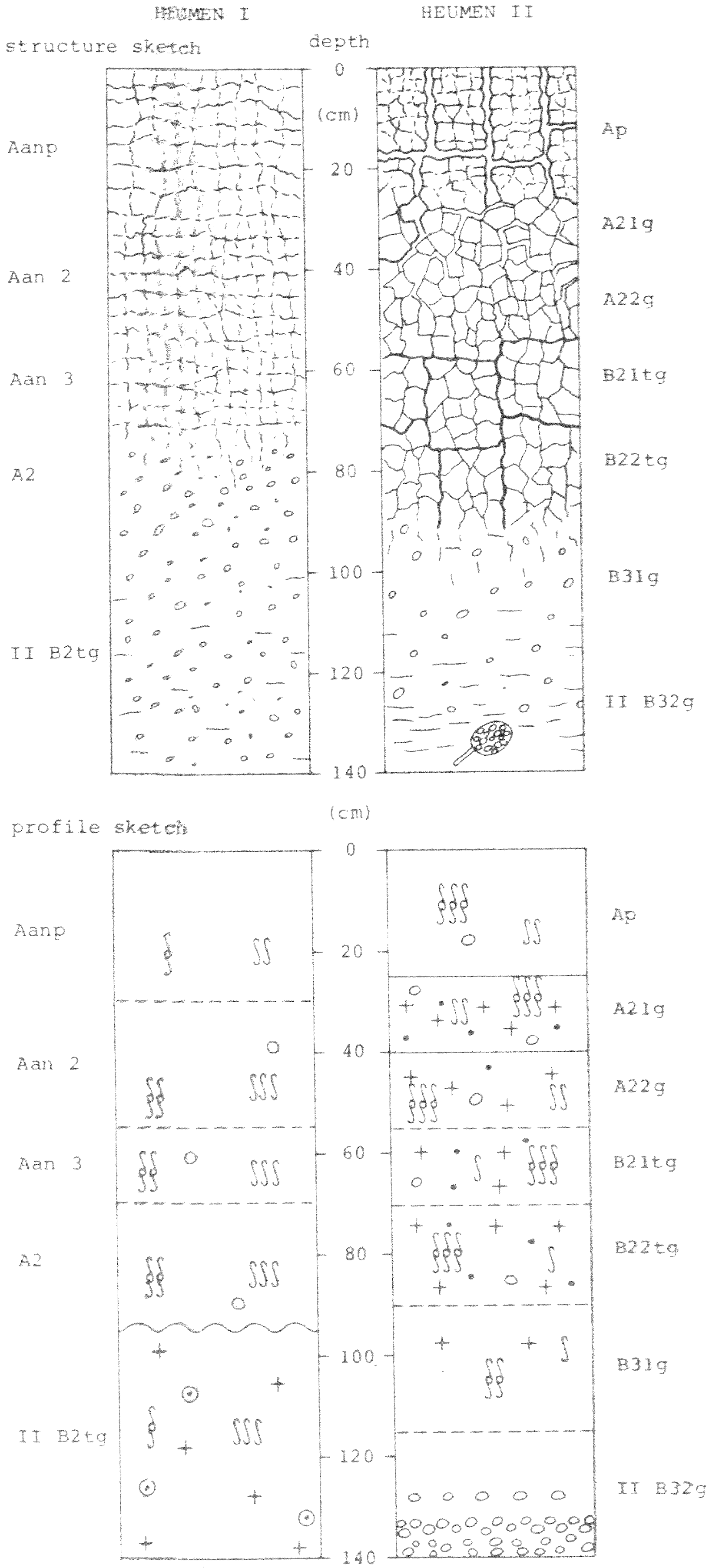
LL 1: Poorly drained, slightly mottled gray sandy loam on mottled clay loam soils.
The tilled topsoil is about 30 cm, gray brown and mottled and has about 20 % clay overlying a slightly mottled gray brown sandy loam (10-15 % clay) changing around 80 cm depth into a strongly mottled gray clay loam (30-35 % clay) with root remains.

LL 2: Poorly drained mottled gray clay (loam) soils.
The topsoil is about 20 cm, dark gray brown (10 YR 4/2.5) and mottled and has about 35-40 % clay overlying a mottled gray brown (10 YR 5/2) clay (loam) of the same texture changing around 50 cm into gray (10 YR 6/1) permanently reduced clay of 40 % clay or more with root remains, sometimes changing within 120 cm abruptly into the layered complex with root remains.

KLL 2: Poorly drained mottled gray clay (loam) with a cover of Holocene clay (loam) soils. (soil HeumenIII)
As LL2, but with a cover of 20-50 cm Holocene clay (loam).

KV : <u>Very poorly drained dark gray clay (loam) on peaty material (Holocene) on gray Pleistocene clay soils.</u>

The topsoil consists of dark gray clay (loam) and has 35-45 % clay with much organic matter. Occasionally a sandy (clay) loam with about 20 % clay overlies this heavier material. Between 40 and 70 cm depth, it changes to peaty clayey material (Holocene), abruptly changing between 70 and 100 cm depth into permanently reduced bluish gray Pleistocene clay.


HEUMEN I
HEUMEN II
structure sketch
depth
(cm)
0
20
40
60
80
100
120
140
Aanp
Aan 2
Aan 3
A2
II B2tg
Ap
A21g
A22g
B21tg
B22tg
B31g
II B32g
profile sketch
(cm)
0
20
40
60
80
100
120
140
Aanp
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Aan 3
A2
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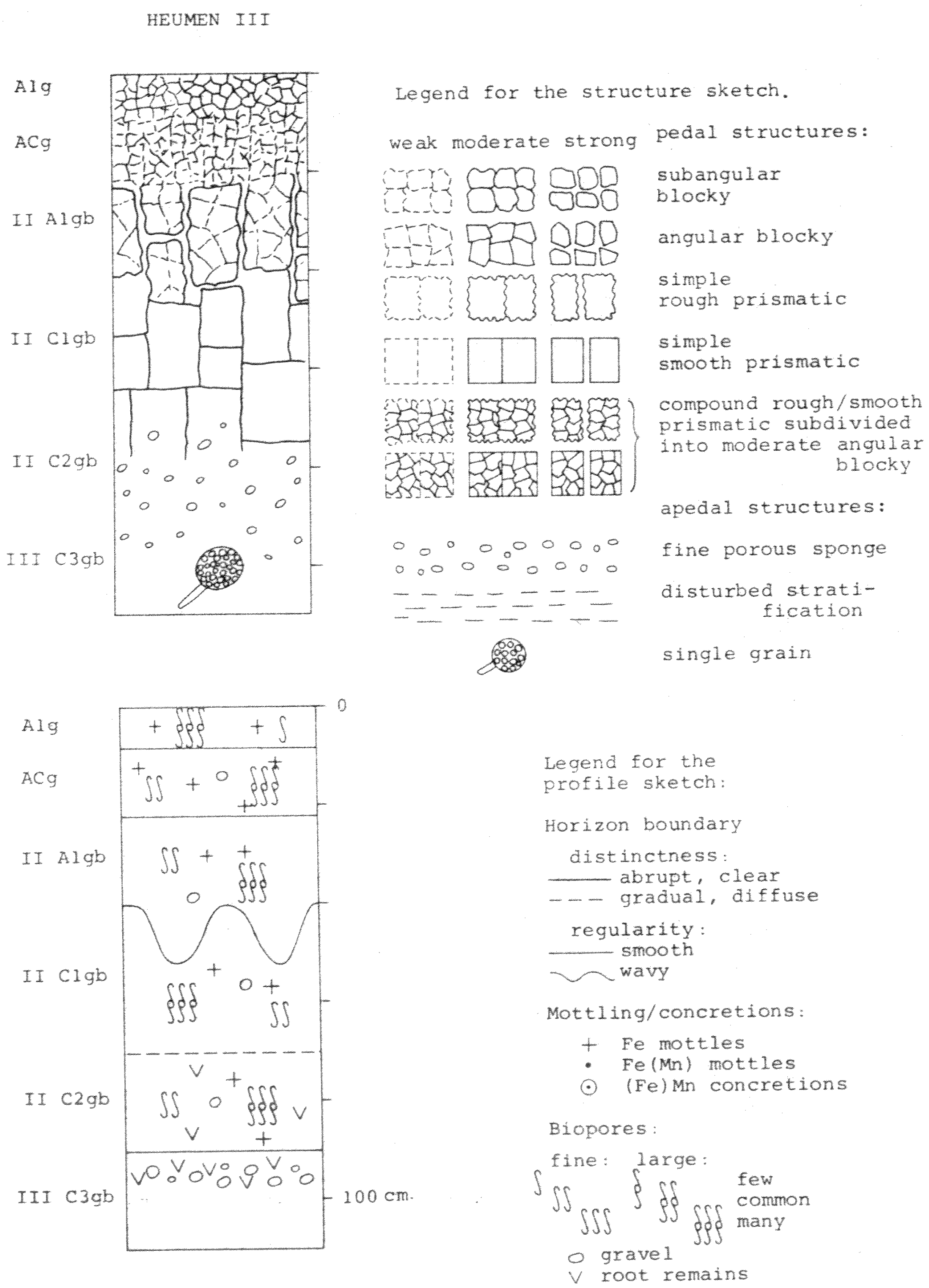
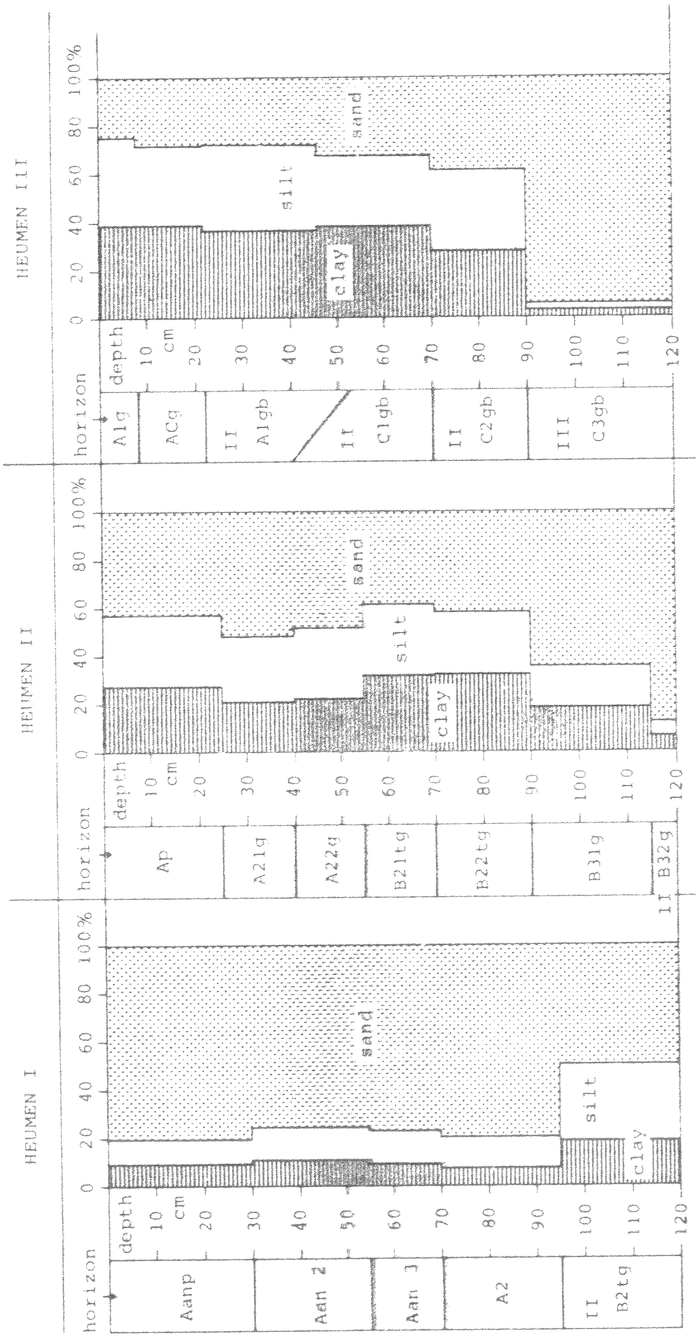



4 : Schematic presentation of structure and other macromorphological observations of Heumen I,II and III.




**HEUMEN I**

| | % $P_2O_5$ | % org. matter | pH-KCl | Md 50 |
|---|---|---|---|---|
| Aan p | 0.23 | 3.1 | 5.2 | 275 um |
| Aan 2 | 0.21 | 0.8 | 4.3 | 205 |
| Aan 3 | 0.18 | 0.5 | 4.2 | 195 |
| A2 | 0.15 | 0.3 | 4.2 | 200 |
| IIB2tg | 0.08 | 0.3 | 4.1 | 135 |

**HEUMEN II**

| | % $P_2O_5$ | % org. matter | pH-KCl | Md 50 |
|---|---|---|---|---|
| Ap | 0.17 | 4.1 | 4.9 | 160 um |
| A21g | 0.06 | 0.3 | 3.9 | 150 |
| A22g | 0.10 | 0.0 | 3.7 | 165 |
| B21tg | 0.08 | 0.1 | 3.7 | 160 |
| B22tg | 0.08 | 0.0 | 3.6 | 150 |
| B31g | 0.04 | 0.0 | 4.1 | 145 |
| IIB32g | 0.06 | 0.3 | 4.1 | 225 |

**HEUMEN III**

| | % $P_2O_5$ | % org. matter | pH-KCl | Md 50 |
|---|---|---|---|---|
| A1g | 0.25 | 8.1 | 5.0 | 165 um |
| ACg | 0.11 | 3.6 | 4.3 | 160 |
| IIA1gb | 0.05 | 1.7 | 3.9 | 175 |
| IIC1gb | 0.08 | 0.0 | 3.8 | 180 |
| IIC2gb | 0.01 | 0.1 | 3.8 | 285 |
| IIIC3gb | 0.01 | 0.6 | 4.7 | 345 |

Fig. 5 : Analytical data of Heumen I, II and III.

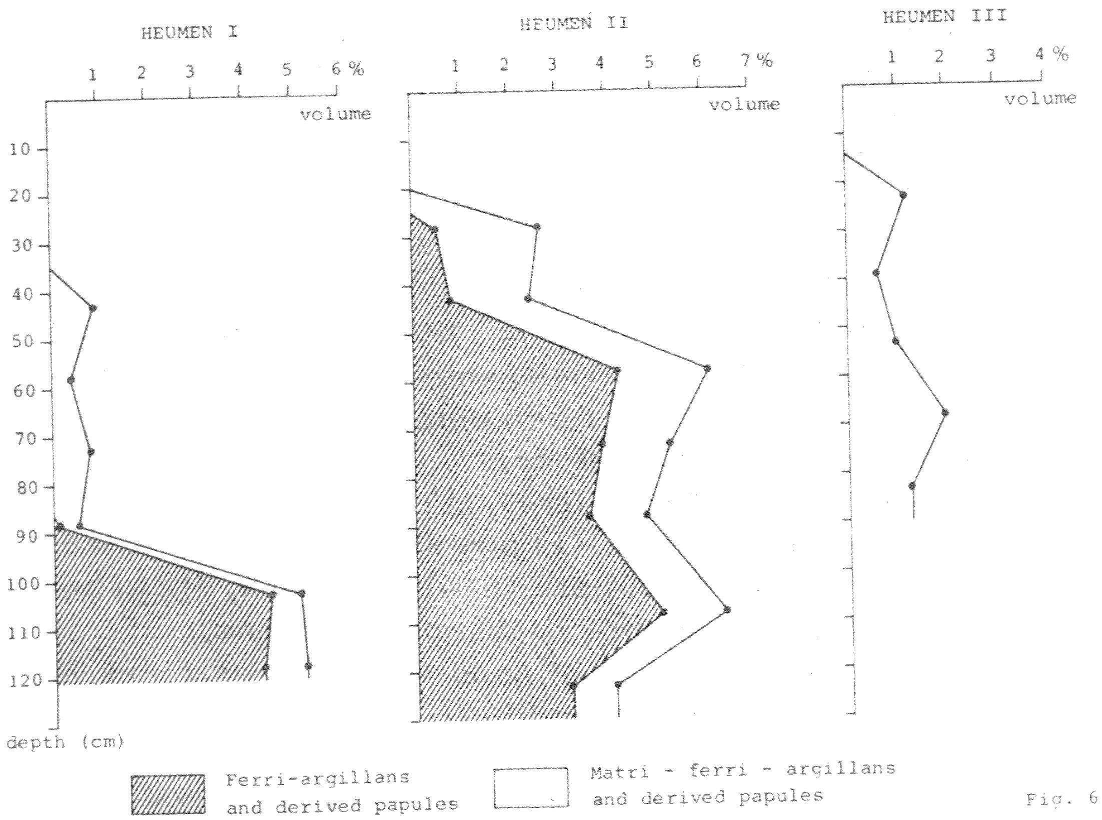



Fig. 6.: Micromorphological quantification of illuviation phenomena in Heumen I, II and III.

Reference to the photos .-

Photo 1: Channel ferri-argillans with a strongly continous orientation and dark, rather sharp extinction phe_ nomena. Soil Heumen I, IIB2tg horizon (100 cm depth); crossed polarizers.

Photo 2: Grainy channel ferri-argillan with a rather stron_ gly continuous orientation and gray, rather diffu_ se extinction phenomena. Soil Heumen I, IIB2tg horizon (100 cm depth); crossed polarizers.

Photo 3: As photo 2, but in plain polarized light to illustra_ te the grainy character.

Photo 4: Normal void matri-ferri-argillan with faint extin_ ction phenomena. On one side of the void a weat_ hering mica is visible. Soil Heumen I, IIBtg hori_ zon (105 cm depth); crossed polarizers.

Photo 5: Oxidized interiors of peds and reduced zones alongs voids (pseudogley) with clay illuviation features features (papulic fabric) predominantly in the oxi_ dized parts. Soil Heumen II, B22tg horizon (70 cm depth); crossed polarizers.

Photo 6: Channel neosesquans covering ferri-argillans and groundmass. Heumen II, B21tg horizon(60 cm depth); nearly crossed polarizers.

Photo 7: Channel neoferran with diffuse boundaries (gley). Soil Heumen III, IIC1gb horizon (45 cm depth); crossed polarizers.

Photo 8: Relict of human activity in the plaggen epipedon (baked loam). Soil Heumen I, Aan 2 horizon (50 cm depth); nearly crossed polarizers.

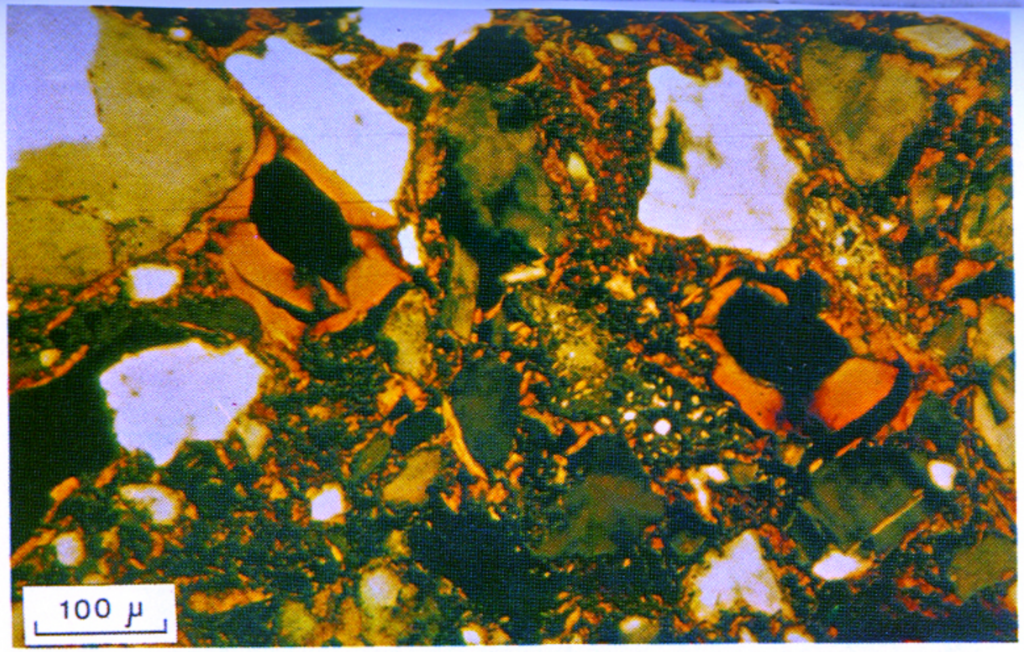


Fig. 1

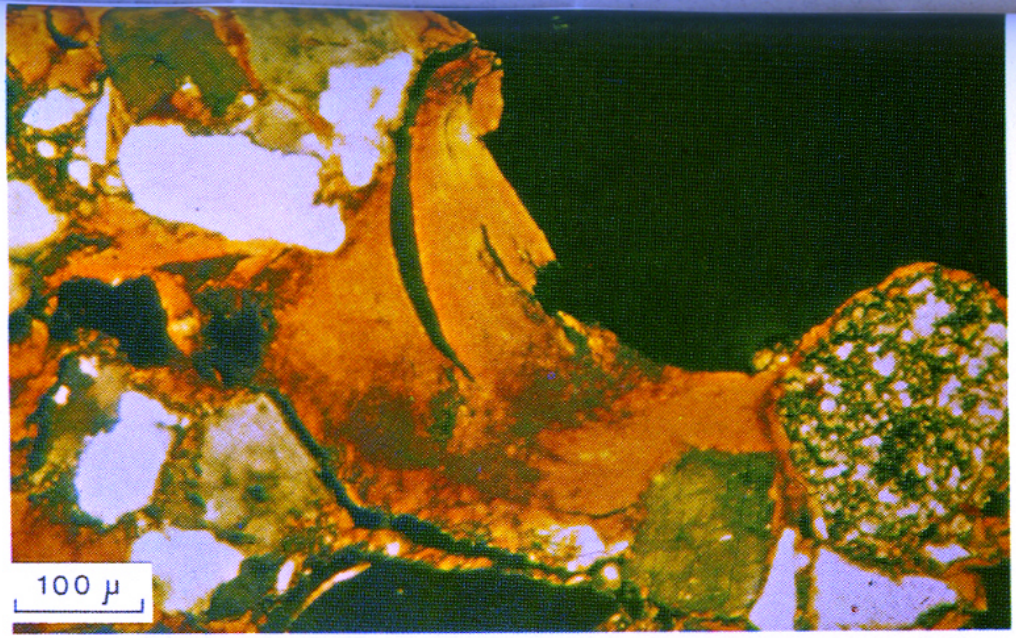


Fig 2

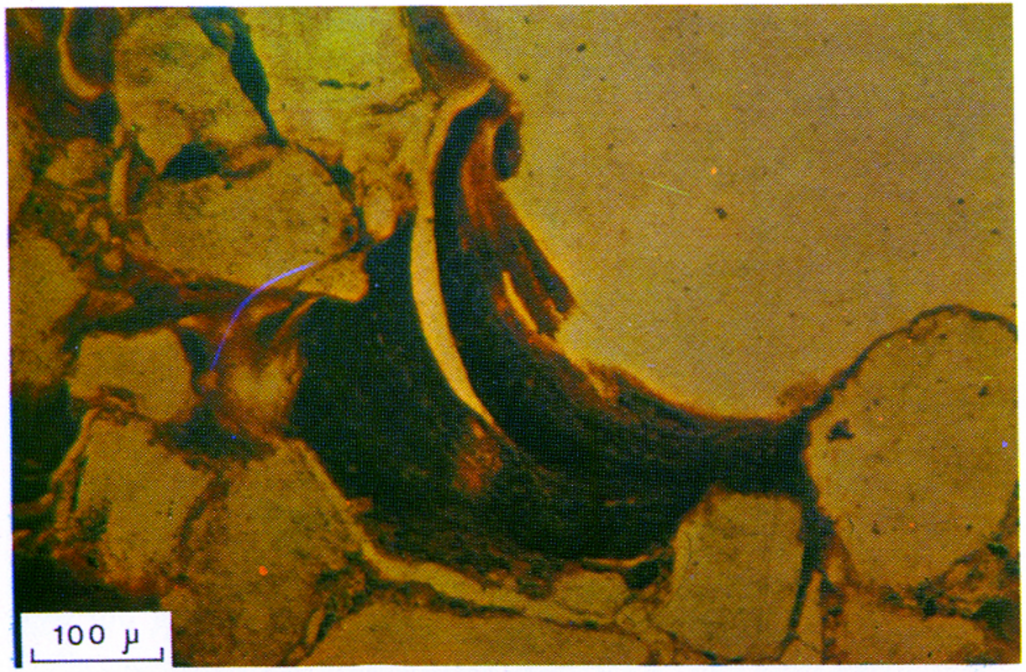


Fig. 3

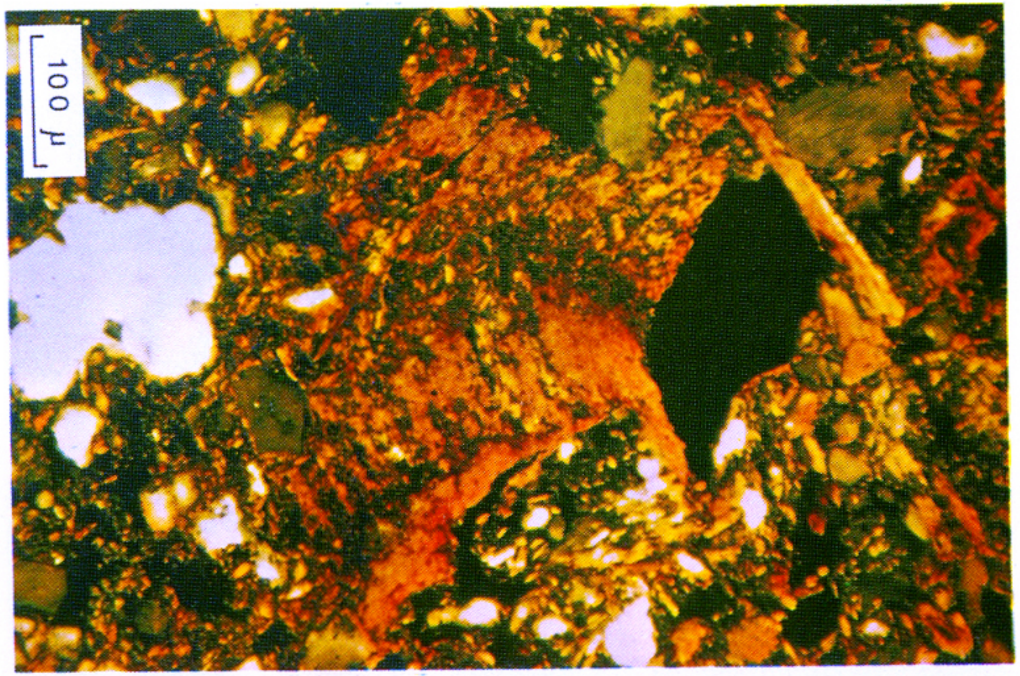


Fig. 4

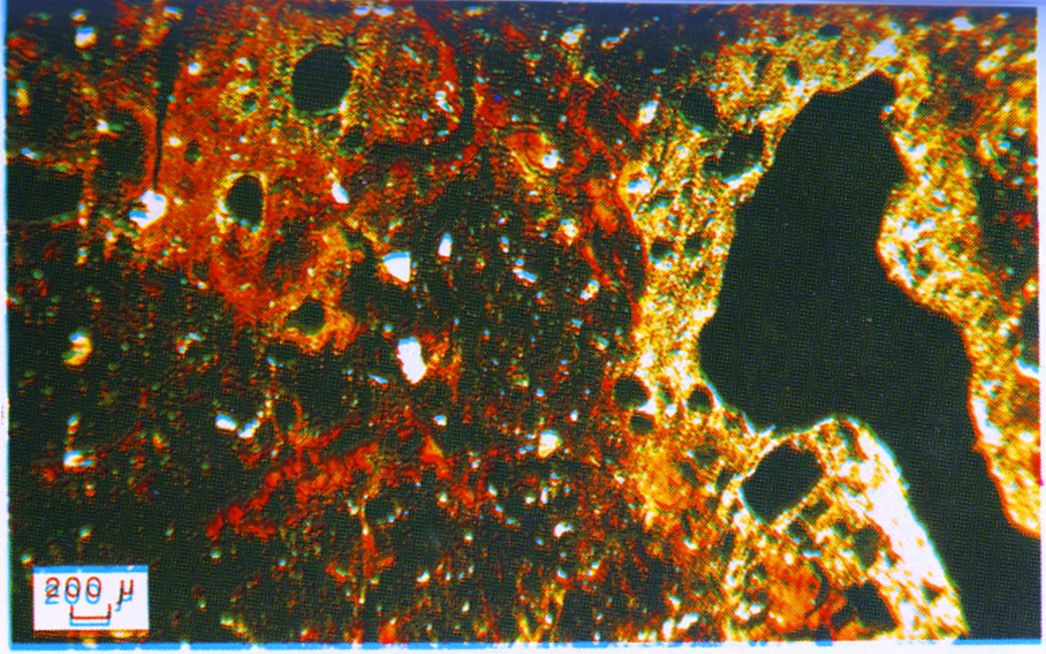


Fig. 5

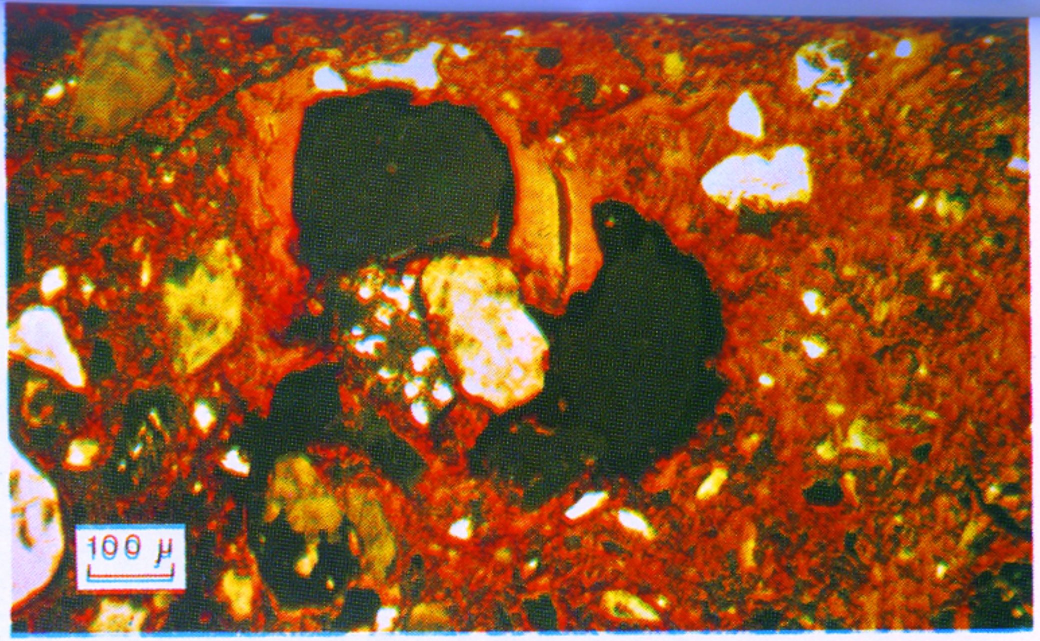


Fig. 6

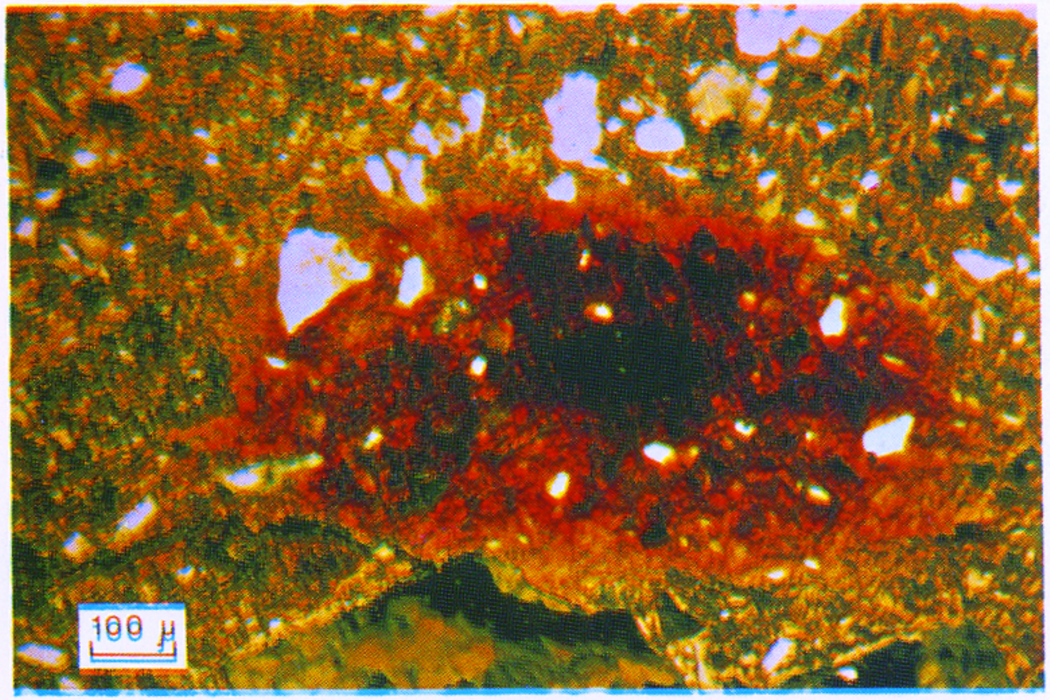


Fig. 7

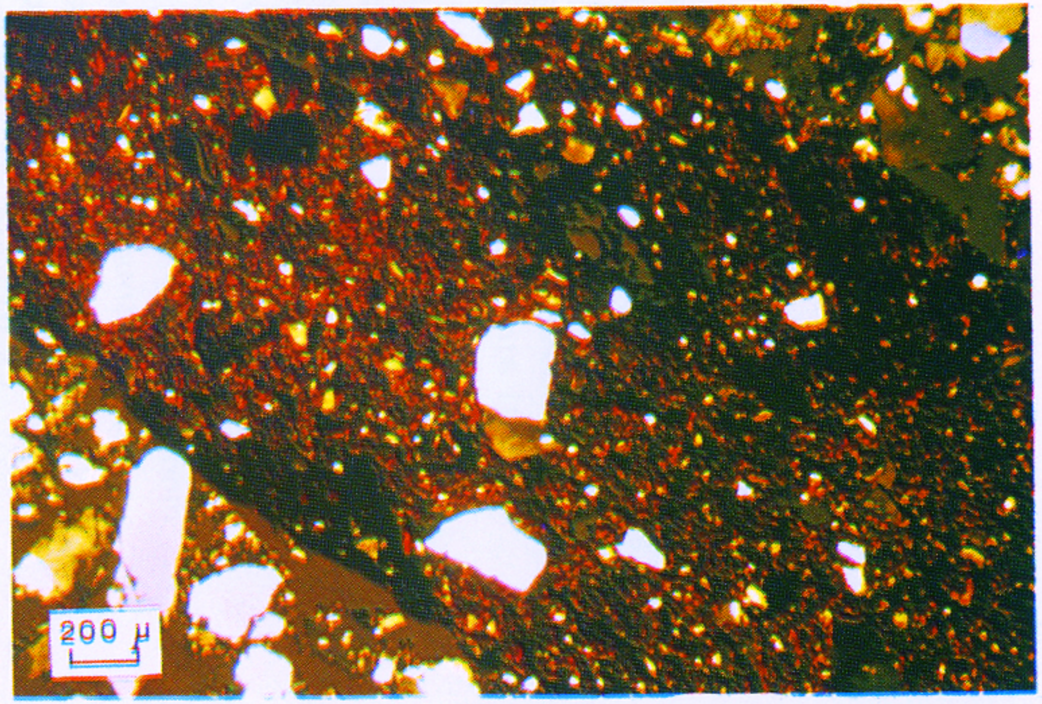


Fig 8

R. MIEDEMA, E. v. ENGELEN, PAPE, Th.

SUMMARY

Braided river sediments of Late Weichselian age occur at the surface in the Eastern part of the Netherlands and adjoining parts of West-Germany. The undulating topography of former gullies with fine textured sediments and slightly elevated ridges with sandy sediments is illustrated by means of a detailed soil map and a cross section. It is possible to recognize a toposequence of well-drained sandy loam soils, imperfectly drained clay loam soils and poorly drained clay soils.

Weathering, resulting in very acid soils, has been illustrated by means of clay mineralogical and micromorphological evidence. Biogenic phenomena decrease from the sandy loam to the clay soil, although large earthworm channels remain present in rather high amounts. The presence of an argillic horizon has been established in the sandy loam and the clay loam soil, presumably formed under conditions of better drainage. No clay illuviation has been found in the clay soil, which shows very clear gley phenomena. In the clay loam soil pseudo-gley and gley occurs with clay decomposition in the bleached areas, whilst in the sandy loam soil (pseudo) gley phenomena are only found in the deep subsoil. This soil has a plaggen epipedon of about 70 cm. Gley and pseudo-gley phenomena are more recent than the clay illuviation. In all three soils relatively recent groundmass illuviation has been found presumably due to agricultural use.

Based on data, the soils are classified as Plaggept Ochraqualf and Haplaquept respectively.

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