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Field Reports No. 18

SOIL STRUCTURE UNDER FOUR LAND USE TYPES IN THE SETTLEMENT NEGUEV, ATLANTIC ZONE OF COSTA RICA

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PREFACE

The work presented in this report was carried out within the context of the Atlantic Zone Programme, a multidisciplinary research programme that started in Costa Rica with a diagnostic study of the planning region Huetar Atlantica to identify, amongst other things, important problems that beset agricultural development of the region so as to enable the selection of relevant development oriented research subjects.

The central theme of the Programme is sustained land use. A study of the soils and their potential, and of possible effects of land use on soil qualities is therefore an important part of the research.

The soils of the Atlantic Zone of Costa Rica have developed in material of volcanic origin. Nevertheless, differences between soil types may be large. In the region strongly weathered soils are encountered. Such soils are often characterized by a weak structure and pose problems when used for permanent agriculture. The present study investigates the effects of different forms of land use on the structure of strongly weathered soils in the settlement project Neguev in the cantons Guacimo en Siquirres, Limón Province. The field work was carried out in the period September-November 1987. Analysis of the soil samples, elaboration of the data and preparation of the report took place in the Netherlands.

The report was presented in partial fulfillment of the requirements for the degree in Soil Science of the Wageningen Agricultural University.

The work was supervised by Dr. W.G. Wielemaker of the Programme.

Dr. Jan F. Wienk
Programme Coordinator

1 INTRODUCTION

This report is the result of the research done for my major thesis on tropical soil science at the Agricultural University of Wageningen.
The object of this research is the impact of landuse, immediately after forestclearing, on soil structure.
The fieldwork has been done in the months october and november 1986 on the asentamiento campesino 'Neguev', a landreform project in the Atlantic Zone of Costa Rica. Fig. 1.1 shows the location of this landreform project within Costa Rica; fig. 1.2 is a topographic map of the 'Neguev' with the investigated sites.
The research is part of a large project of cooperation between CATIE (Centro Agronomico Tropical de Investigacion y de Enseñanza), MAG (Ministerio de Agricultura y de Ganaderia), both in Costa Rica, and the Agricultural University of Wageningen.
The general theme of research of the project is the problem of fast spreading deforestation in the Atlantic Zone of Costa Rica (Vleeshouwer and Wielemaker, 1986). In this project, both the socio-economic and the political aspects of deforestation as the physical impact on the environment will be studied.
To study the physical impact, several landuse systems will be investigated and evaluated on their sustainability (Vleeshouwer and Wielemaker, 1986). This research on the impact of landuse on soil structure totally fits in this theme of investigation. A permanent good soil structure is an essential condition for sustained landuse (Swift, 1985).
The survey area, the southwestern part of the landreform project (fig. 1.2), is formed by old, strongly weathered lahars originating from the Volcán Turrialba. The altitude of the survey area ranges from about 30-60m above sealevel.
To reduce the variables only one soil type is chosen for this research. The investigated soil series, series Germania (Cubero and Acón Ho, 1981) is related to the flat top surface of the lahars. The soils are deep, well drained, uniform yellowish brown and clayey, stoneless, typic dystropepts (Soil Conservation Service, 1975).
In recent years, the tropical rainforest, the natural vegetation of the survey area, is gradually cleared by the farmers and put into pasture with mixed cropping as a farm yard culture. Like everywhere in the Atlantic Zone maize is grown as an important cash crop. The used level of management on the Neguev can be considered as low.
In this research, the mentioned types of landuse; pasture, mixed cropping and maize, will be compared with the natural situation, tropical rainforest. The chosen sites have a mean of 3 years after forest clearing.
So, as change of soil structure due to changed landuse can be proved, this change can be considered as very severe, because a so fast acting deterioration of the soil can make impossible sustained landuse. And, as Swift and Sanchez (1984) pointed out, this has a particular importance in the tropics, where the major demand for increased and sustained efficiency in food production exists.
Untill now, it is proved that removal of the natural vegetation, especially tropical rainforest, can cause changes in the soil

Fig. 1.1

after National Geographic Society, 1986.

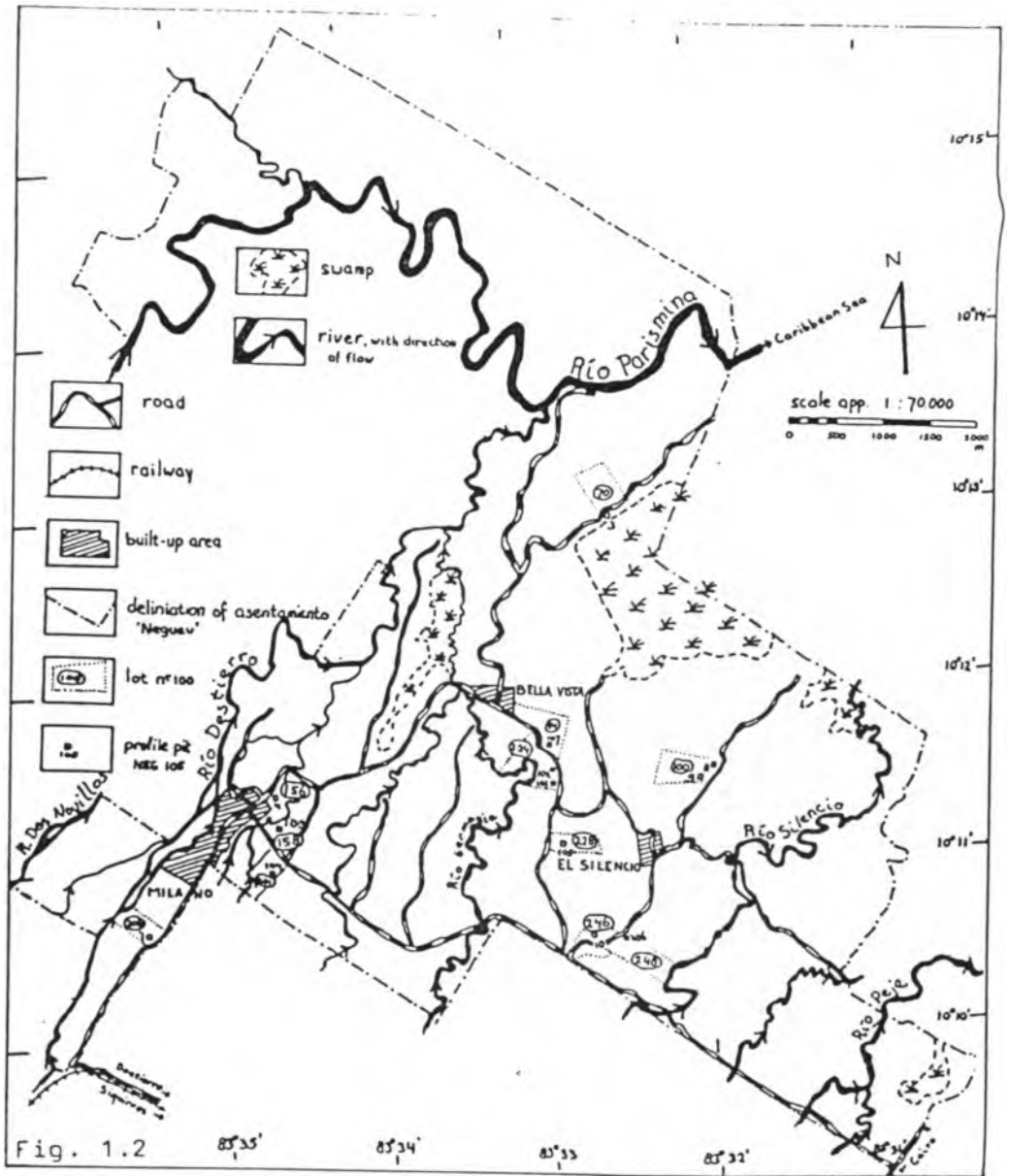

Fig. 1.2

after ITCO, 1980.

Fig. 1.1 Location of the survey area 'Neguev'; Costa Rica; Central America.

Fig. 1.2 Topographic map of the asentamiento campesino 'Neguev' with the location of the investigated sites.

(Krebs et al., 1974; Sanchez, 1976; Allen, 1985). Found is also that these changes, in connection with changed landuse occur more rapidly and intensively in the tropical region, especially on old weathered soils (Allen, 1985).
Most part of the research to the impact of landuse after deforestation on the soil is considering only one aspect. Very much research is done on changes in chemical properties or changes in bulk density. For detailed studies in the Atlantic zone of Costa Rica is referred to Krebs et al. (1974); Werner (1984) and Allen (1985), more in general: Sanchez (1976) and Swift (1985). An integrated approach is still lacking.
Allen (1985) pointed out in her study that an analysis to the effects of deforestation should include data on the physical, biological and chemical properties of soil, especially those related to soil structure, run off, infiltration and erosion.
In this research, run off and erosion do not play a role of any significance, because of the investigated sites are chosen on a flat toplevel.
On the same soil series, infiltration and related soil properties are studied by Spaans (1987).
In this research shall be concentrated on changes in soil structure and related biological, physical and chemical soil properties.
This report can be considered as a mainly qualitative analysis, because the lack of necessary materials, preparation and reliable data do not support a reliable quantification of the results. However, if possible, quantitative results will be mentioned.

But before any results are presented, chapter 2 will give a description of the environment and the historical development of the survey area. Chapter 3 deals with the methods used to make possible to record the change in soil structure and related properties.
After this background information, the results are presented in two chapters. Chapter 4 deals with the soil structure under the four types of landuse, as described according field and micromorphological observations. In chapter 5 follows the physical, chemical and biological properties related with soil structure.
In the discussion, chapter 6, after the restrictions of this research are indicated, the process of degradation of the soil will be treated, both purely concerning soil structure and concerning the total agro-ecosystem. Last, some classification problems, related to the change of landuse will be mentioned.

2 ASENTAMIENTO CAMPESINO 'NEGUEV'

2.1 location and history

The landreform project, where the field survey of this research took place, has an area of about 5000 ha. It is located in the east of Costa Rica, between Siquirres and Guácimo, in the Provincia Limón. (Lat. 10°08'-10°17' N; Long. 83°29'-83°36' E)
The survey area covers only an area of about 1000 ha in the southwestern part of the asentamiento.

Before ±1980 the whole area of the Neguev was large ownership property and mainly under natural forest or charral.
Only the environment of Milano and Destierro was used as banana plantation and for cattle grazing. However, no part of the hacienda was ever been intensively used, mainly because of the low productivity of the soils.

Around 1980, some communist 'precaristas' possessed parts of land on the Neguev. Then, the hacienda was rapidly sold to the ITCO[1], in these days the costarican landreform office.
The ITCO, now the IDA[2], went on with the implementation of the infrastructure and the distribution of lots of 10-17 ha.
Buyers of the land were not only traditional rural people, like small farmers, plantation workers and landless people, but also refugees from Nicaragua and unemployed people from San José.
Because many of them are not originating from the Atlantic zone, the IDA has started some extention programs on farm management. This organisation does also some research. Therefore, the technical staff of the IDA has located some test plots with plant nutrition and some growing tests on the Neguev.

2.2 landscape

The steeply dissected landscape of the Neguev is formed by old lahar remnants. These lahars are originating from the Volcán Turrialba, situated SW of the survey area. The Turrialba is one of the major volcanoes of the Central Cordillera of Costa Rica.
The slightly NE declining, almost flat surfaces of these lahars form the highest surface of the Neguev. This laharsurface is heavily dissected by small meandering rivers, descending from the same volcano. These rivers pass partly large swamp areas (= yoliyo) in the north eastern lower part of the Neguev. Further discharge of water take place via the Río Destierro and the Río Germania to the Río Parismina. This river flows into the Carribean Sea.

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[1] ITCO = Instituto de tierras y colonización, San José;
Institute for land and colonisation.

[2] IDA = Instituto de Desarollo Agropecuario, San José;
Institute for agricultural development.

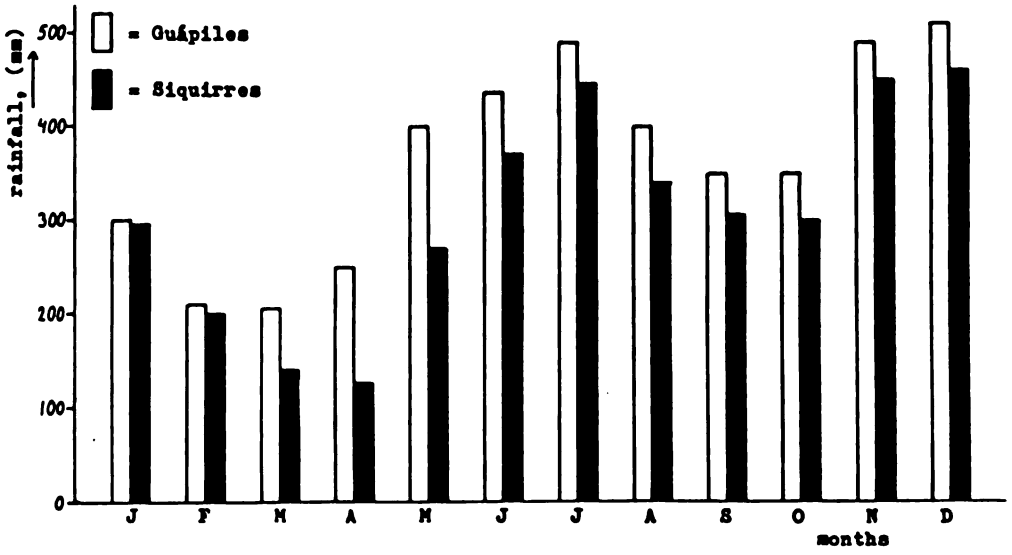
2.3 geology

The total deposit of lahar (Javanese for volcanic debris flow) in the survey area, can be considered as a sequence of overlapping tongues of variable length (Fisher and Schmincke, 1984). The various lahar deposits are alternated with horizontal layers volcanic ashes and tuffeous material (Beks and van Olst, 1986; Kroonenberg, pers.comm.). On the geological map of Costa Rica the just mentioned deposits are indicated as Quaternary Deposits (Min. de I, E & M, 1982).
The lahar material, strongly weathered by time and climate, shows hardly no evidence of fresh volcanic material in the upper first meter. Kaolinite, Gibbsite and a low pH point at that strong weathering.
In some sites, within 2 meters below the surface, ironcemented tufflayers can be found.

2.4 climate

The only known temperature data of the Neguev are those from the weatherstation El Carmen, situated just outside the area (lat. 10°13'N, long. 83°29'E). The mean annual temperature is 24.7 °C with a minimum monthly temperature of 23.5 °C and a maximum monthly temperature of 25.9 °C.
Rainfall data are known from the weatherstations of ASBANA[3] in Guápiles and Siquirres (Romero, 1984) and also from the weatherstation El Carmen. Figure 2.1 shows the monthly rainfall in mm from Guápiles and Siquirres (Romero, 1984). For the Neguev, the mean annual rainfall of El Carmen is probably the most accurate (see table 2.1).

Fig. 2.1 Mean monthly rainfall in mm, for the ASBANA weatherstations Guápiles and Siquirres, both in the Atlantic Zone of Costa Rica. The data of Guápiles are calculated over a period of 29 years (1954-1983) and the data of Siquirres over 13 years (1970-1983).



after Romero, 1984.

[3] ASBANA = Asociación Bananera Nacional; C.R.

Table 2.1 Total mean annual rainfall in mm, for three weatherstations in the Atlantic Zone of Costa Rica. The data of Guápiles are calculated over a period of 29 years (1954-1983),the data of Siquirres over 13 years (1970-1983) and the data of El Carmen over a unknown period.

	total mean annual rainfall (mm)
weatherstation	
El Carmen	3746
Guápiles	4390
Siquirres	3700

after Romero, 1984.

Like in the whole Atlantic zone the rainfall is very high and a relatively dry period (summer) of some weeks occurs between february and april (fig. 2.1). In some years there is not such a dry period. This happened in 1986.
Based on the system of Köppen the climate can be classified as an Af or tropical rainforest climate (Köppen and Geiger, 1954).
According to the climatic data the soils in this area have a perudic soil moisture regime and an isohyperthermic soil temperature regime (Soil Conservation Service, 1975).

2.5 deforestation and landuse

At the time the fieldwork took place, end of 1986, besides the swamps only 5 % of the natural vegetation, tropical rainforest was left in the survey area. The main part of the other 95 % has been cleared in the period since 1980. Most of the remaining natural vegetation is known as charral, thinned out tropical rainforest. The trees with commercial value are cut down and some wood is used for own use (timber- and firewood). Compared to natural rainforest, charral has some more scrub and less trees.
Nowadays the farmers are also clearing the charral.
By clearing hardly never burn methods are used. Most of the trees will be cut down and only the leaves and useless branches will be burnt. Not used wood is decayed in two or three years.

The largest part of the Neguev (70 %) is used as pasture. These are extensively grazed by a small cattlestock (of each farmer). The milk is used for own cheese production or is sold to merchants who sell it in the region.
The most widespread grass species are zacote and stargrass.

Almost every farmer uses a part (± 1 ha) of his land for mixed cropping. This landusesystem is a very complex one. Sanchez (1976) defines mixed cropping as a landusesystem where two or more crops grow simultaneously with no distinct row arrangement on the same field per year.
Annual crops are combined with each other and with perennials. Table 2.2 shows the cash and food crops used in the mixed cropping systems in the survey area with their latin names.
In the Neguev the principal crops grown in mixed cropping systems

are plantain and cassava. Cacao and pejibaye are recently promoted by the IDA.

Table 2.2 Crops used in the mixed cropping systems in the survey area. Local, english and latin names are indicated.

crop name	local	english	latin
annuals	frijoles	beans	
	maiz	maize	Zea mays
	ñampi	cocoyam,tania	Colocasia spp.
	tequisque	taro	Xantosoma spp.
	yuca	cassava	Manihot esculenta
perennials	anon chinois		Anona spp.
	banana	banana	Musa spp.
	cacao	cacao	Theobroma cacao
	coco	coco	
	guanabana		Anona maricata
	pejibaye	palm-fruit	Palmae spp.
	plátano	plantain	Musa spp.

Each farmer uses also some hectares of his land for growing cash crops. At the moment maize is a cash crop of growing importance in the Atlantic zone. The maize is harvested when the corn is fullripened. The stems and leaves are not used. The crop distinguishes itself from the other landusetypes because it does not cover the soil the whole year. It is grown as a monoculture, which is sown and harvested within one year. This should have a totally other impact on the soil than the other three mentioned landuse systems. Therefore this landuse is chosen as the fourth type of landuse and because of its growing importance.

Because all four investigated types of landuse are very different to eachother, also the related (agro)ecosystems are.
In this research the degrading influence of the landuse is expressed as degree of openness of the ecosystem.
The forest is considered as a very closed ecosystem. The nutrients are totally recycling, because no material is removed; the physical deterioration by weather influences (raindrops and sunrayes) is negligible, because the plant cover is completely closed and in the forest there is a large diversity of fauna and flora.
At the other, most open, end of the ranking to degree of openness of the ecosystem, the landuse type maize can be found. Its influence on the ecosystem is already described above.
For the four types of landuse the ranking to increasing openness follows from table 2.3. Considered are the aspects of the removal of plant material, the degree of intermittence of the plant cover and the diversity of plant species. The following ranking can be observed: forest (very closed) - mixed cropping - pasture - maize (very open ecosystem).

Table 2.3 Three ecological aspects of the landuse types forest, mixed cropping, pasture and maize.

landuse	forest	mixed cropping	pasture	maize
ecological aspects				
removal of plant material	--	-	+	++
intermittence of the plant cover	--	-	+	++
diversity of plant species	++	+	-	--

-- = very low, - = low, + = high, ++ = very high

2.6 soils

The sites of the investigated soils are chosen within one soil series, the series Germania of the semi-detailed soil map of the Neguev (Cubero & Acón Ho, 1981). The similarity in texture of some investigated sites is shown in table 2.4. This limitation to one soil series has been made to reduce the variables. Further restrictions has been made by chosing the sites only on the flat toplevel of the lahars.

Table 2.4 Texture percentages of the topsoil (0-30 cm) and the subsoil (60-90 cm) of some profiles.

depth	topsoil (0-30 cm)						subsoil (60-90 cm)					
profile	NEG 3	NEG 4	NEG 9	NEG 10	NEG 102	NEG 106	NEG 3	NEG 4	NEG 9	NEG 10	NEG 102	NEG 106
texture,%												
sand	26	16	17	15	17	16	12	12	10	5	9	10
silt	26	27	19	29	26	26	25	25	16	36	22	19
clay	48	57	64	55	57	58	63	63	74	59	69	71

The Germania soil series are deep, porous, well drained, uniform yellowish brown and clayey, stoneless and non-thixotropic soils. According to the Soil Taxonomy, they can be classified as Typic Dystropepts (Soil Conservation Service, 1975). According to the FAO/UNESCO, they can be classified as Dystric Cambisols (FAO, 1987).
During this research on soil degradation a detailed soil survey was carried out in the south western part of the Neguev (Beks & Van Olst, 1986).

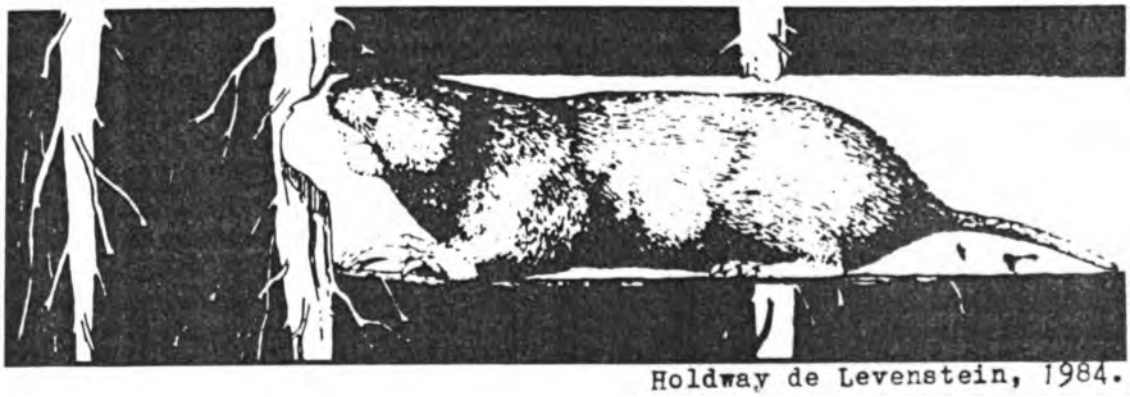
2.7 soil fauna

The most numerous and perhaps the most striking representatives of soil fauna in the Atlantic zone are the leaf cutter ants, Atta cephalotes (Alvarado et al.,1981). The batallions of marching ants, transporting leafs above their heads, are very impressive. They collect the leafs and other plant material in subsoil chambers to grow fungi. These fungi are their food.
Because of their high nest activity, the ants are effective soil movers, transporting material from the AB and B horizons to the surface (Alvarado et al.,1981). Alvarado also found, by comparing active ant mounds with undisturbed soils, that leaf cutter ants incorporate organic matter and aerate and restructure the soil profiles.

Although in Kenya and other tropical regions the termites are the most important representives of the soil fauna (Wielemaker, 1984), their activity in the soil is of only small importance in the Neguev.
The termites occur in small subterranean chambers, mounds were not observed in the survey area.

The taltuza or pocket gopher, Geomydae Orthogeomys, (Holdway de Levenstein, 1984) is considered as a very severe problem by the farmers in the Atlantic Zone. The taltuza, a herbivore, feeds on the roots of crops (fig. 2.2). The most suffering crops are banana, plantain, cacao, coco, cocoyam, cassava and pejibaye.
The 28 cm large rodent, with a subterraneous lifestyle, makes tunnels, mainly down to a depth of 85 cm below the surface. This gallery network can stretched over an area of 250 m².
Taltuzas are widespread over the Atlantic Zone, but often absent in land used for grazing, because the cattle destruct their tunnels (Holdway de Levenstein, 1984).

Fig. 2.2 The taltuza or pocket gopher.



Holdway de Levenstein, 1984.

As everywhere in the world, fieldmice are present in the Atlantic Zone. They collect their food above ground. Their activity in the soil is restricted to burrowing holes.

Dung beetles, Scarabaeidae (paracropids) (Brussaard, 1983), burrow 1 m or even deeper into the soil. The dung beetles make balls of dung, which they transport through 1 cm wide, almost vertical shafts to their nests in the subsoil. By transporting

the dung and burrowing the channels, they play a role in reworking the soil.

Earthworm (Lumbricidae) activity is common in the Neguev. The main activity of earthworms was restricted to the topsoil. They continually rework the soil. Not only by burrowing, but also by passing the soil material through their intestinal tracts. This is important for the incorporation of organic matter.

Many other soil fauna species can be found in the Neguev area. They play an important role in the soil ecosystems, but were discriminated on their size in this research. Only the unconspicious springtails (Collembola), the centipedes (Chilopoda) and the frightening Tarantula spiders (Araneida) can be mentioned. The micromorphological observations showed mite (Acari) excrements. These animals are known for their influence on humification (Marinissen, 1986).

3 METHODS

3.1 study of profile sites

As already mentioned in chapter 2, all sites were chosen within soil series Germania and equally spread over the four investigated landuse types. Figure 1.2 shows a map of the southwestern part of the Neguev with a location of sites. Fourteen sites were studied, four under the natural vegetation (tropical rain forest), four under mixed cropping, three under pasture and three under maize. The forestclearing of the fields of the latter three landuse systems took place within the last six years, with a mean of three years. Table 3.1 shows the names and numbers, actual and anterior landuse and the number of years after clearing of the studied profile sites.

Table 3.1 Names and abbreviations of the studied profile sites, their actual and anterior landuse and the number of years after clearing (mean: 3 years). All soils belong to the Germania soil series (Cubero and Acón Ho, 1981).

landuse		years after	profile site	
actual	anterior	clearing	name	abbreviation
forest	forest	-	Neguev 3	NEG 3
	forest	-	Neguev 101A	NEG 101A
	forest	-	Neguev 101B	NEG 101B
	forest	-	Neguev 102	NEG 102
mixed cropping	forest	6	Neguev 4	NEG 4
	charral	3	Neguev 7	NEG 7
	charral	2	Neguev 9	NEG 9
	charral	4	Neguev 107	NEG 107
pasture	charral	2	Neguev 8	NEG 8
	charral	?	Neguev 103	NEG 103
	charral	4	Neguev 106	NEG 106
maize	charral	4	Neguev 10	NEG 10
	charral	3	Neguev 104	NEG 104
	charral	2	Neguev 105	NEG 105

On each site, a pit was dug and profile descriptions were made. The descriptions were made according to the FAO-Guidelines (FAO, 1977), using the same terms. The soils were classified, based on the Soil Taxonomy system (Soil Conservation Service, 1975) and on the FAO/UNESCO legend (FAO, 1987).

Only the FAO grade-term structureless has got the addition porous massive to divide from other structureless types. A structureless porous massive soil type is a loose, porous soil. In this soil no separate aggregates can be distinguished in the field. The determination of type and abundancy of pores in such a structure-

less porous massive soil is almost impossible, since the porosity is composed of very many irregular micropores. For both the macro- and the micromorphological descriptions of the type of aggregates, the following definitions were used:
Crumb aggregates or crumbs are internal porous to very porous spheroids, build up of several weakly coalesced microaggregates. The crumbs have irregular, rough, mammilated surfaces with no accomodation to the faces of the surrounding aggregates. They are biogene formed.
Granular aggregates or granules are internal dense to very dense spheriods, build up of several strongly coalesced microaggregates. The granules have undulating to smooth surfaces, with no or slight accomodation to the faces of the surrounding aggregates. They are mainly biogene formed.

Not only pure soil structure descriptions of pores and aggregates were made, but also the cutans, mottling and consistence were described. The presence of cutans on aggregates was determined, because cutans can point on a less stable topsoil. Mottling can be a clear indication for structure degradation. Colour, size and abundancy of the mottles were described. The consistence of aggregates is an important measure for the degree of binding of aggregates and so for the stability of structure. In this case only the consistence when moist is given.
Based on the field descriptions a representative profile was chosen for each landuse type. These profiles were sampled for physical and chemical analyses and micromorphological purposes. Besides those representative profiles, some other profiles were sampled for physical and chemical analyses and to support the simultaneously carried out soil survey. Table 3.2 gives a short view of which profiles are sampled and for what purpose.

Table 3.2 Profiles sampled for micromorphological, physical and chemical analysis. The profiles NEG 7, NEG 8, NEG 101, NEG 103, NEG 104, NEG 105 and NEG 107 are not sampled.

analysis	micromorph.	physical	chemical
profile			
NEG 3	-	+	+
NEG 4	-	+	+
NEG 9	+	+	+
NEG 10	+	(+)	+
NEG 102	+	(+)	+
NEG 106	+	+	+

- = not sampled, (+) = sampled, but not determined, + = sampled and determined.

3.2 micromorphological methods

To restrict the number of thin sections, one representative profile of each landuse type was chosen to be sampled. This choice was made by comparing the field descriptions. The profiles

sampled for micromorphological research are shown in table 3.3, together with the numbers and depth of the thin sections and the type of landuse.
For sampling four tins of 8*15*5 cm were used for each profile. They were inserted in the soil in a vertical direction, covering the profile from 0 to 60 cm depth. The tins were taped and send to the Netherlands by air. In the micromorphological laboratory of the AUW[4] the samples were impregnated with plastic. Of each tin, two thin sections, thin (<30µm) slices of soil, of 5*7 cm were prepared (Jongerius and Heintzberger, 1975).

These thin sections (table 3.3) were described according to the guidelines, proposed by Bullock et al. (1985) with the use of a Leitz polarisation-microscope. The micromorphological descriptions were restricted to the microstructure and some pedofeatures. The other in Bullock et al. (1985) mentioned subjects were considered irrelevant for this research.

Table 3.3 Numbers of the thin sections, according to depth and profile. Landuse type of concerned profile is also given. (Numbering of the thin sections, according to the system used by the micromorphological laboratory, Department of Soil Science & Geology, Agricultural University, Wageningen).

landuse	forest	mixed cropping	pasture	maize
profile	NEG 102	NEG 9	NEG 106	NEG 10
depth (cm)				
0 - 7.5	87.142	87.128	87.150	*[a]
7.5-15	87.143	87.129	87.151	*[a]
15 -22.5	87.144	87.130	87.152	87.136
22.5-30	87.145	87.131	87.153	87.137
30 -37.5	87.146	87.132	87.154	87.138
37.5-45	87.147	87.133	87.155	87.139
45 -52.5	87.148	87.134	87.156	87.140
52.5-60	87.149	87.135	87.157	87.141

[a] = sample not present

Not all thin sections were described completely because the aim of the research was only to compare the total view of the profiles with each other. Therefore it seemed not necessary to describe the microstructure and pedofeatures of every thin section, but only of relevant ones. For microstructure, peds and voids are described every other thin section. Pedofeatures like textural, fabric and excremental features were consequentely described of almost each thin section. If occurring, important pedofeatures as amorphous (ferruginous mottles) and crystalline (gibbsite) pedofeatures are described.

[4] AUW = Agricultural University of Wageningen

Because microstructure is very important for this research, it is described to a very high detail. This needed a supplementation on the guidelines of Bullock et al. (1985).
The terminology of the size of the aggregates is therefore adjusted to the terminology of aggregate sizes used for describing the fieldstructure (FAO, 1977). The aggregates are divided into main groups, according to their sizes. These groups, decreasing in size, are peds, micro-peds and micro-aggregates (table 3.4). The micromorphological research will concentrate on the micro-peds. An initial subdivision to size-classes was based on the class divisions proposed by Bullock et al. (1985). This subdivision is tested on usefullness and appeared to be too detailed. Therefore the used size classes are reduced. To make a comparison with the fielddescription easier, the used terminology is adjusted to that of the FAO-guidelines for aggregate size classes (table 3.4).
The same adapted size classes and terminology were used for the description of the voids and pedofeatures. In table 3.4 the used classification and terminology for the micromorphological descriptions can be found.

Table 3.4 Terminology of size classes, used for the micromorphological description of aggregates and voids.

	aggregates[α]		voids
	granular, crumb	(sub)angular blocky	
size class			
< 200 µm	micro	micro	micro
200-1000 µm	very fine	very fine	very fine
1- 2 mm	fine	very fine	fine
2- 5 mm	medium	very fine	medium
5- 10 mm	coarse	fine	coarse
10- 20 mm	very coarse	medium	very coarse
20- 50 mm	*[ø]	coarse	*[ø]
> 50 mm	*[ø]	very coarse	*[ø]

α = a division into main size groups of aggregates is: micro aggregates <200 µm; micropeds 200 µm-5 mm; peds >5 mm.
ø = not observed

after FAO, 1977 and Bullock et al., 1985.

For describing the frequency of aggregates and voids and the abundancy of the fabric and excremental pedofeatures the classes proposed by Bullock et al. (1985) are followed (table 3.5). For the relative small amounts of textural and crystalline pedofeatures an other scale was needed. The scale of abundancy classes proposed by Bullock et al (1985), using the terms rare and occasional, was suitable.
For all purposes, the frequency was visual determined with the aid of black & white estimation charts (Bullock et al, 1985 after FitzPatrick, 1980).
To show the biological activity, a further subdivision of fabric and excremental features to the degree of fragmentation was

neccesary. Strong fragmentation of biogenic pedofeatures indicate strong disturbance of the profile by biological activity. A subdivision to weakly, moderately and strongly fragmented was made.

Table 3.5 Terminology of classes, used for the description of the frequency of aggregates and voids and for the abundancy of fabric and excremental pedofeatures.

terminology	
class	
0 - 5%	very few
5 - 15%	few
15 - 30%	frequent
30 - 50%	common
50 - 70%	dominant
70 -100%	very dominant

Bullock et al., 1985.

3.3 physical methods

The profiles sampled for physical analysis are shown in table 3.6 together with the depth of sampling. The landuse type of the profiles is also given.

Table 3.6 Profiles sampled for physical analysis and depth (cm) of sampling. Landuse type of concerned profile is also given.

horizon		surface	compacted hor.	subsoil
landuse	profile			
forest	NEG 3	5	10	55
	NEG 102[α]	5	15	45
mixed cropping	NEG 4	2	35	85
	NEG 9	5	10	43
pasture	NEG 106[β]	5	23	54
maize	NEG 10[α]	5	10	50

α = bulk density values are not determined.
β = soil moisture content is not determined at higher pF-values.

The physical methods are used to obtain moisture retention curves and bulk density and porosity values. Therefore the profiles were sampled with horizontal core samples. Following the profile descriptions, these cores of 100 cm^3 were carefully inserted close at the surface (± 5 cm depth), in the expected compacted horizon (± 20 cm depth) and below that horizon, in the Bw (± 45 cm depth). At each depth, three undisturbed core samples were taken to allow statistical procedures.
The core samples were analized at the MAG laboratory in Costa Rica. To determine the soil moisture retention curves, the sam-

ples were saturated and subjected to a constant hydraulic pressure at boxes filled with sand. When hydraulic equilibrium is reached, the soil moisture content is determined. This was done for the pF-values 0, 1.7, 2.0 and 2.3. For the pF-value 2.7 not sand but a fine porous kaolinite plate was used. The higher pF-values 3.0, 3.3, and 4.2 were measured on a pressure membrane apparatus on small disturbed samples (Koorevaar and Dirksen, 1982).
By weighting the samples saturated and ovendry, the bulkdensity and the porosity of the soil could be determined and the pF/θ or soil moisture retention curves could be drawn.

3.4 chemical methods

Table 3.2 shows the profiles sampled for chemical analysis. Of these profiles, horizon samples of ±1 kg were collected and kept in plastic bags, according to recommendations of the Soil Survey Manual (Soil Survey Staff, 1951).
The chemical analysis of the samples were carried out partly on the CATIE laboratory, partly on the MAG laboratory, both in Costa Rica.
The soil samples were air-dried, sieved and homogenized before analyzing. The following analytical procedures were used:
soil texture was determined by the hydrometer method; organic matter (org.C = 58% * O.M.) by the Walkley-Black method; total N by the Kjeldahl method; the C/N ratio, determined as a quotient of org.C (%) and total N (%); pH, potentiometrically in H_2O and 0.01M KCl; ΔpH, difference between pH in KCl and in water, as an indication of the net negative charge (Sanchez, 1976); exchangeable cations (Ca^{++}, Mg^{++}, K^{+} and Na^{+}) with 1 N KCl; sum of cations is calculated as total of KCl exchangeable bases; exchangeable acid with KCl; E-CEC or effective cation exchange capacity as the total sum of cations and the exchangeable acid; CEC or total CEC, total extractable cations by NH_4OAc, pH =7; BS (sum of cations), base saturation at soil pH, determined as quotient of the sum of cations and the E-CEC; BS (pH =7), base saturation determined as quotient of sum of cations and the total CEC; and the nutrients P, S, Cu, Zn and Mn.

3.5 biological methods

To obtain biological data, no standardized methods were used. Most of the features indicating biological activity were already integrated in the soil structure descriptions.
Descriptions of pores and particularly of nests and excrements give a good view of the activity of soil fauna. For some profiles these remnants of soil fauna activity were drawn on sheets. In this way a more spatial picture of the biological activity could be obtained.
In the micromorphological descriptions, the relations between soil structure and biological activity were studied on a more detailed level.
However, these macro- and micromorphological descriptions, made on a fixed moment, do not tell much about the present activity of each kind of soil animal. Therefore, during the time the field-work took place, each profile site was studied on presence and

frequency of soil animals. This information together with the information gathered by interviewing the farmers can give a good picture of the present activity of each soil animal. For each species, the activity in one site was compared with the other sites and classified. For classification, the terms high, medium and low biological activity and no signs of activity were used.

3.6 statistical methods

Statistical methods were used to determine significant differences between the physical and chemical data of the natural situation, forest, and those of the other three landuse types. The difference of means test or t-test seemed to be the most appropriate.
The physical data could be adjusted to this test, because triplicate samples were taken. But because a lack of number of replicates, the difference of means test could not be carried out for the chemical data.
However, the correlations between the soil chemical properties and the landuse types (or agro-ecosystems) were evaluated by the Spearman rank correlation test, since such a calculation was based on the number of observations and not necessarily on the number of replicates.
To allow the Spearman test, the landuse types were ranked to degree of openness of the ecosystem. Thus, in increasing order: forest, mixed cropping, pasture and maize.

4 SOIL STRUCTURE

4.1 field observations

The macromorphological or field description of each profile can be found in Appendix A.
In this section summarized descriptions are given for each land-use type. To get a good view, the main characteristics of all observed profiles are expressed in table 4.1.

4.1.1 forest profiles

Profiles: NEG 3, NEG 101A, NEG 101B, NEG 102.

The profiles under forest vegetation have a high porosity and are structureless porous massive. Some profiles show signs of compaction in the topsoil. By these profiles, the upper 10 cm consist of strongly developed, very fine aggregates of the types crumb and subangular blocky.
Over the total depth, the profile has a friable to loose consistence. No mottles and cutans can be found. Many very fine and fine compound packing voids throughout give profiles with a high porosity. Striking are the differences in topsoil of the 101A profile and the 1 m further lain 101B profile. Profile 101A has a moderate angular blocky surface horizon, whereas the profile 101B is completely structureless porous massive. This difference is very well explainable. Profile 101A is situated in a old wheel track and profile 101B in the next lying ants' nest.

4.1.2 mixed cropping profiles

Profiles: NEG 4, NEG 7, NEG 9, NEG 107.

These profiles under mixed cropping vegetation are generally structureless porous massive, except for the upper 20 cm. These topsoils consist of strongly developed very fine and fine subangular blocks. However, the uppermost 5 cm, a mulch layer, consists of strongly developed fine granules.
The consistence is friable in the topsoil, becoming loose in the structureless part.
Between the profiles, there is a rather big variation in topsoil structure. The topsoil in the profiles NEG 4 and NEG 7 is somewhat more angular blocky. The topsoils of the profiles NEG 9 and NEG 107 have an important crumb fraction. Many very fine and fine pores gives profiles with a high porosity.
No mottles or cutans are present in the profiles, except few red fine mottles in the Au1 horizon of NEG 4. The grass as toplayer at profile NEG 4, compared with the mulch as toplayer at the other profiles could be an explanation.

4.1.3 pasture profiles

Profiles: NEG 8, NEG 103, NEG 106.

By the profiles under pasture, the boundary between the structured topsoil and the structureless porous massive subsoil lies at about 30 cm depth. Above this boundary, in the topsoil, the soil structure consists of blocky aggregates. In the uppermost 10 cm mainly moderately developed, fine angular blocks. In the 20 cm below mainly very fine and fine subangular blocks with some addition of crumbs.
The consistence of the angular blocks is firm. The structureless part lower in the profile is friable to very friable. Except for the upper compacted 10 cm, the profiles are highly porous. In two of the three profiles, the profiles NEG 8 and NEG 106, mottling occurs in the first 10 cm. The mottling consists of many orange and gray mottles. Patchy thin cutans of clay and iron only occur in the profile NEG 106. They are present on the walls of some channels in the AB horizon.

4.1.4 maize profiles

Profiles: NEG 10, NEG 104, NEG 105.

The profiles under maize have a structured topsoil till a depth of 30 cm. Below that depth, the soil is structureless porous massive, except for the profile NEG 10. This profile becomes structureless below 60 cm depth.
In the maize profiles, the structured topsoil consists of blocky aggregates, as in the pasture profiles. The blocks consists of mainly moderately developed very fine and fine subangular blocks with an uppermost layer of strongly developed fine angular blocks. This layer has a very firm consistence, the other part of the topsoil is friable to firm. The structureless subsoil has a very friable to loose consistence.
Mottling is present in the form of orange/red mottles in the dark gray angular blocky horizon. Profile NEG 10 has a somewhat stronger developed structure than the other profiles. The consistence of the upper 60 cm varies from firm to extremely firm. In the A besides angular blocks also platy structures are present. They are overlain by thick continuous horizontal cutans of clay and iron(hydr-)oxides. The same type of cutans, but broken and thin, can be found to a depth of 60 cm along the channel walls.

Table 4.1 The principal field characteristics of the topsoil of all investigated profiles.

characteristics		biogenic ..... physicogenic: massive porous	microaggregates β	loose γ	crumb α	very friable γ	granular α	friable γ	subangular α	micropeds β	firm γ	angular α	red fe-mottles	peds β	very firm γ	grey fe-mottles	cutans	platy α	ext. firm γ	gray topsoil
landuse	profile																			
forest	NEG 3	-	x	-	x	-	-	x	x	x	-	-	-	-	-	-	-	-	-	-
	NEG 101A	-	-	-	-	-	-	x	x	x	-	x	-	-	-	-	-	-	-	-
	NEG 101B	x	x	x	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	NEG 102	x	x	x	x	-	x	-	-	x	-	-	-	-	-	-	-	-	-	-
mixed cropping	NEG 4	-	-	-	-	-	-	x	x	x	x	x	x	x	-	-	-	-	-	-
	NEG 7	-	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-	-	-	-
	NEG 9	-	x	x	x	x	x	-	x	x	-	-	-	-	-	-	-	-	-	-
	NEG 107	-	-	x	x	x	x	-	x	x	-	-	-	-	-	-	-	-	-	-
pasture	NEG 8	-	-	-	x	-	-	x	x	x	x	x	x	x	x	x	-	-	-	-
	NEG 103	-	-	-	-	-	-	x	x	x	x	x	-	-	-	-	-	-	-	-
	NEG 106	-	-	-	-	-	-	x	x	x	x	x	x	x	-	x	x	+	-	-
maize	NEG 10	-	-	-	-	-	-	-	-	x	x	x	x	x	x	-	x	x	x	x
	NEG 104	-	-	-	-	-	-	-	x	x	-	x	x	x	x	-	x	-	-	-
	NEG 105	-	-	-	-	-	-	-	-	x	-	x	x	-	x	-	-	-	-	-

α = type of aggregates
β = size of aggregates
γ = consistence
δ = x = present; - = not present

4.2 micromorphological observations

The micromorphological descriptions of the investigated thin sections can be found in Appendix B. Because these descriptions are too detailed to get a good view of the whole profile, the principal characteristics are summarized below and expressed in histograms. These figures (4.1 and 4.2) give a rough impression of the main type of aggregates and voids with depth, based on the detailed descriptions.
The figures 4.1 a t/m d show type, frequency and size of the aggregates by depth for each profile. In the figures 4.2 a t/m d type and abundancy of the voids are given. In the same figures the total porosity is expressed. The suffixes a t/m d of the figures 4.1 and 4.2 indicate the profile. The forest profile is indicated by a, the mixed cropping profile by b, the pasture profile by c and the maize profile by d.

4.2.1 forest profile

profile NEG 102 (fig. 4.1a & 4.2a)

The soil mass consists mainly of fine mass, composed of clay with very few mineral grains. The pedal soil microstructure in the topsoil turns to slightly apedal at 50 cm depth. Strongly developed very porous crumbs and dense granules are the only types of aggregates in the profile.
The frequency of the crumbs increases slightly with depth from common in the topsoil to dominant in the subsoil. The granules decrease from very dominant to common. Throughout the profile the mean size of the crumbs is coarse and the mean size of the granules is fine (fig. 4.1a).

The total estimated porosity of the forest profile decreases slightly with depth. The topsoil has a porosity of 55%, whereas the subsoil has a porosity of 40%. The porosity is mainly composed of inter-aggregate voids. A very few intra-aggregate voids can be found throughout the whole profile. The occurrence of these voids is mainly restricted to dense granules (fig. 4.2a).
The main types of the inter-aggregate voids in this profile, the compound packing voids and interconnected vughs, are located between crumbs, granules and plant material. These voids, ranging in size from micro to fine, are very dominant and have a random distribution troughout the profile. These voids are irregular, rough and not accommodated. The compound packing voids, occurring in the topsoil, are totally interconnected and the interconnected vughs mainly present in the subsoil are partially interconnected.

Other types of observed inter-aggregate voids are channels, chambers and vughs. The channels and chambers, frequent in the topsoil, very few in the subsoil, are partially interconnected. The medium to coarse channels are subrounded, cylindrical and smooth. Close to the surface they are strongly fragmented by biological activity. This fragmentation decreases with depth. Some infillings occur. The irregular and rough inter-aggregate micro vughs occur only in the subsoil.
Types of intra-aggregate voids, which are present in the forest profile are vughs and channels. The size of the vughs is micro and the channels are very fine. The amount of irregular and rough vughs ranges from few in the topsoil to very few in the subsoil. In the subsoil the very few channels are smooth.
Very few trans-aggregate planar voids are also present in the subsoil.

Passage features and excrement pedofeatures are present throughout the whole profile. The aggregates consist for a very dominant part of moderately coalesced excrement pedofeatures. The number of passage features increases from very few in the topsoil to dominant in the subsoil. In the same direction they change from strongly to moderately fragmented. Occasionally gibbsitic features occur as infilling or coating in voids. Very rare intrapedal limpid clay nodules can be found. They originate probably from weathered clay minerals. No ferruginous pedofeatures can de found.

4.2.2 mixed cropping profile (NEG 9)(fig. 4.1b & 4.2b)

The soil mass consist of a fine mass, composed of clay. The pedal soil microstructure in the topsoil changes into a vughy apedal microstructure at 40 cm depth. Below 55 cm depth the soil is again pedal.
Strongly developed crumbs and granules occur in the whole profile. The presence of subangular blocks is restricted to the topsoil. Porous fine crumbs are few at the surface, but increase with depth to very dominant and very coarse at 40 cm depth. The dense granules, coarse and dominant at the surface, decrease in size and frequency to frequent and fine at 40 cm depth. At the surface the fine to medium subangular blocks occur frequent. In the lowest part of the studied profile, very fine granules are very dominant. Micro-aggregates are frequent (fig. 4.1b).

The total estimated porosity of the mixed cropping profile is equal throughout the whole profile. The porosity is 50%. This porosity is mainly composed of inter-aggregate voids. A few intra-aggregate voids can be found throughout the whole profile (fig 4.2b).
The main types of inter-aggregate voids, the compound packing voids and the interconnected vughs, are located between the crumbs, granules and subangular blocks. These voids are very dominant and range in size from micro to coarse. They are irregular, rough and random distributed throughout the profile. In the topsoil occur mainly compound packing voids, in the subsoil mainly interconnected vughs.
Other types of observed inter-aggregate voids are channels, chambers, vughs and planar voids. The very fine and very few channels and chambers are partially interconnected. Some infillings occur. Few irregular and rough inter-aggregate micro vughs are only present in the subsoil.
The few intra-aggregate voids consist of micro vughs. These unconnected irregular voids can be found throughout the whole profile.
Micro planar voids, very few in frequency, occur as wel as inter- as intra-aggregate voids.
Passage features and excrement pedofeatures are present throughout the whole profile. The latter are dominant in the topsoil and slightly decreasing with depth. They have a dense internal ageing and are moderately coalesced.
The passage features, common and strongly fragmented in the topsoil, are also slightly increasing with depth, where they become frequent and moderately fragmented.
Textural pedofeatures occur as rare intrapedal limpid clay nodules in the topsoil.

4.2.3 pasture profile

profile NEG 106 (fig. 4.1c & 4.2c)

The soil mass consists mainly of a fine mass, composed of clay. Only near the surface and in the lowest part of the profile, the microstructure is pedal. From 15 to 50 cm under the surface the microstructure is apedal.

In the topsoil, very dense subangular blocks are the main type of inter-aggregates. They are dominant, medium sized and partially accomodated. Other types of aggregates in the topsoil are very few, strongly developed fine porous crumbs and and frequent medium dense granules. In the subsoil only very fine crumb and granules are present. The crumbs are very dominant and the granules common (fig. 4.1c).
The total estimated porosity of the pasture profile increases with depth. The porosity changes from 20% in the topsoil to 40% in the subsoil. Close to the surface this porosity is composed of even quantities of inter-aggregate and intra-aggregate voids. Below that layer, up to 50 cm depth, only intra-aggregates occur. In the lowest part of the profile the voids are mainly of the intra-aggregate type (fig. 4.2c).
The inter-aggregate voids in the topsoil are planar. These frequently occuring micro voids separate the (sub)angular blocks. They are smooth, random distributed and totally interconnected. The inter-aggregate voids of the subsoil are dominantly compound packing voids. These voids, with a wide range of sizes, are irregular, rough, random distributed and interconnected. The frequent observed very fine channels are the other type of inter-aggregate voids in the subsoil. They have undulating walls, are random distnibuted and are partially interconnected. Crumb infillings occur.
The types of observed intra-aggregate voids are vughs, channels and chambers. At the surface vughs are common, but in the section below, up to 50 cm depth, vughs become very dominant. In the lowest part only a few vughs are present. These vughs are micro to very fine sized. They are irregular, rough and random distributed. In the topsoil they are unconnected and in the lower part they are partially interconnected.
Channels and chambers are very few in the profile, except in the topsoil, where frequent coarse channels can be found. In the rest of the profile micro and very fine channels are present. They are smooth, random distributed and partially interconnected. The channels and chambers occur with infillings.

Excrement pedofeatures and passage features are present throughout the whole profile. The excrement pedofeatures are common and strongly coalesced in the topsoil and increase to be very dominant and moderately coalesced in the subsoil. Passage features are few and very weakly fragmented in the upper 15 cm. Below this zone they are common and moderately fragmented. Besides the passage features, other fabric pedofeatures, bow-like features, occur. Very few moderately fragmented bow-like features are present near the surface.
The occurrence of rare intra-pedal limpid clay nodules and few ferruginous mottles is restricted to the upper 30 cm of the profile. Occasional some fine charcoal is present in the first 15 cm.

4.2.4 maize profile

profile NEG 10 (fig. 4.1d & 4.2d)

Important! No thin sections are prepared of the upper 15 cm. This sample was lost during transport.

The soil mass consists of a fine mass, which is mainly composed of clay. The layer from 15-25 cm depth and the lower part (50-60 cm) of the profile have a pedal microstructure. The middle section, from 25-50 cm is apedal.
In the pedal topsoil moderately to strongly developed subangular and angular blocks are present. The subangular blocks, (very) fine and frequent, are partially accomodated and have undulating surfaces. The dominant and coarse angular blocks are partially accomodated and have smooth surfaces. They are compounded of smaller micro-aggregates, which are only recognizable by their darker colour.
In the subsoil crumbs and granules are the main types of aggregates. Porous, strongly developed microcrumbs are dominant. They are unaccomodated, rough and random distributed. The very dense and strongly developed granules are frequent and very fine. Like the microcrumbs they are also unaccomodated and random distributed but have undulating surfaces (fig. 4.1d).

The total estimated porosity of the maize profile is 15% at 15 cm below the surface. It increases with depth to about 50% in the lower subsoil.
In the topsoil the porosity is composed of inter-aggregate planar voids and a few intra-aggregate micro vughs and micro channels. The dominant occuring very fine planar voids separate the (sub)-angular blocks. These voids are randomly distributed, interconnected and accomodated (fig. 4.2d).
In the apedal middle section of the profile very fine and micro vughs are common. The vughs are irregular, rough, unconnected and have a random distribution. Also very few coarse channels occur. These are cylindrical with smooth walls.
In the lowest pedal layer, both inter- as intra-aggregate voids are present. The inter-aggregate voids consist of few very fine compound packing voids and frequent very fine channels and chambers. As intra-aggregate voids, common both unconnected as interconnected vughs occur. Few trans-aggregate voids micro planes are also observed.

Only the textural pedofeatures are present throughout the whole profile. They occur as rare interpedal continuous dusty clay coatings in planar voids and channels. Only at 15 cm they are occasionally observed. Sometimes, particularly at 60 cm depth discontinuous silt coatings occur. Dusty clay coatings are absent there.
Frequent ferruginous features can be found between 15-30 cm. In the upper part as mottles and in the lower part of the profile as coatings in planar voids and channels.
The passage features and excrement pedofeatures are present in the whole profile, but are very few above 30 cm depth. The weakly fragmented passage features increase with depth to common in the subsoil. The excrement pedofeatures increase with depth to dominant and very dense in the subsoil. In the topsoil they occur as porous continuous infillings.

Fig. 4.1 Frequency with depth of the main types of aggregates of a forest (a), a mixed cropping (b), a pasture (c) and a maize (d) profile. The size of the aggregates is also indicated.

Fig. 4.1a forest profile (NEG 102)

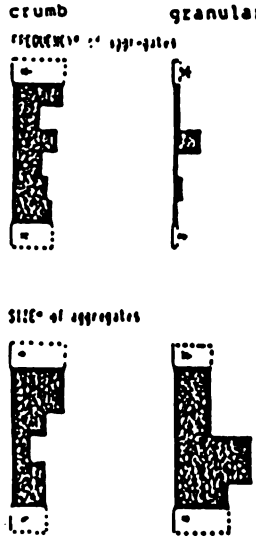


Fig. 4.1b mixed cropping profile (NEG 9)

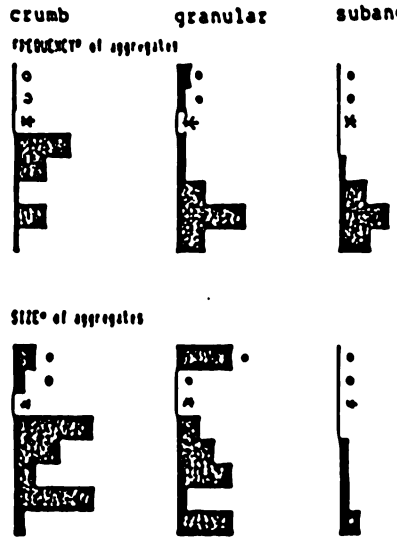


Fig. 4.1c pasture profile (NEG 106)

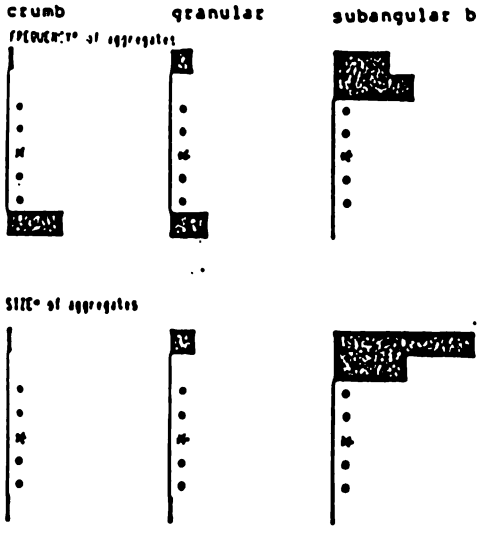


Fig. 4.1d maize profile (NEG 10)

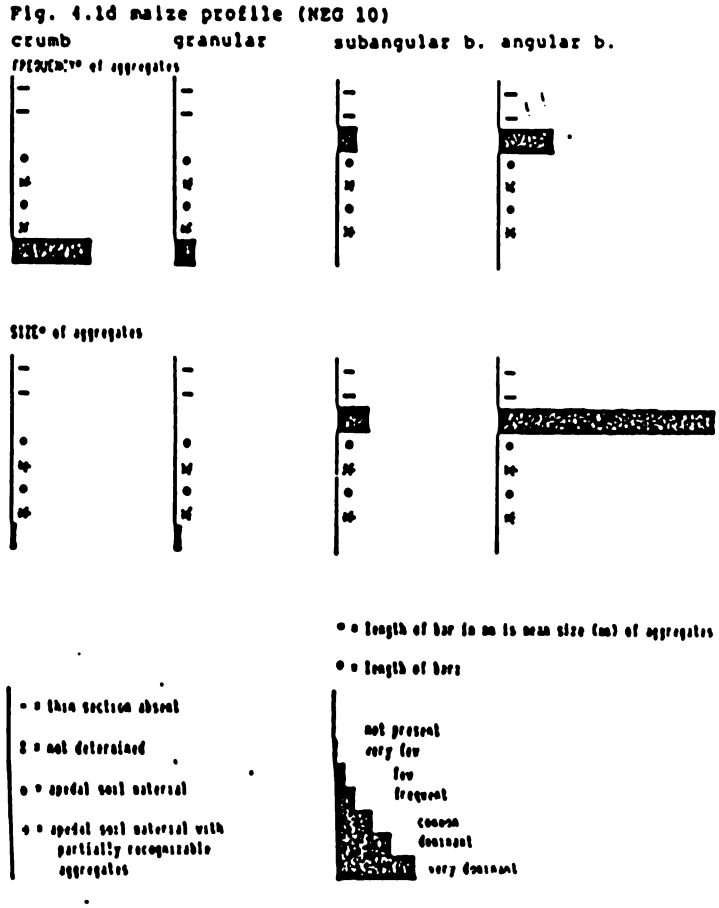
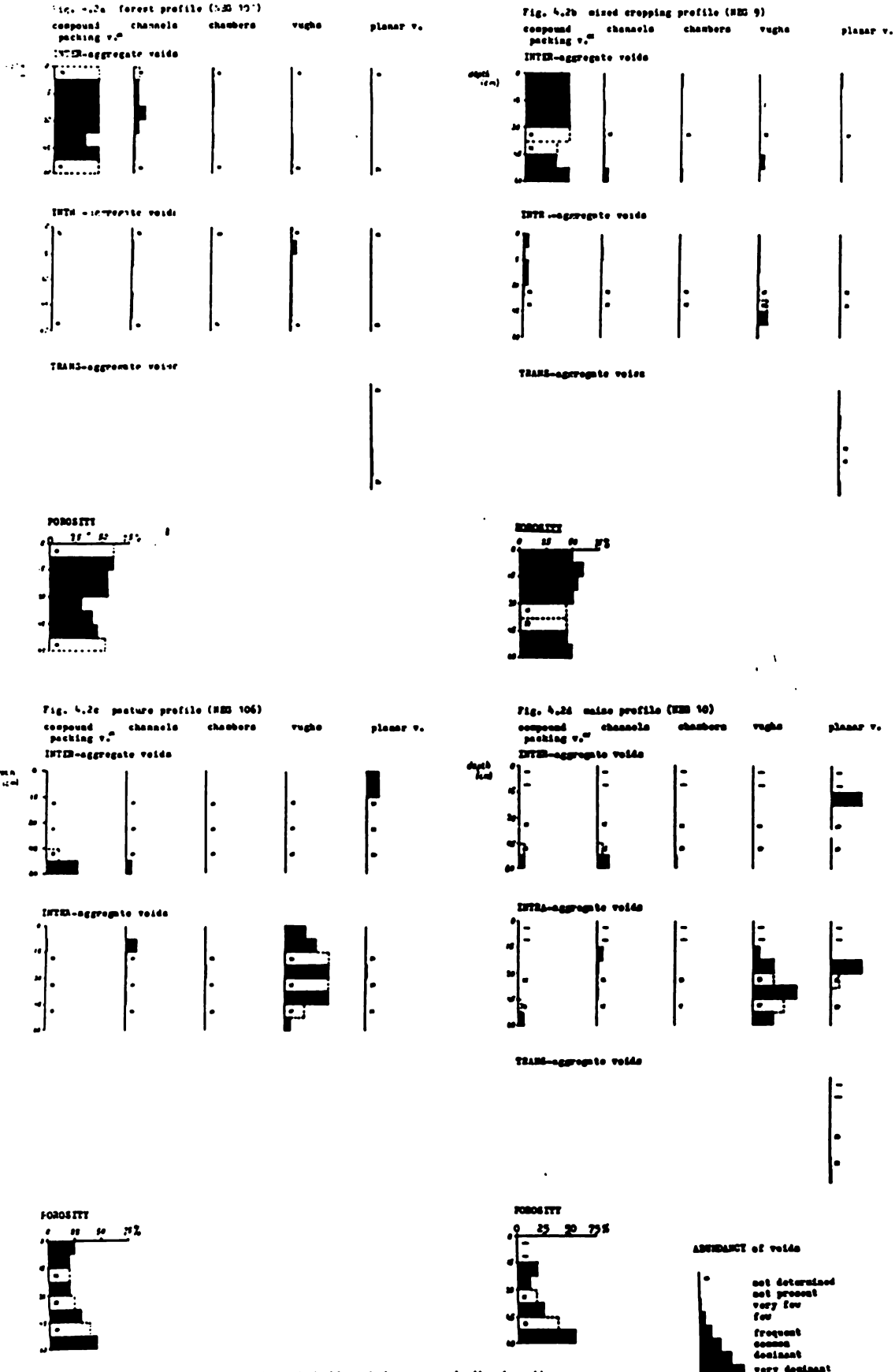


Fig. 4.2 Abundancy with depth of the main type of voids of a forest (a), a mixed cropping (b), a pasture (c) and a maize (d) profile. The total estimated porosity is also expressed.



* = compound packing voids (totally interconnected) in the topsoil and interconnected vughs (partially interconnected) in the subsoil

5 SOIL PROPERTIES RELATED TO SOIL STRUCTURE

In this chapter the results will be given of observations on soil properties more or less related to soil structure. The results are divided into three sections, namely physical (5.1), chemical (5.2) and biological (5.3) soil properties. Not all measured properties have a direct and clear relation to the soil structure. In this study these soil properties were taken into account just to find relations between degradation of soil structure and changes of the soil properties.

5.1 physical soil properties

Not all the results of the physical analysis are as reliable as could be wished. If possible the reliability of the given results will be pointed out.
Table 5.1 shows the mean volumetric water content (θ) in percentages at different moisture tensions, expressed as pF-values. The water content is given for the forest profile (NEG 3), the mixed cropping profiles (NEG 4 and NEG 9) and the pasture profile (NEG 106). Of each profile three horizons were sampled. The standard deviation (n=3) of each percentage is also given.
Because lack of bulkdensity data, the volumetric watercontents of the maize profile (NEG 10) and a forest profile (NEG 102) could not be determined.

Table 5.1 Mean volumetric water content (θ) in percentages at different moisture tensions, expressed as pF-values and at three depths (cm) of the profiles NEG 3, NEG 4, NEG 9 and NEG 106. (S.D. = standard deviation)
(n=3; S.D.= $\sqrt{\frac{\sum (X-x)^2}{n-1}}$)

pF-value			0	1.7	2.0	2.3	2.7	3.0	3.7	4.2
landuse	profile	depth(cm)								
forest	NEG 3	5	62 (2.4)*	58 (1.7)	54 (1.2)	51 (2.2)	50 (2.1)	44 (3.7)	43 (3.4)	41 (3.7)
		10	62 (1.9)	52 (3.3)	47 (3.3)	47 (3.3)	45 (3.7)	32 (2.1)	31 (2.5)	30 (1.6)
		55	59 (2.4)	56 (1.6)	49 (2.4)	47 (0.9)	46 (0.5)	46 (0.8)	44 (0.8)	42 (0.5)
mixed cropping	NEG 4	2	60 (1.6)	58 (1.3)	56 (1.3)	54 (1.4)	46 (1.9)	43 (1.7)	42 (1.7)	35 (1.4)
		35	59 (1.4)	57 (1.4)	52 (2.9)	49 (1.6)	43 (1.4)	42 (1.4)	39 (0.9)	36 (1.4)
		85	55 (0.9)	53 (0.8)	51 (2.2)	48 (2.6)	43 (0.8)	41 (0.5)	38 (0.5)	32 (0.5)
	NEG 9	5	57 (3.7)	49 (2.5)	43 (1.2)	41 (0.9)	40 (1.2)	-β	35 (0.5)	34 (0.8)
		10	60 (2.5)	48 (2.1)	42 (2.1)	39 (0.8)	38 (0.5)	-	29 (1.4)	28 (1.7)
		43	63 (1.3)	55 (2.2)	45 (2.2)	39 (2.2)	38 (2.9)	35 (0.5)	33 (0.5)	32 (0.5)
pasture	NEG 106	5	63 (0.8)	60 (1.2)	56 (1.2)	54 (1.7)	53 (1.2)	-	-	-
		23	55 (3.4)	44 (0.5)	41 (2.4)	38 (1.9)	35 (0.8)	-	-	-
		54	59 (0.8)	50 (0.8)	44 (0.8)	40 (0.5)	39 (0)	-	-	-

* = (S.D.)
β = not determined

Based on the data of table 5.1 the soil water retention curves were drawn (fig. 5.1) for each sampled horizon. In this figure values of the volumetric water content of the surface horizons are marked with a dot (·), those of the 'expected' compacted layer with a cross (x) and those of the subsoil with a circle (o).
Comparing the three curves of each profile it seems that only the soil moisture retention curves of the pasture profile (NEG 106) can be distinguished clearly from each other. The compacted layer (at 23 cm depth) shows a more negative slope coefficient over the traject pF 0 - pF 2,7 than the subsoil curve (54 cm). The curve of the surface horizon is more parallel to the Y-ax, especially over the pF 0 - pF 2.0 traject.
Striking is the abrupt change of the volumetric water content between pF 2.7 and pF 3.0 in most of the curves. Probably this bend of the curve is caused by the change of methods of analysis (3.3). The volumetric moisture content at pF 0 (see table 5.1) is equal to the porosity Ø. This porosity, together with the bulk-density at pF 0 is shown in table 5.2.

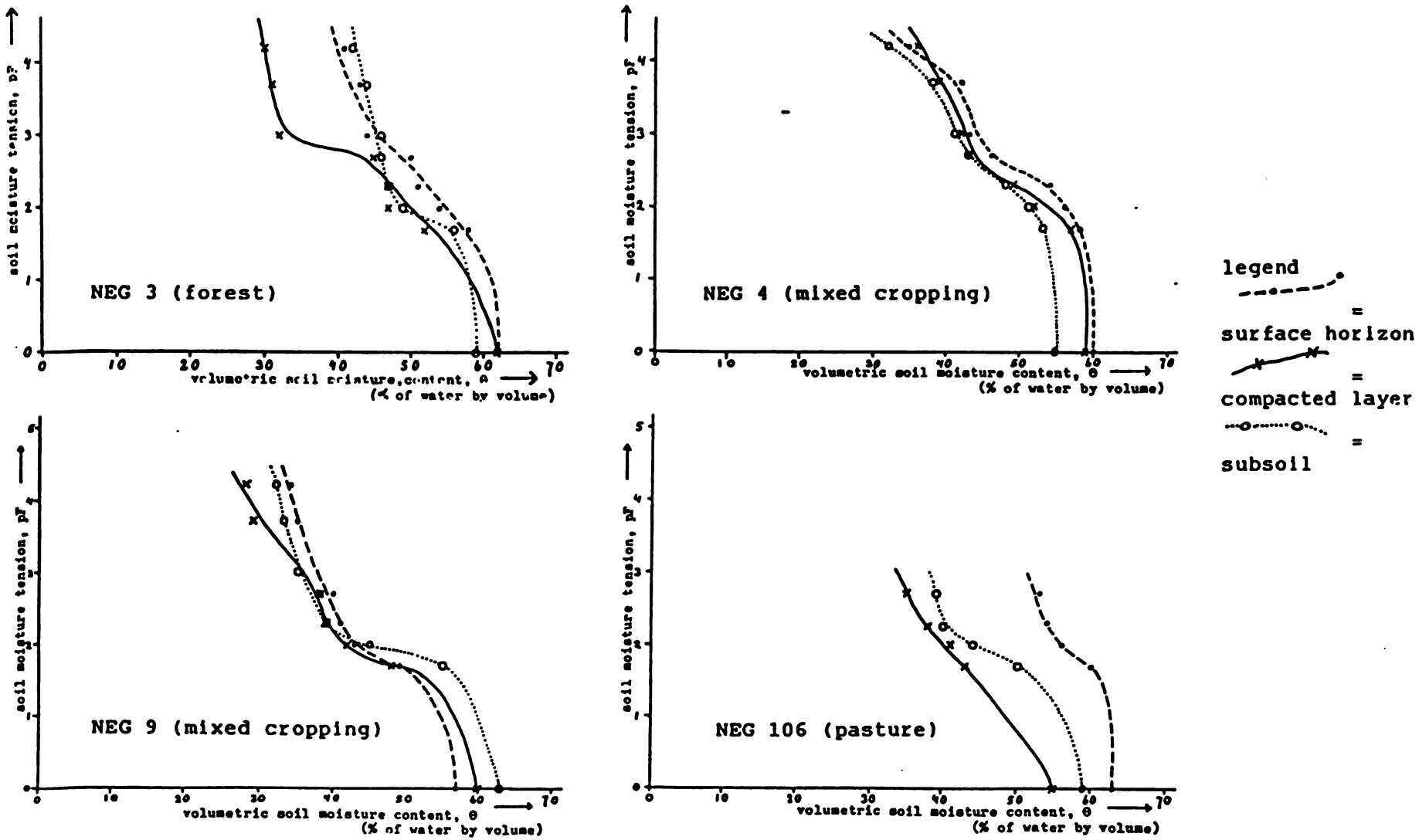
Table 5.2 Porosity (Ø) and bulk density ($^{b}\int_{s}$) values at three depths of the profiles NEG 3, NEG 4, NEG 9 and NEG 106. The porosity is equal to the volumetric water content at pF 0. (S.D. = standard deviation)
($n=3$; S.D. = $\sqrt{\left\{ \frac{\Sigma (X-x)^2}{n-1} \right\}}$).

			Ø (%)	$^{b}\int_{s}$ (g/cm³)
landuse	profile	depth (cm)		
forest	NEG 3	5	62 (2.4)*	0.63 (0.05)
		10	62 (1.9)	0.61 (0.04)
		55	59 (2.4)	0.81 (0.01)
mixed cropping	NEG 4	2	60 (1.6)	0.89 (0.04)
		35	59 (1.4)	0.92 (0.03)
		85	55 (0.9)	0.81 (0.01)
	NEG 9	5	57 (3.7)	0.71 (0.01)
		10	60 (2.5)	0.63 (0.04)
		43	63 (1.3)	0.70 (0.01)
pasture	NEG 106	5	63 (0.8)	0.86 (0.01)
		23	55 (3.4)	0.82 (0.04)
		54	59 (0.8)	0.79 (0.02)

* = (S.D.)

Comparing the bulkdensities of the compacted layer with the bulkdensities of the surface horizon and the subsoil, no clear differences occur (table 5.2).
Also expressed in porosity, the compacted layers do not show a clear lower porosity compared with the other horizons.
Remarkable are the very low values of the bulkdensities. For these soils, nearly ultisols and without a clear resemblance with andepts, normally bulkdensity values of more than 1.0 g/cm³ can be expected. The reliability of the bulkdensity values and the derived porosity values and soil moisture retention curves can be severely doubted. Therefore the comparising between these curves of the different profiles is of no use.

Fig. 5.1 Soil water retention curves of a forest (NEG 3) and pasture (NEG 106) profile and two mixed cropping profiles (NEG 4 & NEG 9). For each profile different curves for the surface horizon (.), the expected compacted layer (x) and the subsoil (o) are drawn.



5.2 chemical soil properties

The results of the chemical analysis are shown in Appendix C. To show changes in some major chemical properties of the soil the Spearman rank correlation test was used. The results of these tests are given in table 5.3 (topsoil) and 5.4 (subsoil). For the topsoil the weighted mean value of each soil property over the upper 30 cm was taken. Most visible degradation took place in the upper 30 cm, so if related chemical degradation occurred it would be in this layer. As reference the change in soil properties in the subsoil is taken. Therefore, per property the weighted mean value over 60-90 cm was calculated.

Table 5.3 Weighted mean values of some principal chemical soil properties in the topsoil (0-30 cm). Reliability of the Spearman rank correlation test is indicated.

landuse	forest		mixed cropping		pasture	maize	d^2*	reliability*
profile	MEG 3	MEG 102	MEG 4	MEG 9	MEG 106	MEG 10		
chemical property								
C (%)	3	2	2	2	3	3	18	-
N (%)	-	0.3	0.3	0.2	0.3	0.3	12	-
C/N	-	8	14	12	10	9	18.5	-
pH-H_2O	4.8	4.1	4.6	4.1	4.3	5.3	20.5	-
pH-KCl	3.8	3.9	4.5	3.8	3.9	4.7	12.5	-
E-CEC	-	4.8	2.3	6.1	7.2	9.5	3.5	* (+)▾
CEC-pH 7	29	24	21	25	27	26	31	-
E-CEC/CEC	-	0.20	0.11	0.24	0.26	0.36	3.5	* (+)
BS (eff)	-	26	71	29	47	94	3.5	* (+)
BS (pH 7)	-	5	8	7	12	33	0.5	** (+)
Ca exch	1.0	0.8	0.9	1.0	1.5	4.4	6.5	* (+)
Mg exch	0.6	0.3	0.6	0.4	0.8	2.4	6.5	* (+)
K exch	0.2	0.2	0.2	0.2	0.9	1.9	4	*** (+)
P avail	7	8	6	6	8	30	19.5	-

* = $d^2 = \sum (i - s_i)^2$, with i= rank number of the landuse type. These are ranked to increasing openess of the ecosystem (forest-mixed cropping-pasture-maize). s_i= rank number of the chemical property value belonging to i. These are ranked to increasing value.

* = Reliability is expressed as follow: reliability < 80% -, no correlation
reliability 80-90% *
reliability 90-95% **
reliability > 95 % ***

▾ = a positive sign indicates a larger value of the chemical soil property prior to an opener ecosystem (positive correlation).

Table 5.4 Weighted mean values of some principal chemical soil properties in the subsoil (60-90 cm). Reliability of the Spearman rank correlation test is indicated.

landuse	forest		mixed cropping		pasture	maize	d^2[a]	reliability[b]
profile	NEG 3	NEG 102	NEG 4	NEG 9	NEG 106	NEG 10		
chemical property								
C (%)	0.9	0.5	1.5	0.4	0.4	0.3	57	-
N (%)	-	0.07	0.11	0.09	0.08	0.10	7.5	-
C/N	-	13	13	5	5	3	25.5	-
pH-H_2O	5.3	4.3	4.7	4.3	3.8	4.6	44.5	-
pH-KCl	4.0	4.1	4.9	4.0	3.9	4.3	31.5	-
E-CEC	-	3.4	1.3	4.2	4.9	4.6	7.5	-
CEC-pH 7	24	22	15	29	26	23	28	-
E-CEC/CEC	-	0.15	0.09	0.14	0.19	0.20	8.5	-
BS (eff)	-	15	80	23	15	65	9	-
BS (pH 7)	-	2	7	3	3	13	3.5	8 (+)[c]
Ca exch	1.0	0.1	0.4	0.5	0.3	0.7	31	-
Mg exch	0.9	0.1	0.4	0.2	0.1	0.3	39	-
K exch	0.1	0	0.2	0.1	0.1	1.9	9	8 (+)
P avail	11	6	5	5	5	12	32	-

[a] = $d^2 = \sum (i-s_i)^2$, with i= rank number of the landuse type. These are ranked to increasing openess of the ecosystem (forest-mixed cropping-pasture-maize). s_i= rank number of the chemical property value belonging to i. These are ranked to increasing value.

[b] = Reliability is expressed as follow: reliability < 80% -, no correlation
reliability 80-90% 8

[c] = a positive sign indicates a larger value of the chemical soil property prior to an opener ecosystem (positive correlation).

The nulhypothesis (H_o) by this test was: No correlation between the chemical soil property and the openness of the ecosystem (2.5). And the other, alternative hypothesis (H_a) was : Existence of a negative or positive correlation.
The landuse types were ranked to increasing degree of openness of the ecosystem, namely forest - mixed cropping - pasture - maize. Within each soil property the data were ranked to increasing value.
In the topsoil a positive correlation appeared at a reliability or level of significance of 95% for exchangeable K, at a reliability of 90% for base saturation (pH 7), and at a reliability of 80% for effective CEC, exchangeable Ca, exchangeable Mg, base saturation (effective) and the Effective CEC/CEC (pH 7) ratio.
In the subsoil a positive correlation appeared at a reliability of 80% for exchangeable K and base saturation (pH 7.0).

5.3 biological soil properties

As mentioned in the chapter Methods (3.5), no special methods were carried out to determine the biological influence on the soil structure.
Table 5.5 shows the estimated activity of the soil fauna species and fig. 5.2 shows the drawings made of the biological activity in some profiles.

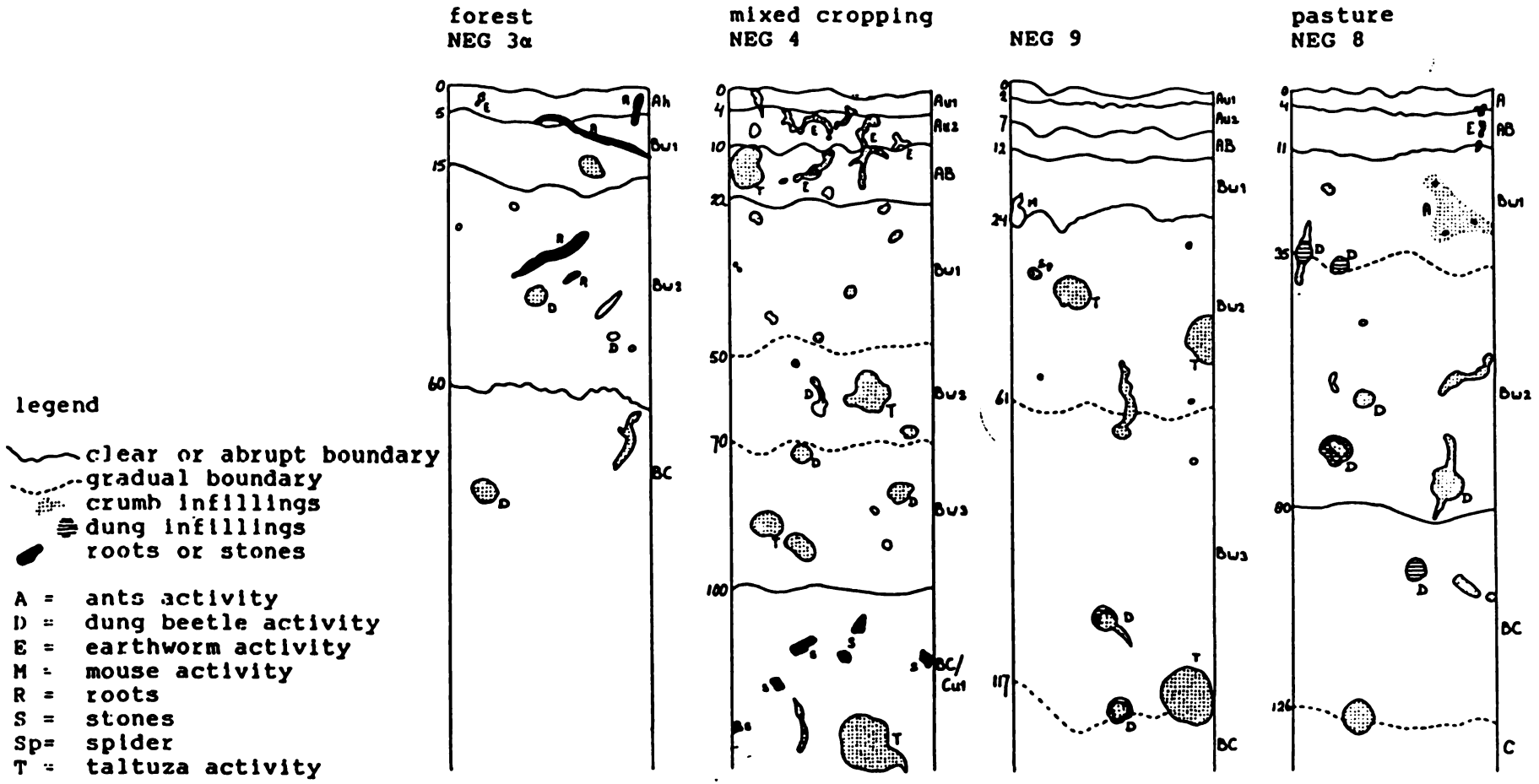
Table 5.5 Activity of soil fauna species, estimated for the described profiles. Profiles are grouped to landuse types.

landuse	forest			mixed cropping				pasture			maize		
profile	NEG 3	NEG 101	NEG 102	NEG 4	NEG 7	NEG 9	NEG 107	NEG 8	NEG 103	NEG 106	NEG 10	NEG 104	NEG 105
soil fauna													
leafcutter ant	++	+++	++	-	+	+	-	-	+	-	-	-	-
termite	-	-	-	-	-	+	-	-	++	-	-	++	-
taltuza	-	-	+	++	++	++	+++	+	-	-	-	+	+
mouse	-	-	-	-	+	+	-	+	-	-	-	-	-
dung beetle	+	-	-	-	-	+	+	++	+++	++	+	-	-
earthworm	-	++	-	++	+	-	++	-	++	++	++	-	++
spider	-	-	+	-	-	-	-	-	+	-	+	+	-

- no signs of activity; + low activity; ++ medium activity; +++ high activity

The forest profiles show relative high activity of leaf cutter ants. In profile NEG 101 even a displacement by the ants of 25 dm^3 soil per m^2 per day was measured. By this enormous activity of ants in the forest, the activities of other species became almost negligible. Although, activity of other animals, especially of earthworms, taltuzas, dung beetles and spiders were recorded.
In the mixed cropping profiles the activity of the leaf cutter ant was relatively low. Under this landuse type the taltuza had the highest activity, also compared to the other landuse types. Earthworms showed a relatively medium activity. A wide range of soil animal species was present, with low activity.
In the pasture profiles, the dung beetle was the most remarkable and active animal. Earthworms have a relative medium activity under pasture. Many other soil animal species are also present and all of them showed a low activity.
At the profiles under maize, no species with a high activity were observed in the soil. Earthworms had a medium activity in these profiles. Low activity occurred by taltuza, dung beetle and spider.

Fig. 5.2 Profiles with signs of biological activity.



α = in Bw1 and Bw2 ants are very dominant, although not indicated

6 DISCUSSION

In this chapter first of all the restrictions belonging to this research will be mentioned. In this chapter, the accuracy and reliability of the results will be discussed. Next the degradation of the soil structure in relation with the type of landuse will be described. Therefore, the structure of the soil under the natural vegetation, forest will be compared with the soil structure under mixed cropping, pasture and maize. In the last section it is tried to explain the degradation of the soil structure in relation with the total ecological changes.

6.1 restrictions

The principal restriction on this research is perhaps the qualitative way in which the results are presented. However, a qualitative research is not necessarily working restrictive. Often, descriptions give a more complete and coherent picture of the process taking place than loose figures. But in a sense, it is restrictive because descriptions make the results difficult to compare and so difficult to prove.
For this research it means that the estimations of size and frequency, used to describe the soil structure and the biological properties can only be compared within this research. Likewise the porosities estimated at the micromorphological observations. The only quantitative results, the physical and chemical data are not used for the overall syntheses. The physical data appeared to be useless and the chemical data of no interest for this research.

As already mentioned in section 5.1, all physical results are not very reliable, because of the unlikely low bulk density values. Because the soil moisture retention curves and the porosity values are derived of these bulk density values, they also are not confident. As a substitution for these porosity values, the micromorphological observations can act. They can not be considered as absolute percentages and can only be compared within this research.
The other quantitative results, which are not used in this discussion, are the chemical data. This time, there is no reason to doubt the reliability of the data. The results of the Spearman rank correlation tests (table 5.3 & 5.4) proved positive correlations between some chemical soil properties and the sequence forest - mixed cropping - pasture - maize. In the topsoil (0-30cm) this positive correlation concerned the following chemical soil properties: Ca exch., Mg exch., eff. CEC, eff. BS and the eff. CEC/CEC (pH 7) ratio. For these soil properties no positive correlation was proved in the subsoil (60-90cm).
In the subsoil a positive correlation existed for K exch. and BS (pH =7), which was strengthened in the topsoil. In most literature a leaching of nutrients and a decrease in CEC and BS after clearing the forest is described (e.g. Allen, 1985; Swift, 1985; Sanchez, 1976). So, the in this study observed increase in nutrients, CEC and BS can not be related to the removal of the natural vegetation. This increase gave rise to suppose that

nutrients are added, neutralizing the leaching effects. It is highly probable that fertilizers are supplied to the mixed cropping system and certainly to maize, a cash crop. The supply of dung by cattle could have the same consequences for pasture landuse.

6.2 soil structure degradation

To describe the process of soil degradation related to landuse, comparison should take place with the begin situation. For this discussion all comparisons of the soil structure shall be made with the structure uder the natural vegetation, tropical rainforest (2.5). If porosity percentages are given, referred is to the estimated porosities of fig. 4.2. At the end of this section a second explanation of the distribution of pore sizes shall be given, considering the porosity values of the physical analysis (table 5.2).
According to the field descriptions (4.1.1), the forest soil is uniform structureless porous massive with a friable to loose consistence. The more detailed micromorphological descriptions show the existence of aggregates. The structureless soil appears to consist of coarse very porous crumbs and fine dense granules (fig. 4.1a).
The topsoil has a porosity of 55% decreasing with depth but remaining high (40%) in the subsoil (fig. 4.2a). The many very fine voids, mainly compound packing voids, gives the soil its high porosity. The voids are totally interconnected in the topsoil and partially in the subsoil. Besides the compound packing voids, the porosity consists of other biogenic voids as channels and vughs. To a large depth, the forest soils show signs of high biological activity.
Not only the mentioned biogenic voids but also the large quantities of passage and excrement pedofeatures point at that high biological activity (4.2.1)The passage and excrement pedofeatures are strongly fragmented in the topsoil and moderately fragmented in the subsoil. That strong fragmentation point at higher or more recent biological activity in the topsoil compared to the subsoil.

By comparing the soils horizontally, it appears that the subsoil structure under forest is the same for the mixed cropping, pasture and maize soils (fig. 4.1 & 4.2). The subsoil is structureless porous massive, very friable (4.1) and with a porosity of 40 - 50% (fig. 4.2), mainly consisting of biogen voids. Micromorphological observations show dominantly porous crumbs and common very fine dense granules (fig. 4.1 and fig. 6.1).
Excrement pedofeatures are dominant and passage features are common, both moderately fragmented (fig. 4.2)

Further comparison shows that the topsoils under the different landuse types do not have the same structure as the forest soils, so soil degradation seems to be restricted to the upper part of the profile. Table 6.1 shows the main topsoil characteristics for the four types of landuse. Figure 6.2, photos of the thin sections, shows the micromorphological differences.

Fig. 6.1 Soil microstructure of the subsoil under forest (a), mixed cropping (b), pasture (c) and maize (d).

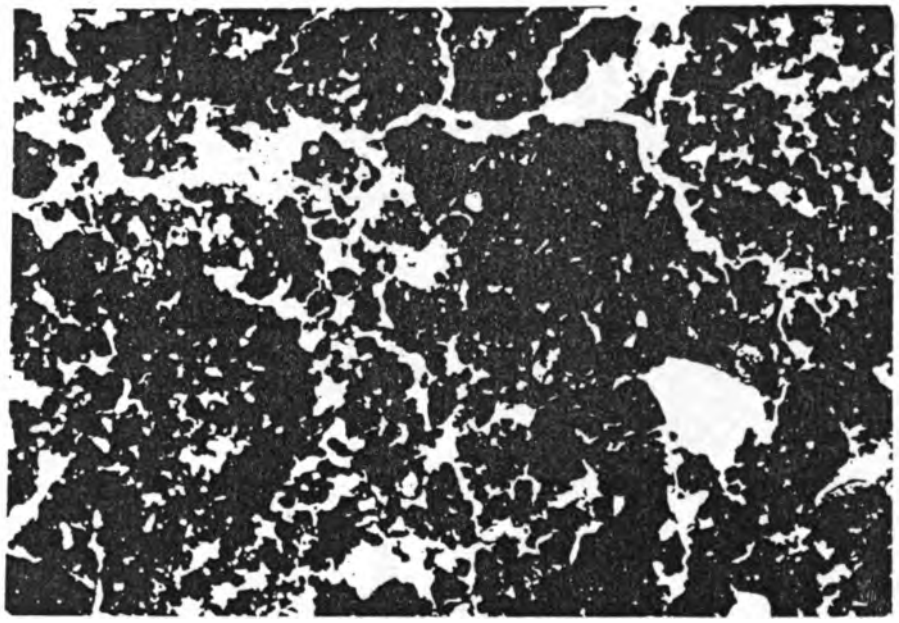


Fig. 6.1a Subsoil forest profile (NEG 102; thin section nr. 87.149).

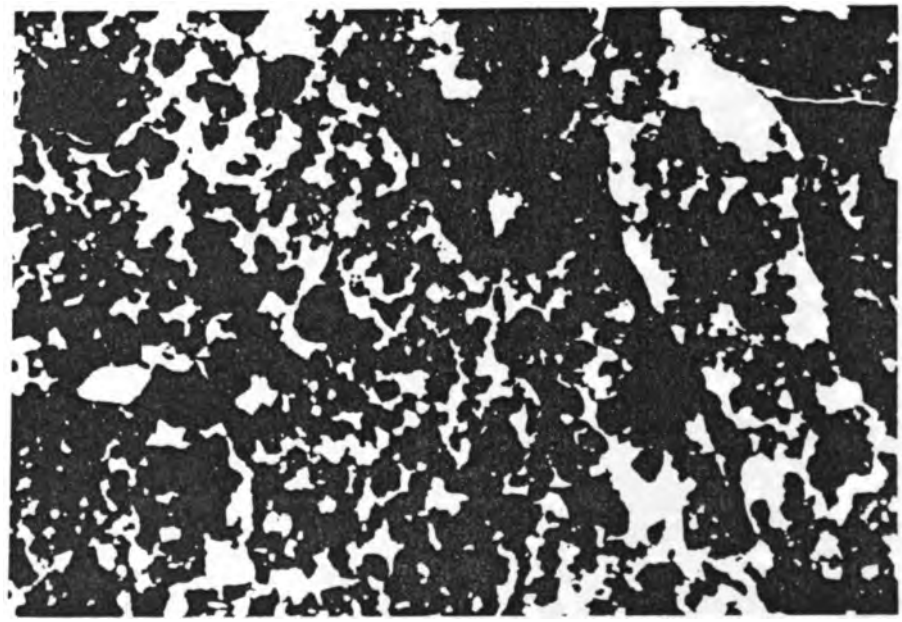


Fig. 6.1b Subsoil mixed cropping profile (NEG 9; thin section nr. 87.135).

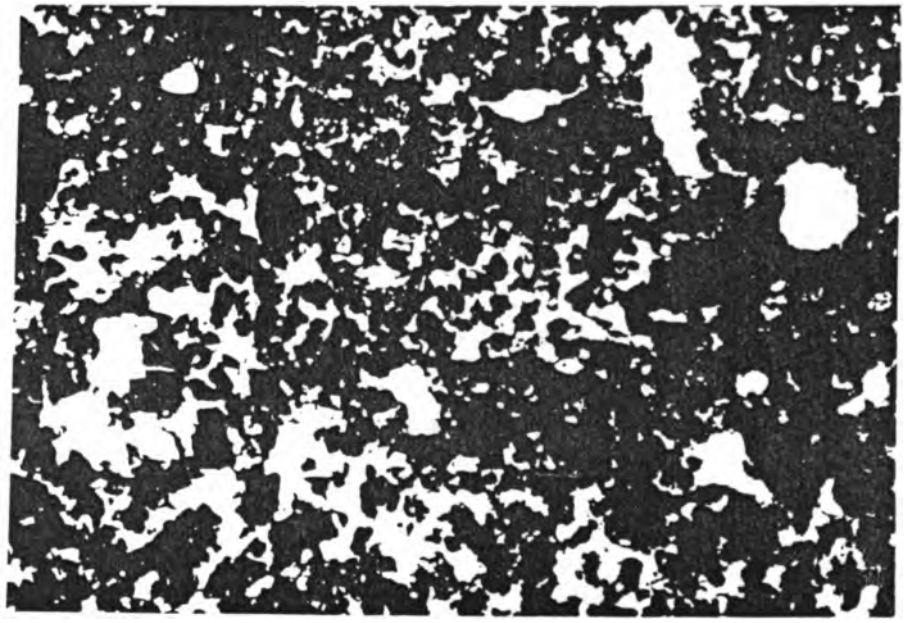


Fig. 6.1c Subsoil pasture profile (NEG 106; thin section nr. 87.157).

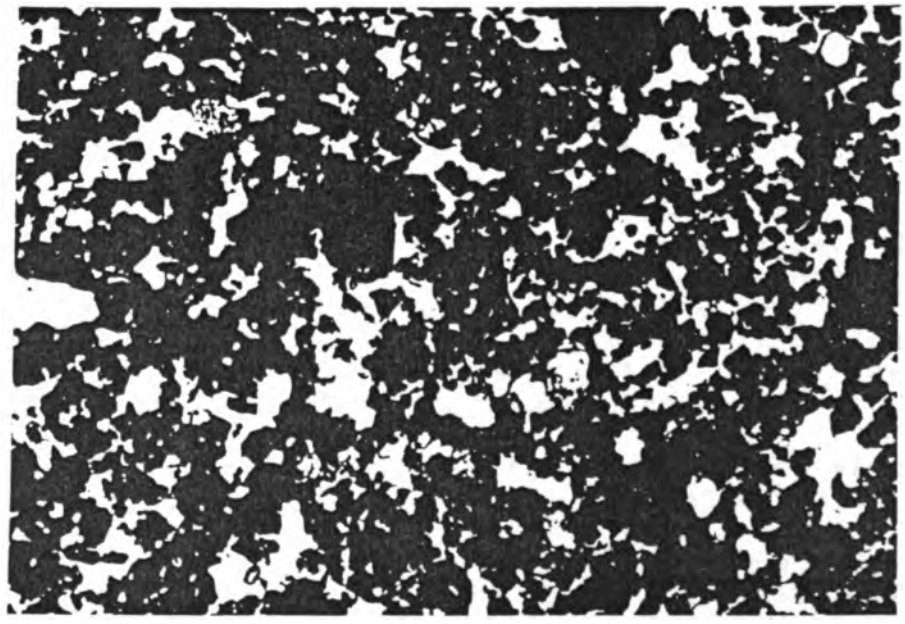


Fig. 6.1d Subsoil maize profile (NEG 10; thin section nr. 87.141).

Table 6.1 The main morphological characteristics of the topsoil under forest, mixed cropping, pasture and maize.

landuse	crumb	porous	micropeds	unaccomodated	loose-very friable	str.fragm.passage f.	mod.coal.excrement f.	compound packing v.	est.porosity>40%	granular	dense	friable	channels-chambers	inter-aggregate v.	interconnected	peds	subangular	firm-very firm	part.accomodated	planar v.	intra-aggregate v.	str.coal.excrement f.	est.porosiy<40%	unconn.vughs	ferruginous mottles	angular	ext.firm	very dense	accomodated	clay-ferr.coatings
	biogenic																													physicogenic
forest	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X														
mixed cropping					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X											
pasture										X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X					
maize														X	X	X	X	X	X	X			X		X	X	X	X	X	X

Because of the compaction, the topsoil becomes less porous. If looking at the estimated porosity values, only the mixed cropping soil shows a porosity (50%) equal to the forest soil porosity (55%). The topsoil porosity of the pasture soil is less than half of it (20%) and probably even lower for the maize soil (15% on 15 cm depth)(fig. 4.2). The voids, in the forest and mixed cropping soils yet mainly biogenic are mainly physicogenic in the maize soil (planar voids). The pasture soils show both type of voids (fig. 4.2a).
The landuse type maize and in a less degree pasture have a compacting influence on the void space. The impact of mixed cropping on the voids can be compared to forest.
The transition of a structured toplayer to a structureless subsoil is absent in the forest topsoil. For the other soil types, the transition is more obvious. It is located at about 20 cm depth for the mixed cropping soils, at about 30 cm for the pasture soils and at even deeper than 30 cm for the maize soils. If looking at the structure one can see denser and sharper aggregates according the same sequence. The main type, occurring in the forest topsoil are coarse very porous crumbs, in the mixed cropping soils coarse dense granules, in the pasture soils medium dense subangular blocks and in the maize soil coarse very dense angular blocks (fig 4.1a). Thus together with the increasing openness of the ecosystem, the aggregates become more denser and angular.
The compaction, which appears in the topsoil has also its influence on the flow of water. The water is stagnating in the compacted layer and because organic matter is present, reduction and oxidation processes take place. In the pasture and maize soils, orange and gray mottles are found in the upper 10 cm, indicating pseudogley. In the most compacted maize profile (NEG 10) even coatings of ironoxides along channels and pedfaces are found, in a greyish reduced topsoil. In the forest and mixed cropping soils, no mottling is found. This is explainable, because no compaction occurred in these soils.

Fig. 6.2 Soil microstructure of the topsoil under forest (a), mixed cropping (b), pasture (c) and maize (d).

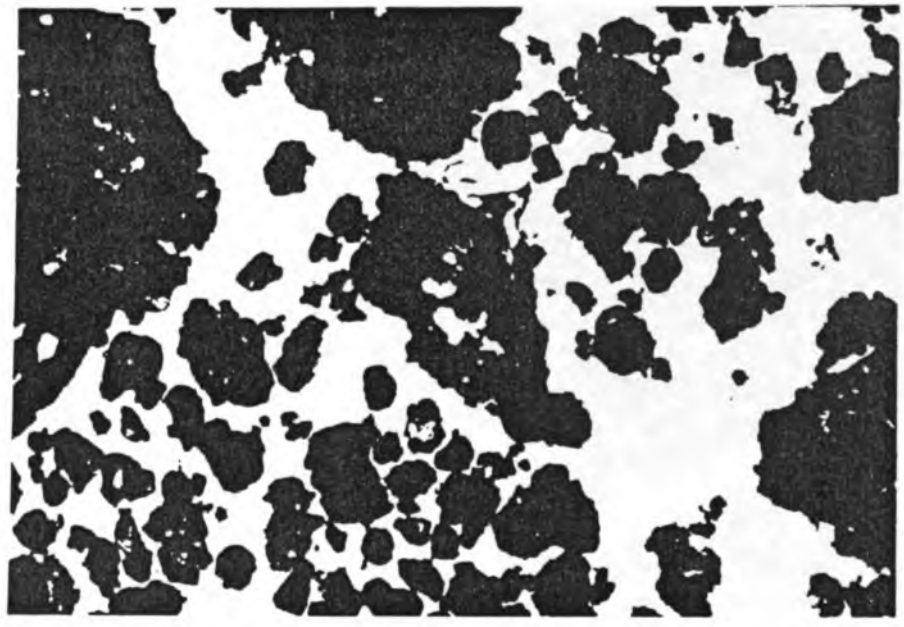


Fig. 6.2a Topsoil forest profile (NEG 102; thin section nr. 87.142).

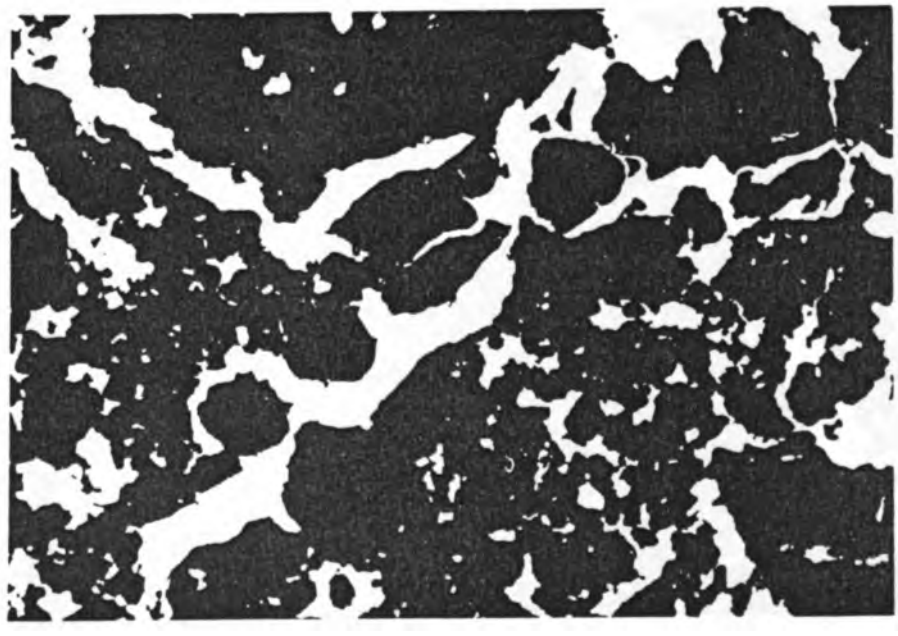


Fig. 6.2b Topsoil mixed cropping profile (NEG 9; thin section nr. 87.129).

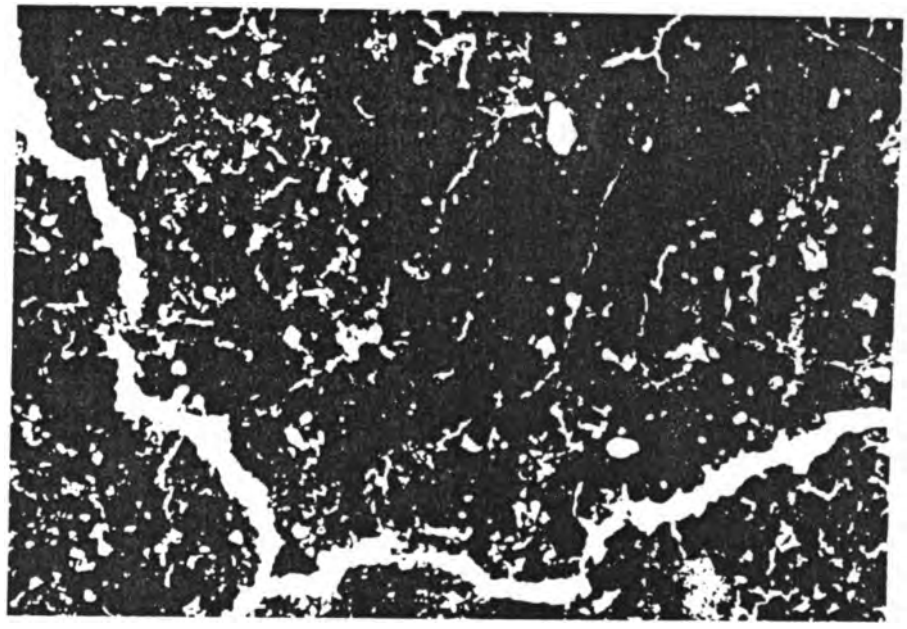


Fig. 6.2c Topsoil pasture profile (NEG 106; thin section nr. 87.150).

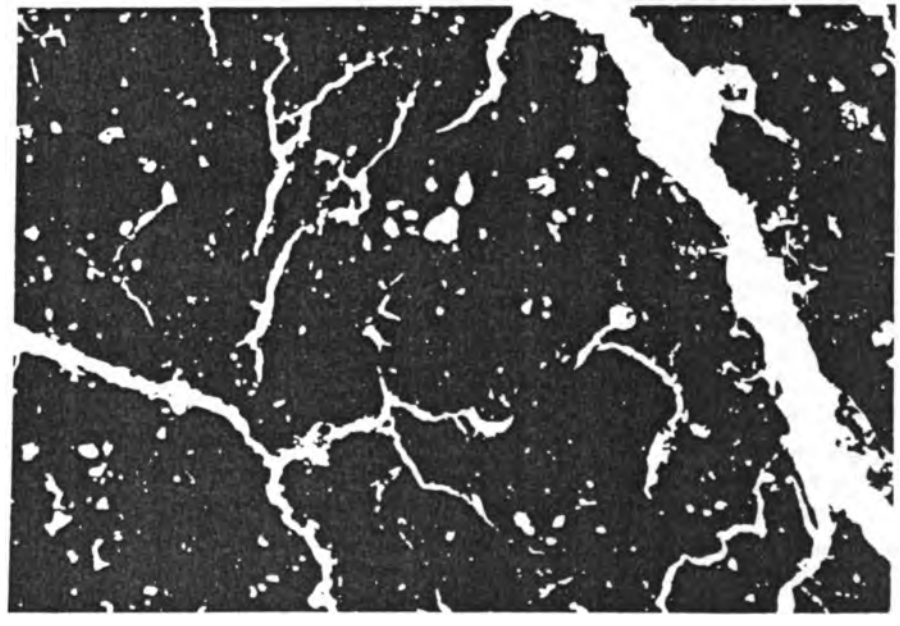


Fig. 6.2d Topsoil maize profile (NEG 10; thin section nr. 87.136).

Textural pedofeatures, particularly clay coatings, are found in both the pasture as the maize profile. In the pasture profile the coatings are just patchy and thin, along the channels and ped faces, but in the maize soils they occur also as thick continuous horizontal coatings. In the forest and mixed cropping soils no textural pedofeatures were found (4.2). Because the time after forest clearing is just 3 years for both the pasture and the maize soils, the transport of clay should be recent. In Surinam, Ketelaars (1975) and de Boer (1972) both observed a recent transport of clay after forest clearing. De Boer (1972) gives as a cause for this translocation of clay that it might be an indirect consequence of the slash and buring of the natural vegetation. Mobilisation of clay, preceding the clay transport can be originated by mechanical and chemical causes. A mechanical cause can be the impact of raindrops on a dry soil. The increase in pH as a result of enrichment of the soil by ash, can be a chemical cause (Ketelaars, 1975, after de Boer, 1972). In the Neguev, the impact of raindrops on the soil, seen the high rainfall intensities, is very likely a cause. Especially the often uncovered soil of the maiz landuse system is sensitive. The mobilisation of clay by burning can be excluded as a cause, because burning methods are hardly used. Perhaps the enrichment of the soil by fertilizing can cause clay mobilisation, although an increase in pH is not proven (5.2).
Compared to the forest soils, the other soils diminish in excrement pedofeatures, according the sequence mixed cropping-pasture-maize soils. The amount and degree of development of the passage features also decrease till very few and weakly developed in the maize profile (4.2). Both indicate a diminishing biological activity.

Summarizing it can be concluded that the compaction of the soil structure increases according to the sequence forest (no degradation)-mixed cropping- pasture-maize (strong degradation), thus according the increasing openness of the ecosystem. For the mixed cropping soils the degradation of the soil structure is only visible by the increasing compaction of the aggregates. The porosity and type of voids remains the same as under forest. The biological activity is somewhat decreased.
For the soils under pasture not only the aggregates are compacted to dense subangular blocks, but also the porosity is decreased by compaction. This compaction causes some stagnating of water on the topsoil. The biological activity is strongly decreased compared to the situation under forest. A small amount of clay is illuviated because of instability of the topsoil.
For the maize soils, the compaction is even stronger. The porosity in the topsoil is strongly reduced and the aggregates have become very dense and angular, sometimes even platy. The vertical flow of water is strongly stagnated in the topsoil. The biological activity in the soil is also strongly diminished. In the maize soils also clay illuviation occurs, because of instability of the topsoil.
So far, the conclusion if considered the estimated porosities. But starting from the porosities, determined by physical analysis, an other picture of the pore size distribution can be developed.
Comparison of the different types of landuse shows a high top- and subsoil porosity (60%, table 5.2) for both forest, mixed

cropping and pasture. The porosity for maize is not determined in with physical methods.
Because the aggregates in the topsoil become denser, according the sequence forest - mixed cropping - pasture, a sustained high total porosity is only explainable considering the inter-aggregate voids. These voids have to become coarser to maintain a porosity of 60%. So, the pore size distribution has to change from relatively many fine and few coarse voids in forest topsoils to few fine and many coarse voids in pasture topsoils.
Considering the estimated porosities (fig. 4.2), there should not necessarily be such a strong increase in coarse voids.

6.3 synthesis

In this last section of the discussion a draft will be given of how the soil structure changes under the different landuse types and by what factors this change is influenced. Therefore, not only the results of this research are used, but also some non-proven hypotheses. Further research is needed to support this synthesis.

The cause of the very loose porous soils under forest is probably the soil animal with the highest soil biological activity in the forest, the leaf cutter ant (Atta cephalotes) (table 5.5). Continually, they transport fresh soil material from the B-horizon to the surface, disturbing the profile highly (2.7). Moreover, the ants fill subsoil chambers with plant material on which they grow fungi. By doing so, the ants do not only rework the soil but also incorporate organic matter in the profile. The whole soil is shifted into stable microaggregates, which slightly conglomerate to very porous crumbs.
Probably, these microaggregates thanks their stability to the influence of the organic matter and the fungi. Maybe the fungi give the microaggregates a repellent coating, which prevent further aggregation.
To preserve the important influence of ants on the soil structure, their requirements on the environment should be satisfied. An important requirement is the presence of certain trees, needed for the plant material to grow fungi. These trees are perhaps not present in the mixed cropping system, because ants have only a low activity in the mixed cropping soils (table 5.5). Also the use of fungi-killing $CuSO_4$, a widespread remedy in the banana cultivation can have disminuished the number of leaf cutter ants.
In the mixed cropping system, the important role of the ant in the forest is taken over by the taltuza or pocket gopher. This rodent prefers the mixed cropping system because of the fruit trees. The roots of these trees are his food (2.7). By burrowing subterraneous tunnels, this animal disturbes the soil completely. Material from the subsoil is transported to the topsoil, but the taltuza has no influence on the incorporating of organic matter.
The soil is still loose and porous, but in the topsoil part of the microaggregates stuck together to dense granules. Probably because of the high disturbance of the soil still crumbs and loose microaggregates occur in the topsoil. Together with the mulching, the soil remains highly porous.
In the pasture profile both ants and taltuzas are almost absent, because of lack on food sources. Besides, the taltuza avoids

pasture, because the cattle destruct their tunnels (2.7). Trampling the topsoil by cattle is often mentioned as a principal cause of the degradation of the soil structure. On the investigated soil series, also the low disturbance by the soil fauna plays a role. The principal animal in these pasture soils, the dungbeetles, rework the soils on a low level compared to the ants and taltuzas. Together with the earthworms, which have an activity restricted to the topsoil, they burrow vertical shafts, not transporting much soil material. These channels facilitate the flow of water through the compacted toplayer. But because the beetles and worms do not transport much fine structured material to the subangular topsoil, this horizon remains compacted.
In the profiles under maize, all soil animals have a low activity. The monoculture of maize makes the life circumstances uncomfortable for all main soil fauna species. The ants lack their leafs, the taltuzas their roots and the beetles the dung. Moreover, part of the year the topsoil is exposed to sunrays and heavy rainfall. This has both a direct degrading effect (impact of raindrops) as an indirect degrading effect (rise of soil temperature). The soil structure becomes less stable. Because of all these influences on the soil structure, the original structure of stable microaggregates coalesceto very dense coarse angular blocks. This compacted layer stagnates the flow of water. This makes the structure only more instable. Because there are almost no deep burrowing animals in the maize soils, fresh loose subsoil material is hardly added on the topsoil, so degradation goes on.

As we search for sustained landuse, an permanent good soil structure is an essential condition. All three types of landuse investigated, have a more or less degrading influence on the soil structure. For the Germania soil series on the Neguev, the mixed cropping system appears to be the most suitable type of sustained landuse. The compaction is minimal and there is a continuous process of supply of loose stable subsoil material by the taltuza. The mulching provides, by incorporating of organic matter, also a stable and loose topsoil. But still remains a big problem, before recommending the mixed cropping system for sustained landuse. The farmers do not like the fruittree harming taltuza and use all their posibilities to destroy the taltuzas as a plague (Holdway de Levenstein, 1984).
Maize and pasture are not suitable as types of sustained landuse. Both hardly have any supply of subsoil aggregates and incorporation of organic matter. Besides, both are also compacted by external forces. Perhaps the silvopastoril system (CATIE, 1985) could be a solution for the pasture. This system, traditional in Costa Rica, uses hedges to enclose the pasture, shaping small forest ecosystems within the pasture. The soil biological activity will increase and with a good choice of tree species, the ants will return.
For the maize, perhaps the only solution is the use of an intercropping system. In that way the soil remains covered the whole year and the soil becomes richer on soil fauna species.

6.4 soil classification problems

While classifying the analyzed profiles according the Soil Taxonomy-system (Soil Conservation Service,1975), it appeared that not all soils could be classified as Typic Dystropepts (table 6.2).

Table 6.2 Classification according Soil Taxonomy (Soil Conservation Service, 1975) of the analysed profiles.

landuse	profile	classification
forest	NEG 3	Typic Humitropept*
	NEG 102	Typic Dystropept
mixed cropping	NEG 4	Typic Dystropept
	NEG 9	Typic Dystropept
pasture	NEG 106	Typic Dystropept
maize	NEG 10	Ultic Tropudalf

* = BS is not determined. Compared to the other profiles, a low BS is most likely.

One forest profile is classified as Typic Humitropept, because of its higher organic C content. Statistically this difference is probably not provable (see table 5.3 and 5.4) but the classification system draws inflexible lines and separates the same soil into two different Great Groups.
Comparison of the classification of the maize profile (NEG 10) with the other profiles shows a major change. The maize profile has to be classified as Ultic Tropudalf, thus a change in Order occurs. The classification as Ultic Tropudalf is based on the presence of clay illuviation and a higher base saturation. Both characteristics are mentioned respectively in the sections 6.1 and 6.2, as the results of change in landuse.
If the change in landuse causes a change in Order, so fast after forest clearing (table 3.1), severe considerations should be made on the usefullness of this classification system for soils so sensitive for deterioration.

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APPENDIX A. FIELD PROFILE DESCRIPTIONS

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 3 - FOREST

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Humitropept
FAO/ UNESCO : prel. Umbric Cambisol

Date of observation : 15 - 10 - 1986 : Described by Jelle Beks, Angelique Lansu and Paul van Olst.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 70, 10 m E of the road, on top of a hill.
Topographical map : Hoja Guácimo 3446 I, 586.5 E, 244.4 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 15 m above sealevel.

Topography : Moderately steep (20 %), 25 m long, profile is situated on top.

Micro topography : None.

Drainage : Well drained, slow runoff, very rapid internal drainage.

Vegetation : Secundary tropical rainforest, used for fire wood.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.20 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : Some places, but very few.

Salt or alkali : Not present.

Soil fauna : Ants beetles and small insects.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : daily heavy rainfall, but yesterday dry with sunshine.

BRIEF DESCRIPTION OF THE PROFILE

A well drained profile, almost uniform in colour (reddish brown) and texture (clay). The strong very fine subangular and crumb structure in the topsoil changes with depth in a structureless massive porous subsoil.
The whole profile is friable, very porous and very permeable. Root distribution is normal.

PROFILE DESCRIPTION

Important !! All colours are according the Japanese soil colour carts. The Japanese hues 7.5 YR and 5 YR are slightly comparable with respectively the hues 10 YR and 7.5 YR of the American Munsell colours.

Ah 0 - 5 cm. Brown to dark brown (7.5 YR 4/4) moist, clay; strong very fine subangular blocky; few very fine crumb; slightly sticky, slightly plastic, friable moist; many very fine and fine pores and few micro tubular pores; abundant medium to very fine roots; abrupt wavy boundary (no samples analised, pF samples : 1,2,3; thin section 4).

Bw1 5 - 15 cm. Dark reddish brown (5 YR 3/4) moist; strong very fine and fine subangular blocky; frequent crumb; sticky, slightly plastic, friable moist; many very fine and fine pores; very frequent medium to very fine roots; abrupt, wavy boundary (pF samples : 4, 5, 6).

Bw2 15 - 60 cm. Reddish brown (5 YR 4/4) moist, clay; moderate very fine and fine subangular blocky; frequent crumb; sticky, slightly plastic, friable moist; many very fine and fine pores; very frequent medium to very fine roots, few coarse roots; diffuse, wavy boundary
(pF samples : 7, 8, 9).

BC 60+ cm. Yellowish red (5 YR 4/6) moist, clay; structureless, massive porous; sticky, slightly plastic, friable moist; many very fine and fine pores; very frequent very fine and fine roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 4 - MIXED CROPPING

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Typic Dystropept
FAO/ UNESCO : Dystric Cambisol

Date of observation : 17 - 10 - 1986 : Described by Jelle Beks, Angelique Lansu and Paul van Olst.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 156, at the NE-end of the village Milano, 15 m E of the road, 5 m S of the house, in the coconut-orchard.
Topographical map : Hoja Guácimo 3446 I, 583.0 E, 241.1 N.

Physiographic position : On top of flat upper plain of steeply dissected lahar remnants, elevation about 35 m above sea-level.

Topography : flat surface (0 %).

Micro topography : None.

Drainage : Well drained, very slow runoff, rapid internal drainage.

Vegetation/actual landuse : Mixed cropping (coconuts and pasture). The grass is grazed by calfs.

Anterior landuse : Before 1980 : Secundary tropical rainforest.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 2.10 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 4 cm strongly compacted,
4 - 22 cm moderately compacted.

Salt or alkali : Not present.

Soil fauna : Earthworms, dungbeetles and taltuzas.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : very rainy.

PROFILE DESCRIPTION

Au1 0 - 8 cm. Dark brown (10 YR 3/3) moist, clay; strong to moderate fine angular blocky; sticky, slightly plastic, firm moist; broken moderately thick red cutans, probably of clay minerals with iron oxides and hydroxides, mainly on horizontal ped faces; few medium pores; abundant roots; abrupt smooth boundary.

Au2 8 - 14 cm. Very dark gray (10 YR 3/1) moist, few red fine distinct sharp mottles, clay loam; strong very fine and fine angular blocky and strong medium platy; slightly sticky, slightly plastic, extremely firm moist; continuous moderately thick cutans, probably of clay minerals with iron oxides and hydroides, on horizontal plates and on pores and root channels; few unfilled very fine and fine pores (common pores filled with red cutans); few roots; clear wavy boundary.

Au3 14 - 17 cm. Very dark gray brown (10 YR 3/2) moist, few fine distinct sharp red and orange mottles, clay; strong fine angular blocky; slightly sticky, slightly plastic, very firm moist; broken moderately thick cutans, probably of clay minerals with iron oxides and hydroides, on pores and root channels; few fine pores; few roots; abrupt wavy boundary.

AB 17 - 30 cm. Dark brown to brown (10 YR 4/3) moist, clay; moderate to strong medium angular blocky; slightly sticky, slightly plastic, very firm moist; broken thin cutans of clay minerals with organic matter on vertical ped faces; many fine (& micro) pores; common roots, concentrated along vertical pedfaces; clear wavy boundary.

Bw1 30 - 66 cm. Dark yellowish brown (10 YR 4/4) moist, clay; weak to moderate fine angular blocky; slightly sticky, slightly plastic, firm moist; broken thin cutans of clay-minerals with organic matter on vertical pedfaces; many very fine pores, few fine pores; common roots, concentrated along vertical pedfaces; gradual wavy boundary.

Bw2 66 - 115 cm. Dark yellowish brown (10 YR 4/4) moist, (silty) clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores; few roots; gradual wavy boundary.

BC 115 - 137 cm. Dark yellowish brown (10 YR 3/6) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores; very few roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 7 - MIXED CROPPING

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 21 - 10 - 1986 : Described by Jelle Beks, Angelique Lansu and Paul van Oist.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Pica.
Lot number 206 (William), 1 km N of the village Destierro, 15 m W of the road, 20 m S of the house.
Topographical map : Hoja Guácimo 3446 I, 581.7 E, 239.9 N.

Physiographic position : On the flat upper plain of steeply dissected lahar remnants, elevation about 60 m above sea-level.

Topography : Flat surface, 0 %.

Micro topography : None.

Drainage : Well drained, very rapid internal drainage.

Vegetation/actual landuse : For the past three years mixed cropping (farm -yard) mainly plantains (plátanos) Musa spp, bananas (Musa spp.), tequisque (Xantosoma spp.), cacao (Theobroma cacao), pejibaye (Palmae sp.) used for palmito, yampi (Colocasia spp.) and some other herbs.

Anterior landuse : Before 1983 shrubs (charral), before 1960 tropical rainforest.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.40 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 5 cm slightly compacted,
5 - 23 cm moderately compacted.

Salt or alkali : Not present.

Soil fauna : High activity of earthworms, ants, mice and taltuzas.

Human influence : Charcoal at 60 cm and indian pottery at 40 cm.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : very rainy, but day before dry.

BRIEF DESCRIPTION OF THE PROFILE NEG 101 A & B

A well drained profile, very uniform in texture (clay), colour (dark yellowish brown) and structure (structureless, massive porous).
The whole profile is friable to loose, very porous and very permeable. Only in the upper 10 cm of NEG 101 A some signs of compaction can be recognised.

PROFILE DESCRIPTION NEG 101 A

Au1 0 - 6 cm. Dark brown to brown (10 YR 4/3) moist, clay; moderate very fine and fine angular and subangular blocky; slightly sticky, slightly plastic, friable moist; few medium pores, worm casts deform angular into subangular structures; abundant roots along pedfaces; abrupt smooth boundary.

Au2 6 - 11 cm. Dark yellowish brown (10 YR 3/4) moist, clay; moderate very fine and fine angular blocky; slightly sticky, slightly plastic, friable (mass), very firm (aggregates) moist; few medium pores; abundant roots along the pedfaces; abrupt smooth boundary.

AB 11 - 35 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak very fine angular blocky and structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine and few fine and medium pores; abundant roots; clear wavy boundary.

Bu1 35 - 75 cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine and few fine pores; abundant roots; gradual wavy boundary.

Bu2 75 - 100+ cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable to loose moist; many very fine pores; ants' nest; gradual wavy boundary.

PROFILE DESCRIPTION NEG 101 B (Ants' nest)

A 0 - 25 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; abundant roots; gradual wavy boundary.

B 25+ cm. Enormous ants' nest, dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, loose moist.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 8 - PASTURE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 21 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 100, 15 km N of the village El Silencio, 20 m W of the road, NE of the house.
Topographical map : Hoja Guácimo 3446 I, 588.4 E, 241.7 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 25 m above sealevel.

Topography :Almost flat surface, 1 %.

Micro topography : Local sites with bad drainage (pools).

Drainage : Well drained, very slow runoff, rapid internal drainage.

Vegetation/actual landuse : Pasture, extensively used.

Anterior landuse : Before 1984 scrub (charral).

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.35 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 4 cm strongly compacted,
4 - 11 cm slightly compacted.

Salt or alkali : Not present.

Soil fauna : High activity of (dung)beetles, ants and earthworms. Dungbeetle-burrows on 70 to 90 cmdepth, burrows of talturas or mice (diameter 8 mm) filled with crumb and loose material. Fauna especially active below 10 cm.

Human influence : Charcoal at 4 cm below the surface.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly warm and sunny, daily a few rain.

BRIEF DESCRIPTION OF THE PROFILE

A well drained dark yellowish brown profile, uniform in texture (clay) throughout its depth. The profile is almost uniform structureless, massive porous, very permeable and friable.
The structure of the A-horizon is strong, mainly crumb and granular and loose of consistence.
Root distribution is normal.

PROFILE DESCRIPTION

Au1 0 - 4 cm. Dark brown (10 YR 3/3) moist, clay; strong very fine to medium granular and crumb; slightly sticky, slightly plastic, loose moist;very frequent roots; clear smooth boundary.

Au2 4 - 9 cm. Dark yellowish brown (10 YR 3/4) moist, clay; strong very fine to medium crumb and few granular; slightly sticky, slightly plastic, loose moist; very frequent roots; clear smooth boundary.

Au3 9 - 23 cm. Dark yellowish brown (10 YR 3/4) moist, clay; strong very fine crumb; slightly sticky, slightly plastic, loose moist; very frequent roots; clear wavy boundary.

AB 23 - 35 cm. Dark yellowish brown (10 YR 4/3) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; frequent roots; clear irregular boundary.

Bw1 35 - 82 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores; frequent roots; gradual wavy boundary.

Bw2 82 - 103+ cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores; common roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 9 - MIXED CROPPING

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Typic Dystrepept
FAO/ UNESCO : Dystric Cambisol

Date of observation : 24 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Noguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 100, 1.1 km NE of the village El Silencio, 30 m W of the road, S of the house.
Topographical map : Hoja Guácimo 3446 I, 588.3 E, 241.6 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 25 m above sealevel.

Topography : Almost flat surface.

Micro topography : None.

Drainage : Well drained, very rapid internal drainage.

Vegetation/actual landuse : In cultivation, mixed cropping (farmyard) mainly plantains (plátanos) (Musa spp.) cassave (yuca) (Manihot esculenta), some guanabanas (Ancona muricata) and cacao (Theobroma cacao).

Anterior landuse : Before 1984 scrub (charral).

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled (upper 2 cm dry).

Groundwater table : Depth not known, not encountered within 1.17 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 2 - 7 cm moderately compacted,
7 - 12 cm slightly compacted.

Salt or alkali : Not present.

Soil fauna : High activity of taltuzas, ants, field mice and dungbeetles. Taltuza-burrows (diameter 15 cm) and mice-burrows (diameter 5 cm).

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly warm and sunny, daily few rain. Dry for the past 2 days.

BRIEF DESCRIPTION OF THE PROFILE

Well drained profile, apart from some waterstagnation in the moderately compacted A-horizon. These upper 20 cm have a moderate fine (sub) angular structure, a dark brown colour, a clay texture and are firm when moist.
The underlying B-horizons of strong brown clay tend to a dark yellowish brown, silt loam C-horizon, with few volcanic gravel. These lower horizons are structureless massive porous, friable and very permeable, except for some stagnation in the C-ironpan.
Root distribution is somewhat restricted in the A-horizon.

PROFILE DESCRIPTION

Important !! All colours are according the Japanese soil colour carts. The Japanese hues 7.5 YR and 5 YR are slightly comparable with respectively the hues 10 YR and 7.5 YR of the American Munsell colours.

Au1 0 -4 cm. Dark brown to brown (7.5 YR 4/3) moist, few fine disinct sharp red mottles, clay; strong very fine angular and subangular blocky; slightly sticky, slightly plastic, firm moist; few fine pores; very frequent very fine and fine roots; abrupt, smooth boundary.

Au2 4 - 10 cm. Dark brown to brown (7.5 YR 4/3) moist, clay; moderate fine and medium angular blocky; sticky, slightly plastic, friable moist; few fine pores, few rounded fine (4-6mm) massive worm casts; frequent very fine and fine roots; abrupt wavy boundary.

AB 10 - 22 cm. Dark brown to brown (7.5 YR 4/4) moist, clay; moderate fine and medium subangular blocky; slightly sticky, plastic, firm moist; few fine pores, taltuza burrow filled with crumb; common very fine and fine roots; diffuse wavy boundary.

Bw1 22 - 50 cm. Strong brown (7.5 YR 4/6) moist, clay; structureless, massive porous; slightly sticky, plastic, friable moist; many very fine pores, few very fine pores, burrows filled with crumb; common very fine and fine roots; gradual wavy boundary.

Bw2 50 - 70 cm. Strong brown (7.5 YR 4/6) moist, clay; structureless, massive porous; slightly sticky, plastic, friable moist; many very fine pores, common fine pores, few medium pores, burrows filled with crumb; very few fine roots, abundant very fine roots; gradual, wavy boundary.

Bw3 70 - 100 cm. Strong brown (7.5 YR 4/6) moist, clay; structureless, massive porous; sticky, plastic, friable moist; few fine and medium pores, many very fine pores, burrows filled with crumb; frequent very fine roots, very few fine roots; diffuse, wavy boundary.

BC/Cu1 100 - 210 cm. Brown (7.5 YR 5/4) moist, few distinct clear orange and black mottles, silt loam; weak fine subangular blocky; sticky, slightly plastic, friable moist; many very fine pores, few medium pores; very few rounded gravel, weathered (iron pan); very few, very fine and fine roots.

C 210+ cm. Dark yellowish brown (10 YR 4/6) moist, orange and ocer mottles occur.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 10 - MAIZE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Ultic Tropudalf
FAO/ UNESCO : Haplic Alisol

Date of observation : 29 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 246, 1.5 km S of the village El Silencio, 15 m. W of the road, 5 m N of the house.
Topographical map : Hoja Guácimo 3446 I, 585.8 E, 239.3 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 40 m above sealevel.

Topography : Almost flat surface, 1 %.

Micro topography : None.

Drainage : Moderately well drained, moderate internal drainage.

Vegetation/actual landuse : In cultivation, maize (Zea Mays).

Anterior landuse : Before 1982 scrub (charral), thereafter pasture, beans and maize.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled, except for the first 10 cm which are dry.

Groundwater table : 1.15 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 8 cm moderately compacted,
0 - 17 cm strongly compacted,
17 - 30 cm moderately compacted,
30 - 66 cm slightly compacted.

Salt or alkali : Not present.

Soil fauna : Activity of dungbeetles (with dung filled channels and burrows), earthworms and spiders.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly warm and sunny, daily a few rain

BRIEF DESCRIPTION OF THE PROFILE

A well drained dark yellowish profile. The clayey texture changes into silt loam below 80 cm depth. Below 45 cm, the profile becomes gavelly and thixotropic with a petroferric horizon at 130 cm. The whole profile is structureless massive porous, friable, permeable, except for the slightly compacted AB-horizon. This horizon consists of very fine angular blocks, is slightly gravelly, has a firm consistance and is non thixotropic.

PROFILE DESCRIPTION

A 0 - 5 cm. Dark brow (10 YR 3/4) moist, clay; moderate to strong very fine subangular blocky; slightly sticky, slightly plastic, friable moist; many very fine to fine pores, few medium pores; very few gravel (0.3 cm); few very fine roots; abrupt smooth boundary.

AB 5 - 23 cm. Dark yellowish brown (10YR 4/4) moist, clay; strong very fine and fine angular blocky; slightly sticky, slightly plastic, firm moist; many vey fine pores, few fine and medium pores; few very fine and fine roots; diffuse wavy boundary.

Bw1 23 - 45 cm. Brown to dark brown (10 YR 4/3) moist, clay; weak very fine subangular blocky and structureless massive porous; slightly sticky, slightly plastic, friable moist; few fine pores, many very fine pores, few coarse pores filled with crumb; pieces of indian pottery (40 cm); abundant very fine roots, few fine roots; diffuse wavy boundary.

Bw2 45 - 80 cm. Brown to dark brown (10 YR 4/3) moist, clay loam, slightly gravelly; structureless, massive porous; slightly sticky, slightly plastic, friable moist; few fine pores, many very fine pores, few coarse pores filled with crumb; few gravel, angular, strongly weathered; charcoal (60 cm); few vey fine and fine roots, very few medium roots; diffuse, wavy boundary, thixotropic.

Bw3 80 - 125 cm. Dark yellowish brown (10 YR 4/4) moist, silt loam, gravelly; weak fine subangular blocky to structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores, few fine pores; few small gravel (3 cm), weathered, frequent large gravel, strongly weathered; few very fine and very few fine roots; abrupt smooth boundary; very thixotropic.

Bms 125 - 140 cm. Petroferric horizon, dark yellowish brown (10 YR 4/4) moist, silt loam, very gravelly; structureless, massive porous; slightly sticky, slightly plastic, friable moist, weally cemented by iron and manganese forming a broken platy pan; few fine pores, many medium pores; very frequent large gravel, strongly weathered; few fine roots; very thixotropic.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 101 A&B - FOREST

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 4 - 11 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Pica.
Lot number 224, 1.2 km SE of the village Bella Vista, in the wood on the opposit of the grocery, 20 m W of the road.
Topographical map : Hoja Guácimo 3446 I, 586.0 E, 241.4 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 20 m above sealevel.

Topography : Almost flat surface, 2 %.

Micro topography : None.

Drainage : Well drained, very rapid internal drainage.

Vegetation/actual landuse : Secundary tropical rainforest, used for firewood.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.00 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 101 A : 0 - 11 cm moderately compacted (by tractor),
101 B : not compacted.

Salt or alkali : Not present.

Soil fauna : 101 A : Activity of leafcutterants (Atta sp), other insects and earthworms. Worm-cast-structures between 6 and 11 cm and very high activiy of ants between 75 and 100+ cm.
101 B : Very high activity of leafcutterants (Atta sp.)(Ants's nest).

Humen influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly warm and dry.

BRIEF DESCRIPTION OF THE PROFILE

This profile is well drained and uniform in texture (clay) and colour (dark yellowish brown). Below 35 cm depth, the profile is structureless, massive porous, friable and permeable
In the topsoil, the strongly compacted first 4 cm are mottled, slightly permeable, firm and have a fine angular blocky structure. This changes into a weak subangular blocky to crumb structure, very friable and very permeable.
Root distribution is normal, except for the first 10 cm, where only expedal roots are present.

PROFILE DESCRIPTION

A 0 - 4 cm. Very dark gray brown (10 YR 3/2) moist, many brown gray medium faint diffuse and few orange fine distinct sharp mottles, clay; moderate to strong fine and medium angular blocky, slightly sticky, slightly plastic, firm and very firm moist; few fine pores; pieces of charcoal; frequent very fine to medium roots; abrupt smooth boundary.

AB 4 - 11 cm. Dark brown to dark yellowish brown (10 YR 3/4) moist, clay; moderate very fine and fine subangular blocky, few crumb; slightly sticky, slightly plastic, friable moist; few vey fine and fine pores; frequent very fine to medium roots; clear wavy boundary.

Bw1 11 - 35 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak fine, subangular blocky, common crumb; slightly sticky, slightly plastic, very friable moist; many very fine, common fine and few medium pores; frequent very fine to medium roots; gradual wavy boundary.

Bw2 35 - 80 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; non sticky, slightly plastic, friable moist; many very fine and few fine pores; frequent very fine to medium roots; gradual wavy boundary.

BC 80 - 126 cm. Dark yellowish brown (10 YR 3/6) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine, common fine and few medium pores; few roots; gradual wavy boundary.

C 126 - 135+ cm. (Dark) yellowish brown (10 YR 4/6) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, firm moist; many very fine and common fine pores; few roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 102 - FOREST

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Typic Dystropept
FAO/ UNESCO : Dystric Cambisol

Date of observation : 7 - 11 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 224, 1.0 km SE of the village Bella Vista, in the wood, 10 m W of the road.
Topographical map : Hoja Guácimo 3446 I, 585.9 E, 241.5 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 20 m above sealevel.

Topography : Flat surface, 0 %.

Micro topography : None.

Drainage : Well drained, very rapid internal drainage.

Vegetation/actual landuse : Secondary tropical rainforest, partially used for firewood.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.03 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : None.

Salt or alkali : Not present.

Soil fauna : Very high activity of leafcutter ants (Atta sp.)(nest Ø 15 cm). Also taltuzas (burrow Ø 10 cm) and spiders.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly dry, warm and sunny.

BRIEF DESCRIPTION OF THE PROFILE

Deep, well drained, dark yellowish brown profile, uniform in texture (clay) throughout its depth. Structure in topsoil is strong and fine granular with a compacted layer between 2 and 12 cm depth, consisting of strong fine subangular bloks. The subsoil (below 24 cm) is structureless, massive porous. The whole profile is friable, very porous and very permeable. Root distribution is normal.

PROFILE DESCRIPTION

Au1 0 - 2 cm. Very dark gray brown (10 YR 3/2) dry, dark brown (10 YR 3/3) moist, clay; strong fine granular; slightly sticky, slightly plastic, loose (mass), very firm (final aggregates), very few pores; mulch layer; abundant roots; abrupt smooth boundary.

Au2 2 - 7 cm. Dark brown (10 YR 3/3) moist, clay; strong fine and very fine subangular blocky, frequent crumb; slightly sticky, slightly plastic, very friable (mass), firm (final aggregates) moist; many very fine, few medium pores; abundant roots; abrupt wavy boundary.

AB 7 - 12 cm. Dark yellowish brown (10 YR 3/4), clay; moderate very fine subangular blocky, dominant strong fine crumb; slightly sticky, slightly plastic, very friable (mass), friable (final aggregates) moist; many very fine and common fine pores; abundant roots; clear wavy boundary.

Bw1 12 - 24 cm. Dark yellowish brown (10 YR 3/4) moist, clay; strong fine crumb, slightly sticky, slightly plastic, loose moist; many very fine pores; common roots; clear wavy boundary.

Bw2 24 - 61 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous, strong very fine crumb; slightly sticky, slightly plastic, friable moist; common very fine pores, many fine pores, few medium pores; common roots; gradual wavy boundary.

Bw3 61 - 117 cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; common very fine pores, many fine pores, common medium pores; common roots; gradual wavy boundary.

BC 117+ cm. Dark yellowish brown (10 YR 3/6) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; few fine and very fine pores; few roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 103 - PASTURE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 19 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 158, 0.5 km SE of the village Milano, 150 m N of the road, third pasture.
Topographical map : Hoja Guácimo 3446 I, 582.9 E, 241.0 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 45 m above sealevel.

Topography : Almost flat surface, 2 %.

Micro topography : None.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : Pasture.

Anterior landuse : Scrub (charral).

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.33 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 9 cm moderately compacted,
9 - 38 cm slightly compacted.

Salt or alkali : Not present.

Soil fauna : Activity of dungbeetles (frequent burrous with Ø between 17 and 38 cm), leafcutterants (Atta sp.)(nests with Ø between 17 and 79 cm), spiders, earthworms (casts with Ø between 0 and 9 cm), termites (nests with Ø between 9 and 17 cm) and centipedes.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Daily heavy rainfall.

PROFILE DESCRIPTION

A 0 - 9 cm. Very dark gray brown (10 YR 3/2) moist, clay; strong very fine an fine angular and subangular blocky; slightly sticky, slightly plastic, firm moist; few very fine and medium pores, frequent fine pores; abundant roots; abrupt smooth boundary.

AB 9 - 17 cm. Dark yellowish brown (10 YR 3/4) moist, clay; moderate and strong fine subangular blocky; slightly sticky, slightly plastic, friable moist; few very fine and frequent fine and medium pores; very frequent roots; clear wavy boundary.

Bw1 17 - 38 cm. Dark yellowish brown (10 YR 3/4) moist, clay; moderate fine subangular blocky and structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine and frequent fine pores; very frequent roots; gradual wavy boundary.

Bw2 38 - 79 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; very frequent roots; clear wavy boundary; thixotropic.

BC 79 - 108 cm. Dark yellowish brown (10 YR 4/4) moist, silt loam, very gravelly (5-10 cm); structureless, massive porous; slightly sticky, slightly plastic, very friable moist; patchy moderately thick black cutans, probably of sesquioxides, on faces; many very fine pores; very frequent coarse gravel, angular, strongly weathered; frequent roots; clear wavy boundary; very thixotropic.

C 108 - 133+ cm. Dark yellowish brown (10 YR 4/6) moist, silt loam, gravelly; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; frequent coarse gravel (tuffacious), strongly weathered; common roots; very thixotropic.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 104 - MAIZE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 7 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 201, 0.7 km SE of the village Milano, 150 m S of the road.
Topographical map : Hoja Guácimo 3446 I, 582.7 E, 240.4 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 45 m above sealevel.

Topography : Almost flat surface, 1 %.

Micro topography : None.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : In cultivation, maize and some beans.

Anterior landuse : Maize, before 1983 pasture and shrubs.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.27 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 9 cm moderately compacted,
9 - 16 cm strongly compacted.

Salt or alkali : Not present.

Soil fauna : Activity of taltuzas (burrows with Ø of 15 cm), spiders, lizards, termites (nests with Ø between 16 and 25 cm) and ants.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Warm and sunny, but daily some rainfall.

BRIEF DESCRIPTION OF THE PROFILE

This well drained profile is almost uniforrm in colour (dark yellowish brown), slightly changing from a dark brown A-horizon to a yellowish brown C-horizon.
The uniforrm clay texture of the topsoil becomes silt loam and gravelly below 79 cm, with thixotropic properties. The moderate (very) fine subangular blocky structure in the upper 10 cm (friable permeable) changes into a moderately compacted layer at 9-16 cm depth consisting very firm, mottled moderate fine angular blocks and which is slightly permeable. The undelying horizons are structureless, massive porous, very friable and very permeable.

PROFILE DESCRIPTION

Au1 0 - 5 cm Very dark gray brown (10 YR 3/2) moist, clay; weak and moderate very fine and fine subangular blocky; slightly sticky, slightly plastic, friable moist; common fine and very fine pores, few medium pores; abundant roots; abrupt smooth boundary.

Au2 5 - 9 cm. Dark brown (10 YR 3/3) moist, clay; moderate fine subangular blocky; slightly sticky, slightly plastic, friable moist; common fine and medium pores, few fine pores; frequent roots, along vertical pedfaces; clear wavy boundary.

Au3 9 - 16 cm. Dark brown (10 YR 3/3) moist, few fine distinct sharp orange mottles, clay; slightly sticky, slightly plastic, very firm moist; few fine and medium pores; few roots, along vertical pedfaces; abrupt wavy boundary.

Bw1 16 - 25 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak fine subangular blocky and very fine crumb; slightly sticky, slightly plastic, friable moist; patchy thin cutans, probably of clay minerals with iron oxides and hydroxides; many very fine and frequent fine and medium pores, termite's burrow; common roots; clear wavy boundary.

Bw2 25 - 79 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; common roots; gradual wavy boundary; slightly thixotropic.

BC 79 - 127 cm. Dark yellowish brown (10 YR 4/6) moist, silt loam, slightly gravelly; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; few coarse tuffaceous gravel, strongly weathered; few roots; gradual wavy boundary; thixotropic.

C 127+ cm. Yellowish brown (10 YR 5/8) moist, silt loam, gravelly; structureless, massive porous; slightly sticky, slightly plastic, friable moist; common very fine pores; frequent coarse tuffaceous gravel, weathered; very few roots; very thixotropic.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 105 - MAIZE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 21 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 229, 2 km SSE of the village Bella Vista, 200 m E of the road, 20 m N of the house.
Topographical map : Hoja Guácimo 3446 I, 586.0 E, 240.7 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 35 m above sealevel.

Topography : Flat surface, o %.

Micro topography : None.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : In cultivation, maize.

Anterior landuse : Maize, before 1984 secondary tropical rainforest.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.00 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 12 cm strongly to moderately compacted.

Salt or alkali : Not present.

Soil fauna : Activity of earthworms (Ø casts between 0 and 12 cm) and talturas (Ø burrows between 30 and 64 cm).

Human influence :

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Daily heavy rainfall.

BRIEF DESCRIPTION OF THE PROFILE

Well drained, dark yellowish brown profile, almost uniform in texture (clay), tending to slightly gravelly silt loam below 64 cm depth.
The structure in the moderately compacted topsoil (0-12 cm) is strong (very)fine (sub)angular blocky and firm. The underlying horizons are structureless massive porous, friable and very permeable.

PROFILE DESCRIPTION

Au1 0-5 cm. Dark brown (10 YR 3/3) moist, few very fine sharp distinct red mottles, clay; strong very fine and fine angular blocky; slightly sticky, slightly plastic, friable moist; few medium pores; very frequent roots; abrupt smooth boundary.

Au2 5-12 cm. Dark yellowish brown (10 YR 3/4) moist, few very fine sharp distinct red mottles, clay; strong very fine and fine angular blocky, very few crumb; slightly sticky, slightly plastic, friable moist; few medium pores; very frequent roots; abrupt wavy boundary.

Bw1 12-30 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak fine subangular blocky and stuctureless massive porous; slightly sticky, slightly plastic, friable moist; few medium and many very fine pores; very frequent roots; clear wavy boundary.

Bw2 30-64 cm. Dark yellowish brown (10 YR 3/4) moist, clay; stuctureless massive porous, common crumb; slightly sticky, slightly plastic, loose moist; many very fine and fine pores; very frequent roots; gradual wavy boundary.

BC 64-100+ cm. Dark yellowish brown (10 YR 3/4) moist, (silt)-loam, slightly gravelly; stuctureless massive porous; slightly sticky, slightly plastic, friable moist; many very fine and common fine pores; very few tuffaceous gravel, weathered; few roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 106 - PASTURE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Typic Dystropept
FAO/ UNESCO : Dystric Cambisol

Date of observation : 24 - 11 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 248, 1 km S of the village El Silencio , 7 m E of the road.
Topographical map : Hoja Guácimo 3446 I, 586.4 E, 239.8 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 35 m above sealevel.

Topography : Almost flat surface, 1 %.

Micro topography : None.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : In cultivation, pasture (zacote).

Anterior landuse : Before 1982 shrubs (charral).

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 0.89 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 6 cm strongly compacted,
6 - 14 cm moderately compacted.

Salt or alkali : Not present.

Soil fauna : Activity of earthworms (8 casts 0 to 14 cm) and dungbeetles (8 casts 0 - 60 cm).

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Daily heavy rainfall.

BRIEF DESCRIPTION OF THE PROFILE

A well drained profile, uniform in colour (dark yellowish brown) and texture (clay).
The structure in the mottled A-horizon (0-14 cm) is moderate very fine angular blocky, firm and slightly permeable. Under a transition layer of very fine subangular blocks, below 29 cm depth, there will be a uniform structerless massive porous mass, friable and very permeable.

PROFILE DESCRIPTION

Au1 0-6 cm. Dark brown (10 YR 3/3) moist, common medium distinct clear orange and common coarse faint diffuse gray mottles, clay; moderate and strong angular blocky; slightly sticky, slightly plastic, firm moist; few very fine, fine and medium pores; very frequent roots abrupt smooth boundary.

Au2 6-14 cm. Dark brown to brown (10 YR 4/3) moist, few medium distinct clear orange mottles, clay; moderate very fine angular blocky; slightly sticky, slightly plastic, friable moist; common very fine and few fine pores; very frequent roots; abrupt smooth boundary.

AB 14-29 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak and moderate very fine subangular blocky; slightly sticky, slightly plastic, friable moist; patchy thin cutans, probably of clay minerals with ironoxides and hydroxides, on pores and root channels; many very fine and few fine and medium pores; very frequent roots; gradual wavy boundary.

Bv2 29-43 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless massive porous, frequent crumb; slightly sticky, slightly plastic, friable moist; many very fine, common fine and few medium pores; very frequent roots; gradual wavy boundary.

Bv3 43-64 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless massive porous; slightly sticky, slightly plastic, very friable moist; many very fine and few fine pores; frequent roots; gradual wavy boundary.

BC 64-89+ cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless massive porous; slightly sticky, slightly plastic, friable moist; many very fine and few fine pores; common roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 107 - MIXED CROPPING

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 24 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 229, 0.8 km E of the village Bella Vista, 10 m N of the road.
Topographical map : Hoja Guácimo 3446 I, 586.1 E, 241.9 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 25 m above sealevel.

Topography : Gently sloping, 3 %, upper part of the slope.

Micro topography : Taltuza mounds.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : In cultivation, mixed cropping, mainly cacao (Theobroma cacao), plantain (Musa spp.) and cassave (yuca)(Manihot esculenta).

Anterior landuse : Before 1982 scrub (charral) and secondary tropical rainforest.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 0.90 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : None.

Salt or alkali : Not present.

Soil fauna : Activity of earthworms (@ casts 1 to 12 cm), old dungbeetle nest (@ between 68 and 90+ cm), small insects and a very high activity of taltuzas.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Daily heavy rainfall.

BRIEF DESCRIPTION OF THE PROFILE

Well drained profile, very permeable, uniform in texture (clay) and colour (dark yellowish brown).
The structure in the A-horizon consists of strong very fine and fine subangular blocks and granulars, all very friable.
The underlying horizons are structureless massive porous.

PROFILE DESCRIPTION

Ah1 0-1 cm. Very dark brown (10 YR 2/2) moist, clay; strong very fine and fine granular; slightly sticky, slightly plastic, loose (mass), extremely firm (aggregates) moist; very frequent roots (exped); abrupt, smooth boundary.

Ah2 1-6 cm. Very dark gray brown (10 YR 3/2) moist, clay; strong very fine and fine subangular blocky; slightly sticky, slightly plastic, very friable (mass), very firm (aggregates) moist; few fine exped pores (in cracks) and common medium pores; very frequent roots; abrupt wavy boundary.

Ah3 6-17 cm. Dark brown (10 YR 3/3) moist, clay; strong very fine and fine subangular blocky, frequent crumb; slightly sticky, slightly plastic, very friable (mass), firm (aggregates) moist; few medium and common fine pores (exped); very frequent roots; abrupt wavy boundary.

AB 17-37 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless massive porous; slightly sticky, slightly plastic, friable moist; many very fine and fine pores, common medium pores; very frequent roots; clear wavy boundary.

Bw1 37-68 cm. Dark brown to brown (10 YR 4/3) moist, clay; structureless massive porous; slightly sticky, slightly plastic, very friable moist; many very fine, few fine and medium pores; frequent roots; gradual wavy boundary.

Bw2 68-90+ cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless massive porous; slightly sticky, slightly plastic, friable moist; many very fine and few fine pores; common roots.

APPENDIX B. DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

NEG 9 - MIXED CROPPING

GENERAL:
thin section number: 87.128
profile: NEG 9
location: Provincia de Limón, Costa Pica
date: 11 June 1987
horizon: Au1/Au2
depth: 0-7.5 cm

MICROSTRUCTURE:
granular structure, very open
TYPES: Mainly granular, in the lower part some strong developed subangular blocks, in the upper part more crumbs.

PEDS: types with intergrades:
crumbs; strongly developed; few, mainly ≤ 500 µm, very fine, rough surfaces, random distribution, porous.
granules; strongly developed; dominant, mainly 1-5 mm, fine and medium, range from 200 µm-7mm, mainly rough, some smooth; random distribution, dense, range from porous to very dense.
subangular blocks; strongly developed; frequent, usually 2-5 mm, very fine, undulating surface; random to clustered distribution, dense.

VOIDS:
total estimated porosity: approx. 50 %
inter-aggregate voids:
compound packing voids; between crumbs, granulars, subangular blocks and plant fragments; wide range of sizes, 45% of area, very dominant, irregular shapes, mainly rough walls, interconnected, random distribution.
planar voids; separating subangular blocks, usually 50-200 µm wide and up to 20 mm long, micro, 2% of area, very few, weakly horizontal oriented.
channels; clear channels, partly with loose discontinuous infillings of excremental material (micro), round to elongate, size 200-1000 µm, very fine, 2% of area, very few, walls undulating to rough.
chambers; one chamber of 1.5 mm, connected with a very fine channel, undulating walls, no infillings.
intra-aggregate voids:
compound packing voids; between partially fused aggregates within peds, irregular shape, ≤ 200 µm; and vughs; within peds, irregular shape, < 100 µm; 3% of area, very few to few; packing void/vugh distinction is not obvious.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare intrapedal clay nodules (possible weathered minerals), 100µm, limpid b-fabric.
FABRIC PEDOFEATURES:
bow-like features: none
passage features:
closer packed fabric along channels, common, thickness 1-2 mm, external cylindrical or vermiform shaped with a diffuse boundary, internal very dense crumb, faint contrast, distribution related to channels, strongly fragmented, no intact pores.
EXCREMENT PEDOFEATURES:
few excrements; mainly not fragmented or deformed; red ellipsoidal mite excrements, 2-20 µm, micro, in plant remnants; dark-brown, mammilated earthworm excrements, 1-2 mm, fine, and other ellipsoidal excrements; dense internal ageing, strong coalescence (formation of granulars) and a weak disintegration, undulating surface roughness and a random basic distribution, composed of org. fine material with clay and tissue fragments.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.129
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 7 july 1987
horizon: AB/Bw1
depth: 7.5-15 cm

MICROSTRUCTURE:
very porous crumb structure
TYPES:
mainly crumbs, in the upper part coarse granular peds and fine and medium subangular blocks, in the lower part fine and medium crumbs.

PEDS: types with intergrades:
crumbs; strongly developed; very dominant, mainly 2-5 mm, medium; rough surfaces; random distribution; porous.
granules; strongly developed; few, mainly 5-10 mm, coarse, undulating surfaces; random distribution; very dense, but with a porous fringe.
subangular blocks; strongly and moderately developed; few, mainly clustered with crumbs, range from 1-10 mm, very fine and fine.
microaggregates; clustered subangular blocks and crumbs.

VOIDS:
total estimated porosity: approx. 60 %
inter-aggregate voids:
compound packing voids; between crumbs, granules, subangular blocks and plant fragments, wide range of sizes, 50% of area, very dominant, irregular shapes, rough walls, interconnected, random distribution.
intra-aggregate voids:
compound packing voids; between the clustered microaggregates, irregular shape; and vughs; irregular shape; and channels, 100 µm, micro, within peds.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:

rare intrapedal micro clay nodules.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant, vermiform, 200-500 µm, very fine, dense crumb structure with a distinct contrast, low variability and strongly fragmented.
EXCREMENT PEDOFEATURES:
many types; ellipsoidal to mammilated excrements, dense internal ageing, moderately coalescence, weakly in some crumbs, wide size range, fine and medium, very dominant, undulating to rough surfaces, darkbrown, infillings and clustered into peds.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.130
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 22 june 1987
horizon: Bw1
depth: 15-22.5 cm

MICROSTRUCTURE:
very porous crumb structure, very open.
TYPES: Mainly strongly developed porous crumbs and dense granules.

PEDS: types with intergrades:
crumbs; strongly developed, common: few coarse, >5 mm; very few fine and medium, 1-5 mm; and frequent very fine, 200-1000 µm; total size range, 50 µm-10 mm, fine ones are referred to channels, very fine ones random distributed or clustered together; all with rough surfaces, porous to very porous.
granules; strongly developed; dominant, mainly 1-5 mm, fine and medium; whole range of 100 µm-5 mm is present, usually subrounded to subangular; rough surfaces, except for the medium granules, distribution pattern of medium granulas related to the channels, very fine to medium granules are random distributed; microgranules are moderately clustered; dense to very dense.
subangular blocks; present as an integrate of granules; strongly developed; few, 1-5 mm, very fine; undulating surface; dense to very dense; random basic distribution.

VOIDS:
total estimated porosity: approx. 55 %
inter-aggregate voids:
compound packing voids; very dominant; between crumbs, granules and plant fragments;wide range of sizes; irregular shapes; rough walls; random arrangement and interconnected.
channels; very few; 50-100 µm, micro, round to elongate; length 40 mm.
intra aggregate voids:
compound packing voids and vughs; irregular shapes; size ≤200 µm, few in coarse crumbs, very few in other crumbs and granules.
trans-aggregate voids:
planar voids; ≤50 µm, micro; occurence in fine and medium peds.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare intrapedal clay nodules, yellow colour, isotropic.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
along channels; frequent; 500-1000 µm, very fine; external vermiform to cylindrical with a clear boundary; rough inner wals and a porous internal structure; faint to distinct contrast with adjecent material; maderate variability; mainly strongly fragmented, but with a wide range; very few intact pores.
EXCREMENT PEDOFEATURES:
very dominant; but very few intact excrements (some mite and earthworm exc. recognizable), forming very dense microaggregates coalesced into porous crumbs and dense granules.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.131
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 7 july 1987
horizon: Bw2
depth: 22.5-30 cm

MICROSTRUCTURE:
very porous to porous crumb structure
TYPES: Mainly medium porous crumbs and very fine and fine granules.

PEDS: types with intergrades:
crumbs; strongly developed; common to dominant; mainly 2-5 mm, medium common porous crumb; few crumb microaggregates; 50-200 µm, micro, rough surfaces; random distribution.
granules; strongly developed; common; mainly 200 µm-2mm, very fine and fine; undulating to smooth; random distribution; subrounded; dense; granular microaggregates.
subangular blocks; strongly developed; few; mainly 500-1000 µm; undulating surface; random distribution; very dense.

VOIDS:
total estimated porosity: approx. 50 %
inter-aggregate voids:
compound packing voids; between crumbs, granules and subangular blocks; very dominant, 45% of area; wide range of sizes; irregular shapes; rough walls; partially interconnected; random distribution.
intra-aggregate voids:
compound packing voids and vughs between partially fused aggregates within peds.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant to very dominant; 200-1000 µm, very fine; external vermiform; diffuse sharpness; undulating inner walls; internal very dense; prominentcontrast; medium variability; moderate to strongly fragmented.
EXCREMENT PEDOFEATURES:
dominant; many recognizable excrements; internal ageing dense; weakly to moderately coalesced; mainly ≤200 µm, micro; medium brown; large amounts as porous continuous infillings in fine pores.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.132
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 22 june 1987
horizon: Bw2
depth: 30-37.5 cm

MICROSTRUCTURE:
porous crumb structure, open to close.
TYPES: Strongly developed medium crumbs and very fine granules.

PEDS: types with intergrades:
crumbs; strongly developed; very dominant, mainly 2-5 mm, medium, range from 100 µm-7 mm; rough surfaces; dense; random distribution; distribution of few coarse crumbs related to channels; microaggregates clustered.
granules; strongly developed; frequent, mainly 200-1000 µm, very fine; wide range from 200 µm-5 mm; undulating surfaces; random distribution; (sub)rounded.

VOIDS: not described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant; lesser passage f. in de lower denser part; 200-1000 µm; external vermiform; clear sharpness; undulating to rough inner walls; internal dense crumb structure; distinct contrast with adjacent matrix; high variability; moderately to strongly fragmented; few intact channels.
EXCREMENT PEDOFEATURES:
frequent; very few intact excrements; internal very dense; moderately coalesced into porous to dense crumbs.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.133
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw2
depth: 37.5-45 cm

MICROSTRUCTURE:
very porous to dense crumb structure
TYPES: crumbs and granules; wide range of sizes

PEDS: not described in detail.

VOIDS:
inter-aggregate voids:
channel; 8 mm, coarse; possibly a wormchannel.
other voids not described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; 200-500 µm; external vermiform; diffuse sharpness; internal very dense crumb structure; distinct to prominent contrast; high variability; moderately to strongly fragmented.
EXCREMENT PEDOFEATURES:
common; internal dense; moderately coalesced; rough; some occurence as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.134
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 25 june 1987
horizon: Bw2
depth: 45-52.5 cm

MICROSTRUCTURE:
porous to dense crumb structure, transition to vughy structure, closed.
TYPES: Mainly apedal soil material; a aggregated crumb mass with a vughy structure, smaller micropeds are recognizable in this apedal soil material because of their denser internal porosity and dark brown colour.

PEDS: types with intergrades:
crumbs; strongly developed; few, mainly 1-2 mm, fine, smooth to rough; and 200-500 µm, very fine, rough; unaccomodated; random distribution; fine crumbs slightly related to channels; porous.
granules; strongly developed; mainly 200-1000 µm, very fine, wide size range, 20 µm-5 mm; rough; subrounded; very dense; fine granules are smooth, subangular, very dense; random distribution.

VOIDS:
total estimated porosity: approx. 45 %
inter-aggregate voids:
compound packing voids; between crumbs and granules; dominant; 30% of area; rough; irregular; 100-1000 µm; micro and very fine; partially interconnected.
vughs; few; 200-1000 µm; rough walls; random distrbution; unconnected.
channels; few intact; 200-1000 µm; smooth walls.
intra-aggregate voids:
vughs; within the apedal soil material; 10% of area; micro; irregular rough walls; random distribution.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
few; 200-1000 µm; external vermiform; clear sharpness; smooth to undulating walls; internal very dense structure; birefringence in intact channels; faint contrast with adjecent material in very dense parts; distinct contrast in porous parts; weakly fragmented.
EXCREMENT PEDOFEATURES:
common; but very few intact excrements; internal dense to very dense; moderately coalesced; some occur as discontinuous, incomplete infilings of earthworm and mite excrements.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.135
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw2
depth: 52.5-60 cm

MICROSTRUCTURE:
porous crumb structure
TYPES: Compound structure of very fine and fine very dense granules and subangular blocks and very porous microcrumb.

PEDS: types with intergrades:
crumbs; strongly developed; frequent; usually ≤500 µm, micro; rough surfaces; unaccomodated; clustered; mainly as infillings and along channels; porous.
granules; strongly developed; dominant; range of sizes 500 µm- 2 mm, very fine and fine; undulating surfaces; random distribution; very dense.
subangular blocks; moderately developed; few; 1-5 mm; very fine; smooth to undulating; unaccomodated; random distributed; very dense.

VOIDS:
total estimated porosity: approx. 50 %
inter-aggregate voids:
compound packing voids; between crumbs, granules and subangular blocks; very dominant; 45% of area; irregular shape; rough walls; random distribution; partialy interconnected.
channels; few; mainly 200 µm, very fine, vide range of sizes 50 µm- 2 mm, usually with infillings and smooth walls.
chambers; very few; 1-2 mm, fine, connected with very fine channels; 200-500 µm, very fine, connected with a micro channel; smooth walls.
intra-aggregate voids:
vughs; within crumbs and granules; very few; 100-500 µm; iregular shape; rough walls; clustered;unconnected.
trans-aggregate voids:
planar voids; very few; ≤50 µm, micro; smooth walls; zig-zag orientation.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
AMORPHOUS PEDOFEATURES:
very few; (hypo)coatings of ferrogunious material.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
frequent; ≤500µm; external vermiform with diffuse boundary; rough to undulating inner walls; medium variability; moderately fragmented.
EXCREMENT PEDOFEATURES:
dominant; internal very dense; moderately coalesced; rough; occur as porous continuous and discontinuous infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

NEG 10 - MAIZE

GENERAL:
thin section number: 87.136
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: 10 june 1987
horizon: Au3/AB
depth: 15-22.5 cm

MICROSTRUCTURE:
crack structure/angular structure.
TYPES: Mainl · coarse angular blocky structure, frequent very fine subangular blocks.

PEDS: types with intergrades:
subangular blocks; moderately developed; frequent; 2-5 mm, very fine; undulating surfaces; partially accommodated; clustered; internal very dense.
angular blocks; moderately and strongly developed; dominant; mainly 220 mm; coarse; range 5-30 mm; smooth surfaces; partially accomodated; clustered; internal very dense; compounded of smaller micropeds as granules and subangular blocks; only recognizable by their darker colour.

VOIDS:
total estimated porosity: approx. 20 %
inter-aggregate voids:
planar voids; separating the angular blocks; dominant; 14% of area; 200-500 µm; very fine; range ≤500 µm; undulating vals; moderately oriented; perpendicular to each other; interconnected.
intra-aggregate voids:
vughs;within peds; few, 2% of area; 50-100 µm; irregular valls; rough; random distributed; unconnected.
channels;few, 2% of area; 100-200 µm; smooth valls; random distributed; partially with infillings of excrements.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
dusty clay and clay & silt; rare to occasional; thickness mainly 20 µm, with a range of 20-150 µm; coating; yellow to orange colour; white to yellow birefringence colours; few birefringence; strong birefringence of external boundary, inner valls birefringence absent, microlaminated; clay & silt p.f. parallel layered; interpedal distribution in planar voids.
AMORPHOUS PEDOFEATURES:
frequent; ferrogineous mottles.
FABRIC PEDOFEATURES: because of the very dense soil material, fabric p.f. are absent.
EXCREMENT PEDOFEATURES:
very few to few; mayor part are mite excrements; porous internal ageing; moderately coalesced; ≤50 µm; ellipsoidal; smooth; dark brown; org.matter and clay; occurrence as porous discontinuous infillings in channels.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.137
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: AB
depth: 22.5-30 cm

MICROSTRUCTURE:
vughy to spongy microstructure
TYPES: The mainly apedal material shows a vughy to sponghy microstructure, the pedality of this structure is only showed by rustbands, which deliniate coarse angular blocks, there is no evidence of discrete aggregates.

PEDS: none; the soil material is apedal.

VOIDS:
total estimated porosity: approx. 12 %
intra-aggregate voids:
vughs; common; 4% of area; 200-500µm, very fine; irregular; rough valls; random distributed; unconnected.
channels; very few; 1% of area; 10 mm, coarse; cylindrical; smooth valls; probably of dung beetle.
planar voids; dominant; 8% of area; thickness 500-1000 µm, very fine; smooth valls; moderately oriented; parallel to inclined; weakly accomodated; interconnected.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
dusty clay in coatings; rare; thickness 20-50 µm; yellow to orange colour; mainly isotropic; on inner vall with a white to orange birefringence colour; microlaminated; occurence along coarse channel valls.
AMORPHOUS PEDOFEATURES:
frequent; ferrogineous hypocoatings on ex-ped faces of angular blocks.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
few; 50-500µm; external vermiform; diffuse; smooth to undulating inner vall; faint contrast; low variability; weakly fragmented; some cemented with iron oxyde.
EXCREMENT PEDOFEATURES:
very few; mite excrements recognizable; porous to dense internal ageing; weakly coalesced; 50µm; smooth; brown; occurrence as porous continuous infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.138
profile: NEG 10

location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 30-37.5 cm

MICROSTRUCTURE:
weakly developed subangular blocky.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features:
very few; 500-1000 µm, very fine; cylindrical external shape; clear boundary; porous crumb internal structure; no birefringence; distinct contrast.
passage features:
frequent; thickness 200-1000 µm, very fine; range 200 µm-2 mm; vermiform; diffuse boundary; undulating inner wall; very dense crumb microstructure; distinct to faint contrast; high variability; weakly fragmented.
EXCREMENT PEDOFEATURES:
common; not equal distributed, in upper part frequent and very dense, in lower part dominant and dense; strongly coalesced; <50 µm; ellipsoidal; org.matter/clay; random distribution; some recognizable mite excrements as channel infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.139
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 37.5-45 cm

MICROSTRUCTURE:
dense crumb to vughy microstructure
TYPES: Apedal soil material, showing a dense crumb to vughy microstructure, no discrete aggregates recognizable.

PEDS: none; the soil material is apedal.

VOIDS:
total estimated porosity: approx. 25 %
intra-aggregate voids:
vughs; very dominant; micro; and channels; very few; cylindrical; 10-20 mm, very coarse; smooth walls; probably of a dung beetle.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare; coating; on fringe with channel wall; consisting of micro-laminated dusty clay; with parallel birefringence; thickness 30-60 µm; inner side of clay & silt; layered; isotropic; thickness 30-60 µm; total thickness coating 60-120 µm; moderately fragmented; high variability.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
frequent; vermiform; clear boundary; smooth inner wall; very dense internal microstructure; distinct contrast; medium variability; weakly to moderately fragmented.
EXCREMENT PEDOFEATURES:
common; very few recognizable excrements; very dense internal ageing; moderately coalesced; rounded; smooth; brown; random distribution; occur as discontinuous porous infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.140
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 45-52.5 cm

MICROSTRUCTURE:
vughy to spongy.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare; typic coating; 20-50 µm; dusty clay; yellow colour; low birefringence; microlaminated; low variability.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant; 200-500 µm; range from 50-500 µm; vermiform; clear boundary; smooth to undulating inner wall; low birefringence; distict contrast; medium variability; moderately fragmented.
EXCREMENT PEDOFEATURES:
very dominant; mite and earthworm excrements recognizable; very dense internal ageing; strongly coalesced; 20-1000 µm; rough; mite excrements occur as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.141
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 52.5-60 cm

APPENDIX A. FIELD PROFILE DESCRIPTIONS

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 3 - FOREST

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Humitropept
FAO/ UNESCO : prel. Umbric Cambisol

Date of observation : 15 - 10 - 1986 : Described by Jelle Beks, Angelique Lansu and Paul van Oist.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 70, 10 m E of the road, on top of a hill.
Topographical map : Hoja Guácimo 3446 I, 586.5 E, 244.4 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 15 m above sealevel.

Topography : Moderately steep (20 %), 25 m long, profile is situated on top.

Micro topography : None.

Drainage : Well drained, slow runoff, very rapid internal drainage.

Vegetation : Secundary tropical rainforest, used for fire wood.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.20 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : Some places, but very few.

Salt or alkali : Not present.

Soil fauna : Ants beetles and small insects.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : daily heavy rainfall, but yesterday dry with sunshine.

BRIEF DESCRIPTION OF THE PROFILE

A well drained profile, almost uniform in colour (reddish brown) and texture (clay). The strong very fine subangular and crumb structure in the topsoil changes with depth in a structureless massive porous subsoil.
The whole profile is friable, very porous and very permeable. Root distribution is normal.

PROFILE DESCRIPTION

Important !! All colours are according the Japanese soil colour carts. The Japanese hues 7.5 YR and 5 YR are slightly comparable with respectively the hues 10 YR and 7.5 YR of the American Munsell colours.

Ah 0 - 5 cm. Brown to dark brown (7.5 YR 4/4) moist, clay; strong very fine subangular blocky; few very fine crumb; slightly sticky, slightly plastic, friable moist; many very fine and fine pores and few micro tubular pores; abundant medium to very fine roots; abrupt wavy boundary (no samples analised, pF samples : 1,2,3; thin section 4).

Bu1 5 - 15 cm. Dark reddish brown (5 YR 3/4) moist; strong very fine and fine subangular blocky; frequent crumb; sticky, slightly plastic, friable moist; many very fine and fine pores; very frequent medium to very fine roots; abrupt, wavy boundary (pF samples : 4, 5, 6).

Bu2 15 - 60 cm. Reddish brown (5 YR 4/4) moist, clay; moderate very fine and fine subangular blocky; frequent crumb; sticky, slightly plastic, friable moist; many very fine and fine pores; very frequent medium to very fine roots, few coarse roots; diffuse, wavy boundary
(pF samples : 7, 8, 9).

BC 60+ cm. Yellowish red (5 YR 4/6) moist, clay; structureless, massive porous; sticky, slightly plastic, friable moist; many very fine and fine pores; very frequent very fine and fine roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 4 - MIXED CROPPING

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Typic Dystropept
FAO/ UNESCO : Dystric Cambisol

Date of observation : 17 - 10 - 1986 : Described by Jelle Beks, Angelique Lansu and Paul van Olst.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 156, at the NE-end of the village Milano, 15 m E of the road, 5 m S of the house, in the coconut-orchard.
Topographical map : Hoja Guácimo 3446 I, 583.0 E, 241.1 N.

Physiographic position : On top of flat upper plain of steeply dissected lahar remnants, elevation about 35 m above sea-level.

Topography : flat surface (0 %).

Micro topography : None.

Drainage : Well drained, very slow runoff, rapid internal drainage.

Vegetation/actual landuse : Mixed cropping (coconuts and pasture). The grass is grazed by calfs.

Anterior landuse : Before 1980 : Secundary tropical rainforest.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 2.10 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 4 cm strongly compacted,
4 - 22 cm moderately compacted.

Salt or alkali : Not present.

Soil fauna : Earthworms, dungbeetles and taltuzas.

Human influence : Not present.

Climatic date :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : very rainy.

PROFILE DESCRIPTION

Au1 0 - 8 cm. Dark brown (10 YR 3/3) moist, clay; strong to moderate fine angular blocky; sticky, slightly plastic, firm moist; broken moderately thick red cutans, probably of clay minerals with iron oxides and hydroxides, mainly on horizontal ped faces; few medium pores; abundant roots; abrupt smooth boundary.

Au2 8 - 14 cm. Very dark gray (10 YR 3/1) moist, few red fine distinct sharp mottles, clay loam; strong very fine and fine angular blocky and strong medium platy; slightly sticky, slightly plastic, exstremely firm moist; continuous moderately thick cutans, probably of clay minerals with iron oxides and hydroides, on horizontal plates and on pores and root channels; few unfilled very fine and fine pores (common pores filled with red cutans); few roots; clear wavy boundary.

Au3 14 - 17 cm. Very dark gray brown (10 YR 3/2) moist, few fine distinct sharp red and orange mottles, clay; strong fine angular blocky; slightly sticky, slightly plastic, very firm moist; broken moderately thick cutans, probably of clay minerals with iron oxides and hydroides, on pores and root channels; few fine pores; few roots; abrupt wavy boundary.

AB 17 - 30 cm. Dark brown to brown (10 YR 4/3) moist, clay; moderate to strong medium angular blocky; slightly sticky, slightly plastic, very firm moist; broken thin cutans of clay minerals with organic matter on vertical ped faces; many fine (& micro) pores; common roots, concentrated along vertical pedfaces; clear wavy boundary.

Bw1 30 - 66 cm. Dark yellowish brown (10 YR 4/4) moist, clay; weak to moderate fine angular blocky; slightly sticky, slightly plastic, firm moist; broken thin cutans of clay-minerals with organic matter on vertical pedfaces; many very fine pores, few fine pores; common roots, concentrated along vertical pedfaces; gradual wavy boundary.

Bw2 66 - 115 cm. Dark yellowish brown (10 YR 4/4) moist, (silty) clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores; few roots; gradual wavy boundary.

BC 115 - 137 cm. Dark yellowish brown (10 YR 3/6) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores; very few roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 7 - MIXED CROPPING

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 21 - 10 - 1986 : Described by Jelle Reks, Angelique Lansu and Paul van Oist.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 206 (William), 1 km N of the village Destierro, 15 m W of the road, 20 m S of the house.
Topographical map : Hoja Guácimo 3446 I, 581.7 E, 239.9 N.

Physiographic position : On the flat upper plain of steeply dissected lahar remnants, elevation about 60 m above sea-level.

Topography : Flat surface, 0 %.

Micro topography : None.

Drainage : Well drained, very rapid internal drainage.

Vegetation/actual landuse : For the past three years mixed cropping (farm -yard) mainly plantains (plátanos) Musa spp, bananas (Musa spp.), tequisque (Xantosoma spp.), cacao (Theobroma cacao), pejibaye (Palmae sp.) used for palmito, yampi (Colocasia spp.) and some other herbs.

Anterior landuse : Before 1983 shrubs (charral), before 1960 tropical rainforest.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.40 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 5 cm slightly compacted,
5 - 23 cm moderately compacted.

Salt or alkali : Not present.

Soil fauna : High activity of earthworms, ants, mice and taltuzas.

Human influence : Charcoal at 60 cm and indian pottery at 40 cm.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : very rainy, but day before dry.

BRIEF DESCRIPTION OF THE PROFILE NEG 101 A & B

A well drained profile, very uniform in texture (clay), colour (dark yellowish brown) and structure (structureless, massive porous).
The whole profile is friable to loose, very porous and very permeable. Only in the upper 10 cm of NEG 101 A some signs of compaction can be recognized.

PROFILE DESCRIPTION NEG 101 A

Au1 0 - 6 cm. Dark brown to brown (10 YR 4/3) moist, clay; moderate very fine and fine angular and subangular blocky; slightly sticky, slightly plastic, friable moist; few medium pores, worm casts deform angular into subangular structures; abundant roots along pedfaces; abrupt smooth boundary.

Au2 6 - 11 cm. Dark yellowish brown (10 YR 3/4) moist, clay; moderate very fine and fine angular blocky; slightly sticky, slightly plastic, friable (mass), very firm (aggregates) moist; few medium pores; abundant roots along the pedfaces; abrupt smooth boundary.

AB 11 - 35 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak very fine angular blocky and structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine and few fine and medium pores; abundant roots; clear wavy boundary.

Bw1 35 - 75 cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine and few fine pores; abundant roots; gradual wavy boundary.

Bw2 75 - 100+ cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable to loose moist; many very fine pores; ants' nest; gradual wavy boundary.

PROFILE DESCRIPTION NEG 101 B (Ants' nest)

A 0 - 25 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; abundant roots; gradual wavy boundary.

B 25+ cm. Enormous ants' nest, dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, loose moist.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 8 - PASTURE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 21 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 100, 15 km N of the village El Silencio, 20 m W of the road, NE of the house.
Topographical map : Hoja Guácimo 3446 I, 588.4 E, 241.7 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 25 m above sealevel.

Topography : Almost flat surface, 1 %.

Micro topography : Local sites with bad drainage (pools).

Drainage : Well drained, very slow runoff, rapid internal drainage.

Vegetation/actual landuse : Pasture, extensively used.

Anterior landuse : Before 1984 scrub (charral).

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.35 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 4 cm strongly compacted,
4 - 11 cm slightly compacted.

Salt or alkali : Not present.

Soil fauna : High activity of (dung)beetles, ants and eathworms. Dungbeetle-burrows on 70 to 90 cmdepth, burrows of taltuzas or mice (diameter 8 mm) filled with crumb and loose material. Fauna especially active below 10 cm.

Human influence : Charcoal at 4 cm below the surface.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly warm and sunny, daily a few rain.

BRIEF DESCRIPTION OF THE PROFILE

A well drained dark yellowish brown profile, uniform in texture (clay) throughout its depth. The profile is almost uniform structureless, massive porous, very permeable and friable.
The structure of the A-horizon is strong, mainly crumb and granular and loose of consistence.
Root distribution is normal.

PROFILE DESCRIPTION

Aü1 0 - 4 cm. Dark brown (10 YR 3/3) moist, clay; strong very fine to medium granular and crumb; slightly sticky, slightly plastic, loose moist; very frequent roots; clear smooth boundary.

Au2 4 - 9 cm. Dark yellowish brown (10 YR 3/4) moist, clay; strong very fine to medium crumb and few granular; slightly sticky, slightly plastic, loose moist; very frequent roots; clear smooth boundary.

Au3 9 - 23 cm. Dark yellowish brown (10 YR 3/4) moist, clay; strong very fine crumb; slightly sticky, slightly plastic, loose moist; very frequent roots; clear wavy boundary.

AB 23 - 35 cm. Dark yellowish brown (10 YR 4/3) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; frequent roots; clear irregular boundary.

Bu1 35 - 82 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores; frequent roots; gradual wavy boundary.

Bu2 82 - 103+ cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores; common roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 9 - MIXED CROPPING

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Typic Dystrepept
FAO/ UNESCO : Dystric Cambisol

Date of observation : 24 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Naguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 100, 1.1 km NE of the village El Silencio, 30 m W of the road, S of the house.
Topographical map : Hoja Guácimo 3446 I, 588.3 E, 241.6 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 25 m above sealevel.

Topography : Almost flat surface.

Micro topography : None.

Drainage : Well drained, very rapid internal drainage.

Vegetation/actual landuse : In cultivation, mixed cropping (farmyard) mainly plantains (plátanos) (Musa spp.) cassave (yuca) (Manihot esculenta), some guanabanas (Ancona maricata) and cacao (Theobroma cacao).

Anterior landuse : Before 1984 scrub (charral).

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled (upper 2 cm dry).

Groundwater table : Depth not known, not encountered within 1.17 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 2 - 7 cm moderately compacted,
7 - 12 cm slightly compacted.

Salt or alkali : Not present.

Soil fauna : High activity of taltuzas, ants, field mice and dungbeetles. Taltuza-burrows (diameter 15 cm) and mice-burrows (diameter 5 cm).

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly warm and sunny, daily few rain. Dry for the past 2 days.

BRIEF DESCRIPTION OF THE PROFILE

Well drained profile, apart from some waterstagnation in the moderately compacted A-horizon. These upper 20 cm have a moderate fine (sub) angular structure, a dark brown colour, a clay texture and are firm when moist.
The underlying B-horizons of strong brown clay tend to a dark yellowish brown, silt loam C-horizon, with few volcanic gravel. These lower horizons are structureless massive porous, friable and very permeable, except for some stagnation in the C-ironpan.
Root distribution is somewhat restricted in the A-horizon.

PROFILE DESCRIPTION

Important !! All colours are according the Japanese soil colour carts. The Japanese hues 7.5 YR and 5 YR are slightly comparable with respectively the hues 10 YR and 7.5 YR of the American Munsell colours.

Au1 0 -4 cm. Dark brown to brown (7.5 YR 4/3) moist, few fine disinct sharp red mottles, clay; strong very fine angular and subangular blocky; slightly sticky, slightly plastic, firm moist; few fine pores; very frequent very fine and fine roots; abrupt, smooth boundary.

Au2 4 - 10 cm. Dark brown to brown (7.5 YR 4/3) moist, clay; moderate fine and medium angular blocky; sticky, slightly plastic, friable moist; few fine pores, few rounded fine (4-6mm) massive worm casts; frequent very fine and fine roots; abrupt wavy boundary.

AB 10 - 22 cm. Dark brown to brown (7.5 YR 4/4) moist, clay; moderate fine and medium subangular blocky; slightly sticky, plastic, firm moist; few fine pores, taltuza burrow filled with crumb; common very fine and fine roots; diffuse wavy boundary.

Bw1 22 - 50 cm. Strong brown (7.5 YR 4/6) moist, clay; structureless, massive porous; slightly sticky, plastic, friable moist; many very fine pores, few very fine pores, burrows filled with crumb; common very fine and fine roots; gradual wavy boundary.

Bw2 50 - 70 cm. Strong brown (7.5 YR 4/6) moist, clay; structureless, massive porous; slightly sticky, plastic, friable moist; many very fine pores, common fine pores, few medium pores, burrows filled with crumb; very few fine roots, abundant very fine roots; gradual, wavy boundary.

Bw3 70 - 100 cm. Strong brown (7.5 YR 4/6) moist, clay; structureless, massive porous; sticky, plastic, friable moist; few fine and medium pores, many very fine pores, burrows filled with crumb; frequent very fine roots, very few fine roots; diffuse, wavy boundary.

BC/Cu1 100 - 210 cm. Brown (7.5 YR 5/4) moist, few distinct clear orange and black mottles, silt loam; weak fine subangular blocky; sticky, slightly plastic, friable moist; many very fine pores, few medium pores; very few rounded gravel, weathered (iron pan); very few, very fine and fine roots.

C 210+ cm. Dark yellowish brown (10 YR 4/6) moist, orange and ocer mottles occur.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 10 - MAIZE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Ultic Tropudalf
FAO/ UNESCO : Haplic Alisol

Date of observation : 09 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 246, 1.5 km S of the village El Silencio, 15 m. W of the road, 5 m N of the house.
Topographical map : Hoja Guácimo 3446 I, 585.8 E, 239.3 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 40 m above sealevel.

Topography : Almost flat surface, 1 %.

Micro topography : None.

Drainage : Moderately well drained, moderate internal drainage.

Vegetation/actual landuse : In cultivation, maize (Zea Mays).

Anterior landuse : Before 1982 scrub (charral), thereafter pasture, beans and maize.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled, except for the first 10 cm which are dry.

Groundwater table : 1.15 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 8 cm moderately compacted,
0 - 17 cm strongly compacted,
17 - 30 cm moderately compacted,
30 - 66 cm slightly compacted.

Salt or alkali : Not present.

Soil fauna : Activity of dungbeetles (with dung filled channels and burrows), earthworms and spiders.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly warm and sunny, daily a few rain

BRIEF DESCRIPTION OF THE PROFILE

A well drained dark yellowish profile. The clayey texture changes into silt loam below 80 cm depth. Below 45 cm, the profile becomes gavelly and thixotropic with a petroferric horizon at 130 cm. The whole profile is structureless massive porous, friable, permeable, except for the slightly compacted AB-horizon. This horizon consists of very fine angular blocks, is slightly gravelly, has a firm consistance and is non thixotropic.

PROFILE DESCRIPTION

A 0 - 5 cm. Dark brow (10 YR 3/4) moist, clay; moderate to strong very fine subangular blocky; slightly sticky, slightly plastic, friable moist; many very fine to fine pores, few medium pores; very few gravel (0.3 cm); few very fine roots; abrupt smooth boundary.

AB 5 - 23 cm. Dark yellowish brown (10YR 4/4) moist, clay; strong very fine and fine angular blocky; slightly sticky, slightly plastic, firm moist; many vey fine pores, few fine and medium pores; few very fine and fine roots; diffuse wavy boundary.

Bw1 23 - 45 cm. Brown to dark brown (10 YR 4/3) moist, clay; weak very fine subangular blocky and structureless massive porous; slightly sticky, slightly plastic, friable moist; few fine pores, many very fine pores, few coarse pores filled with crumb; pieces of indian pottery (40 cm); abundant very fine roots, few fine roots; diffuse wavy boundary.

Bw2 45 - 80 cm. Brown to dark brown (10 YR 4/3) moist, clay loam, slightly gravelly; structureless, massive porous; slightly sticky, slightly plastic, friable moist; few fine pores, many very fine pores, few coarse pores filled with crumb; few gravel, angular, strongly weathered; charcoal (60 cm); few vey fine and fine roots, very few medium roots; diffuse, wavy boundary, thixotropic.

Bw3 80 - 125 cm. Dark yellowish brown (10 YR 4/4) moist, silt loam, gravelly; weak fine subangular blocky to structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine pores, few fine pores; few small gravel (3 cm), weathered, frequent large gravel, strongly weathered; few very fine and very few fine roots; abrupt smooth boundary; very thixotropic.

Bws 125 - 140 cm. Petroferric horizon, dark yellowish brown (10 YR 4/4) moist, silt loam, very gravelly; structureless, massive porous; slightly sticky, slightly plastic, friable moist, weakly cemented by iron and manganese forming a broken platy pan; few fine pores, many medium pores; very frequent large gravel, strongly weathered; few fine roots; very thixotropic.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 101 A&B - FOREST

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 4 - 11 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 224, 1.2 km SE of the village Bella Vista, in the wood on the opposit of the grocery, 20 m W of the road.
Topographical map : Hoja Guácimo 3446 I, 586.0 E, 241.4 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 20 m above sealevel.

Topography : Almost flat surface, 2 %.

Micro topography : None.

Drainage : Well drained, very rapid internal drainage.

Vegetation/actual landuse : Secundary tropical rainforest, used for firewood.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.00 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 101 A : 0 - 11 cm moderately compacted (by tractor),
101 B : not compacted.

Salt or alkali : Not present.

Soil fauna : 101 A : Activity of leafcutterants (Atta sp), other insects and earthworms. Worm-cast-structures between 6 and 11 cm and very high activiy of ants between 75 and 100+ cm.
101 B : Very high activity of leafcutterants (Atta sp.)(Ants's nest).

Humen influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly warm and dry.

BRIEF DESCRIPTION OF THE PROFILE

This profile is well drained and uniform in texture (clay) and colour (dark yellowish brown). Below 35 cm depth, the profile is structureless, massive porous, friable and permeable
In the topsoil, the strongly compacted first 4 cm are mottled, slightly permeable, firm and have a fine angular blocky structure. This changes into a weak subangular blocky to crumb structure, very friable and very permeable.
Root distribution is normal, except for the first 10 cm, where only expedal roots are present.

PROFILE DESCRIPTION

A 0 - 4 cm. Very dark gray brown (10 YR 3/2) moist, many brown gray medium faint diffuse and few orange fine distinct sharp mottles, clay; moderate to strong fine and medium angular blocky, slightly sticky, slightly plastic, firm and very firm moist; few fine pores; pieces of charcoal; frequent very fine to medium roots; abrupt smooth boundary.

AB 4 - 11 cm. Dark brown to dark yellowish brown (10 YR 3/4) moist, clay; moderate very fine and fine subangular blocky, few crumb; slightly sticky, slightly plastic, friable moist; few vey fine and fine pores; frequent very fine to medium roots; clear wavy boundary.

Bw1 11 - 35 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak fine, subangular blocky, common crumb; slightly sticky, slightly plastic, very friable moist; many very fine, common fine and few medium pores; frequent very fine to medium roots; gradual wavy boundary.

Bw2 35 - 80 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; non sticky, slightly plastic, friable moist; many very fine and few fine pores; frequent very fine to medium roots; gradual wavy boundary.

BC 80 - 126 cm. Dark yellowish brown (10 YR 3/6) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine, common fine and few medium pores; few roots; gradual wavy boundary.

C 126 - 135+ cm. (Dark) yellowish brown (10 YR 4/6) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, firm moist; many very fine and common fine pores; few roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 102 - FOREST

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Typic Dystropept
FAO/ UNESCO : Dystric Cambisol

Date of observation : 7 - 11 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 224, 1.0 km SE of the village Bella Vista, in the wood, 10 m W of the road.
Topographical map : Hoja Guácimo 3446 I, 585.9 E, 241.5 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 20 m above sealevel.

Topography : Flat surface, 0 %.

Micro topography : None.

Drainage : Well drained, very rapid internal drainage.

Vegetation/actual landuse : Secondary tropical rainforest, partially used for firewood.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.03 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : None.

Salt or alkali : Not present.

Soil fauna : Very high activity of leafcutter ants (Atta sp.)(nest ø 15 cm). Also taltuzas (burrow ø 10 cm) and spiders.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Predominantly dry, warm and sunny.

BRIEF DESCRIPTION OF THE PROFILE

Deep, well drained, dark yellowish brown profile, uniform in texture (clay) throughout its depth. Structure in topsoil is strong and fine granular with a compacted layer between 2 and 12 cm depth, consisting of strong fine subangular bloks. The subsoil (below 24 cm) is structureless, massive porous. The whole profile is friable, very porous and very permeable. Root distribution is normal.

PROFILE DESCRIPTION

Au1 0 - 2 cm. Very dark gray brown (10 YR 3/2) dry, dark brown (10 YR 3/3) moist, clay; strong fine granular; slightly sticky, slightly plastic, loose (mass), very firm (final aggregates), very few pores; mulch layer; abundant roots; abrupt smooth boundary.

Au2 2 - 7 cm. Dark brown (10 YR 3/3) moist, clay; strong fine and very fine subangular blocky, frequent crumb; slightly sticky, slightly plastic, very friable (mass), firm (final aggregates) moist; many very fine, few medium pores; abundant roots; abrupt wavy boundary.

AB 7 - 12 cm. Dark yellowish brown (10 YR 3/4), clay; moderate very fine subangular blocky, dominant strong fine crumb; slightly sticky, slightly plastic, very friable (mass), friable (final aggregates) moist; many very fine and common fine pores; abundant roots; clear wavy boundary.

Bu1 12 - 24 cm. Dark yellowish brown (10 YR 3/4) moist, clay; strong fine crumb, slightly sticky, slightly plastic, loose moist; many very fine pores; common roots; clear wavy boundary.

Bu2 24 - 61 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous, strong very fine crumb; slightly sticky, slightly plastic, friable moist; common very fine pores, many fine pores, few medium pores; common roots; gradual wavy boundary.

Bu3 61 - 117 cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; common very fine pores, many fine pores, common medium pores; common roots; gradual wavy boundary.

BC 117+ cm. Dark yellowish brown (10 YR 3/6) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, friable moist; few fine and very fine pores; few roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 103 - PASTURE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystrocpept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 19 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 158, 0.5 km SE of the village Milano, 150 m N of the road, third pasture.
Topographical map : Hoja Guácimo 3446 I, 582.9 E, 241.0 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 45 m above sealevel.

Topography : Almost flat surface, 2 %.

Micro topography : None.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : Pasture.

Anterior landuse : Scrub (charral).

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.33 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 9 cm moderately compacted,
9 - 38 cm slightly compacted.

Salt or alkali : Not present.

Soil fauna : Activity of dungbeetles (frequent burrows with Ø between 17 and 38 cm), leafcutterants (Atta sp.)(nests with Ø between 17 and 79 cm), spiders, earthworms (casts with Ø between 0 and 9 cm), termites (nests with Ø between 9 and 17 cm) and centipedes.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Daily heavy rainfall.

PROFILE DESCRIPTION

A 0 - 9 cm. Very dark gray brown (10 YR 3/2) moist, clay; strong very fine an fine angular and subangular blocky; slightly sticky, slightly plastic, firm moist; few very fine and medium pores, frequent fine pores; abundant roots; abrupt smooth boundary.

AB 9 - 17 cm. Dark yellowish brown (10 YR 3/4) moist, clay; moderate and strong fine subangular blocky; slightly sticky, slightly plastic, friable moist; few very fine and frequent fine and medium pores; very frequent roots; clear wavy boundary.

Bw1 17 - 38 cm. Dark yellowish brown (10 YR 3/4) moist, clay; moderate fine subangular blocky and structureless, massive porous; slightly sticky, slightly plastic, friable moist; many very fine and frequent fine pores; very frequent roots; gradual wavy boundary.

Bw2 38 - 79 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; very frequent roots; clear wavy boundary; thixotropic.

BC 79 - 108 cm. Dark yellowish brown (10 YR 4/4) moist, silt loam, very gravelly (5-10 cm); structureless, massive porous; slightly sticky, slightly plastic, very friable moist; patchy moderately thick black cutans, probably of sesquioxides, on faces; many very fine pores; very frequent coarse gravel, angular, strongly weathered; frequent roots; clear wavy boundary; very thixotropic.

C 108 - 133+ cm. Dark yellowish brown (10 YR 4/6) moist, silt loam, gravelly; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; frequent coarse gravel (tuffacious), strongly weathered; common roots; very thixotropic.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 104 - MAIZE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 7 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 201, 0.7 km SE of the village Milano, 150 m S of the road.
Topographical map : Hoja Guácimo 3446 I, 582.7 E, 240.4 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 45 m above sealevel.

Topography : Almost flat surface, 1 %.

Micro topography : None.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : In cultivation, maize and some beans.

Anterior landuse : Maize, before 1983 pasture and shrubs.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.27 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 9 cm moderately compacted,
9 - 16 cm strongly compacted.

Salt or alkali : Not present.

Soil fauna : Activity of taltuzas (burrows with Ø of 15 cm), spiders, lizards, termites (nests with Ø between 16 and 25 cm) and ants.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Warm and sunny, but daily some rainfall.

BRIEF DESCRIPTION OF THE PROFILE

This well drained profile is almost uniforrm in colour (dark yellowish brown), slightly changing from a dark brown A-horizon to a yellowish brown C-horizon.
The uniforrm clay texture of the topsoil becomes silt loam and gravelly below 79 cm, with thixotropic properties. The moderate (very) fine subangular blocky structure in the upper 10 cm (friable permeable) changes into a moderately compacted layer at 9-16 cm depth consisting very firm, mottled moderate fine angular blocks and which is slightly permeable. The undelying horizons are structureless, massive - porous, very friable and very permeable.

PROFILE DESCRIPTION

Au1 0 - 5 cm Very dark gray brown (10 YR 3/2) moist, clay; weak and moderate very fine and fine subangular blocky; slightly sticky, slightly plastic, friable moist; common fine and very fine pores, few medium pores; abundant roots; abrupt smooth boundary.

Au2 5 - 9 cm. Dark brown (10 YR 3/3) moist, clay; moderate fine subangular blocky; slightly sticky, slightly plastic, friable moist; common fine and medium pores, few fine pores; frequent roots, along vertical pedfaces; clear wavy boundary.

Au3 9 - 16 cm. Dark brown (10 YR 3/3) moist, few fine distinct sharp orange mottles, clay; slightly sticky, slightly plastic, very firm moist; few fine and medium pores; few roots, along vertical pedfaces; abrupt wavy boundary.

Bv1 16 - 25 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak fine subangular blocky and very fine crumb; slightly sticky, slightly plastic, friable moist; patchy thin cutans, probably of clay minerals with iron oxides and hydroxides; many very fine and frequent fine and medium pores, termite's burrow; common roots; clear wavy boundary.

Bv2 25 - 79 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; common roots; gradual wavy boundary; slightly thixotropic.

BC 79 - 127 cm. Dark yellowish brown (10 YR 4/6) moist, silt loam, slightly gravelly; structureless, massive porous; slightly sticky, slightly plastic, very friable moist; many very fine pores; few coarse tuffaceous gravel, strongly weathered; few roots; gradual wavy boundary; thixotropic.

C 127+ cm. Yellowish brown (10 YR 5/8) moist, silt loam, gravelly; structureless, massive porous; slightly sticky, slightly plastic, friable moist; common very fine pores; frequent coarse tuffaceous gravel, weathered; very few roots; very thixotropic.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 105 - MAIZE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 21 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 229, 2 km SSE of the village Bella Vista, 200 m E of the road, 20 m N of the house.
Topographical map : Hoja Guácimo 3446 I, 586.0 E, 240.7 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 35 m above sealevel.

Topography : Flat surface, o %.

Micro topography : None.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : In cultivation, maize.

Anterior landuse : Maize, before 1984 secondary tropical rainforest.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 1.00 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 12 cm strongly to moderately compacted.

Salt or alkali : Not present.

Soil fauna : Activity of earthworms (@ casts between 0 and 12 cm) and taltuzas (@ burrous between 30 and 64 cm).

Human influence :

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Daily heavy rainfall.

BRIEF DESCRIPTION OF THE PROFILE

Well drained, dark yellowish brown profile, almost uniform in texture (clay), tending to slightly gravelly silt loam below 64 cm depth.
The structure in the moderately compacted topsoil (0-12 cm) is strong (very)fine (sub)angular blocky and firm. The underlying horizons are structureless massive porous, friable and very permeable.

PROFILE DESCRIPTION

Au1 0-5 cm. Dark brown (10 YR 3/3) moist, few very fine sharp distinct red mottles, clay; strong very fine and fine angular blocky; slightly sticky, slightly plastic, friable moist; few medium pores; very frequent roots; abrupt smooth boundary.

Au2 5-12 cm. Dark yellowish brown (10 YR 3/4) moist, few very fine sharp distinct red mottles, clay; strong very fine and fine angular blocky, very few crumb; slightly sticky, slightly plastic, friable moist; few medium pores; very frequent roots; abrupt wavy boundary.

Bw1 12-30 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak fine subangular blocky and stuctureless massive porous; slightly sticky, slightly plastic, friable moist; few medium and many very fine pores; very frequent roots; clear wavy boundary.

Bw2 30-64 cm. Dark yellowish brown (10 YR 3/4) moist, clay; stuctureless massive porous, common crumb; slightly sticky, slightly plastic, loose moist; many very fine and fine pores; very frequent roots; gradual wavy boundary.

BC 64-100+ cm. Dark yellowish brown (10 YR 3/4) moist, (silt)-loam, slightly gravelly; stuctureless massive porous; slightly sticky, slightly plastic, friable moist; many very fine and common fine pores; very few tuffaceous gravel, weathered; few roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 106 - PASTURE

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : Typic Dystropept
FAO/ UNESCO : Dystric Cambisol

Date of observation : 24 - 11 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 248, 1 km S of the village El Silencio , 7 m E of the road.
Topographical map : Hoja Guácimo 3446 I, 586.4 E, 239.8 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 35 m above sealevel.

Topography : Almost flat surface, 1 %.

Micro topography : None.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : In cultivation, pasture (zacate).

Anterior landuse : Before 1982 shrubs (charral).

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 0.89 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : 0 - 6 cm strongly compacted,
6 - 14 cm moderately compacted.

Salt or alkali : Not present.

Soil fauna : Activity of earthworms (0 casts 0 to 14 cm) and dungbeetles (0 casts 0 - 60 cm).

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Daily heavy rainfall.

BRIEF DESCRIPTION OF THE PROFILE

A well drained profile, uniform in colour (dark yellowish brown) and texture (clay).
The structure in the mottled A-horizon (0-14 cm) is moderate very fine angular blocky, firm and slightly permeable. Under a transition layer of very fine subangular blocks, below 29 cm depth, there will be a uniform structerless massive porous mass, friable and very permeable.

PROFILE DESCRIPTION

Au1 0-6 cm. Dark brown (10 YR 3/3) moist, common medium distinct clear orange and common coarse faint diffuse gray mottles, clay; moderate and strong angular blocky; slightly sticky, slightly plastic, firm moist; few very fine, fine and medium pores; very frequent roots abrupt smooth boundary.

Au2 6-14 cm. Dark brown to brown (10 YR 4/3) moist, few medium distinct clear orange mottles, clay; moderate very fine angular blocky; slightly sticky, slightly plastic, friable moist; common very fine and few fine pores; very frequent roots; abrupt smooth boundary.

AB 14-29 cm. Dark yellowish brown (10 YR 3/4) moist, clay; weak and moderate very fine subangular blocky; slightly sticky, slightly plastic, friable moist; patchy thin cutans, probably of clay minerals with ironoxides and hydroxides, on pores and root channels; many very fine and few fine and medium pores; very frequent roots; gradual wavy boundary.

Bw2 29-43 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless massive porous, frequent crumb; slightly sticky, slightly plastic, friable moist; many very fine, common fine and few medium pores; very frequent roots; gradual wavy boundary.

Bw3 43-64 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless massive porous; slightly sticky, slightly plastic, very friable moist; many very fine and few fine pores; frequent roots; gradual wavy boundary.

BC 64-89+ cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless massive porous; slightly sticky, slightly plastic, friable moist; many very fine and few fine pores; common roots.

FULL PROFILE DESCRIPTION PROFILE NO. : NEG 107 - MIXED CROPPING

GENERAL INFORMATION

Classification: Soil name : Series Germania
Soil Taxonomy : prel. Typic Dystropept
FAO/ UNESCO : prel. Dystric Cambisol

Date of observation : 24 - 10 - 1986 : Described by Angelique Lansu.

Location : Asentamiento 'Neguev', Cantón Siquirres, Provincia de Limón, Costa Rica.
Lot number 229, 0.8 km E of the village Bella Vista, 10 m N of the road.
Topographical map : Hoja Guácimo 3446 I, 586.1 E, 241.9 N.

Physiographic position : On top of steeply dissected lahar remnants, elevation about 25 m above sealevel.

Topography : Gently sloping, 3 %, upper part of the slope.

Micro topography : Taltuza mounds.

Drainage : Well drained, rapid internal drainage.

Vegetation/actual landuse : In cultivation, mixed cropping, mainly cacao (Theobroma cacao), plantain (Musa spp.) and cassave (yuca)(Manihot esculenta).

Anterior landuse : Before 1982 scrub (charral) and secondary tropical rainforest.

Parent material : Lahar material.

Moisture condition of the soil : Moist when sampled.

Groundwater table : Depth not known, not encountered within 0.90 m below the surface.

Evidence of erosion : Not visible.

Evidence of compaction : None.

Salt or alkali : Not present.

Soil fauna : Activity of earthworms (Ø casts 1 to 12 cm), old dungbeetle nest (Ø between 68 and 90+ cm), small insects and a very high activity of taltuzas.

Human influence : Not present.

Climatic data :
mean annual precipitation : 3746 mm,
mean annual temperature : 24.7°C (min. 23.5°C, max. 25.9°C),
soil moisture regime : perudic,
season : winter or rainy season,
weather in the previous week : Daily heavy rainfall.

BRIEF DESCRIPTION OF THE PROFILE

Well drained profile, very permeable, uniform in texture (clay) and colour (dark yellowish brown).
The structure in the A-horizon consists of strong very fine and fine subangular blocks and granulars, all very friable.
The underlying horizons are structureless massive porous.

PROFILE DESCRIPTION

Ah1 0-1 cm. Very dark brown (10 YR 2/2) moist, clay; strong very fine and fine granular; slightly sticky, slightly plastic, loose (mass), extremely firm (aggregates) moist; very frequent roots (exped); abrupt, smooth boundary.

Ah2 1-6 cm. Very dark gray brown (10 YR 3/2) moist, clay; strong very fine and fine subangular blocky; slightly sticky, slightly plastic, very friable (mass), very firm (aggregates) moist; few fine exped pores (in cracks) and common medium pores; very frequent roots; abrupt wavy boundary.

Ah3 6-17 cm. Dark brown (10 YR 3/3) moist, clay; strong very fine and fine subangular blocky, frequent crumb; slightly sticky, slightly plastic, very friable (mass), firm (aggregates) moist; few medium and common fine pores (exped); very frequent roots; abrupt wavy boundary.

AB 17-37 cm. Dark yellowish brown (10 YR 3/4) moist, clay; structureless massive porous; slightly sticky, slightly plastic, friable moist; many very fine and fine pores, common medium pores; very frequent roots; clear wavy boundary.

Bw1 37-68 cm. Dark brown to brown (10 YR 4/3) moist, clay; structureless massive porous; slightly sticky, slightly plastic, very friable moist; many very fine, few fine and medium pores; frequent roots; gradual wavy boundary.

Bw2 68-90+ cm. Dark yellowish brown (10 YR 4/4) moist, clay; structureless massive porous; slightly sticky, slightly plastic, friable moist; many very fine and few fine pores; common roots.

APPENDIX B. DETAILED MICROMORPHOLOGICAL DESCRIPTIONS

NEG 9 - MIXED CROPPING

GENERAL:
thin section number: 87.128
profile: NEG 9
location: Provincia de Limón, Costa Pica
date: 11 June 1987
horizon: Au1/Au2
depth: 0-7.5 cm

MICROSTRUCTURE:
granular structure, very open
TYPES: Mainly granular, in the lower part some strong developed subangular blocks, in the upper part more crumbs.

PEDS: types with intergrades:
crumbs; strongly developed; few, mainly ≤ 500 µm, very fine, rough surfaces, random distribution, porous.
granules; strongly developed; dominant, mainly 1-5 mm, fine and medium, range from 200 µm-7mm, mainly rough, some smooth; random distribution, dense, range from porous to very dense.
subangular blocks; strongly developed; frequent, usually 2-5 mm, very fine, undulating surface; random to clustered distribution, dense.

VOIDS:
total estimated porosity: approx. 50 %
inter-aggregate voids:
compound packing voids; between crumbs, granulars, subangular blocks and plant fragments; wide range of sizes, 45% of area, very dominant, irregular shapes, mainly rough walls, interconnected, random distribution.
planar voids; separating subangular blocks, usually 50-200 µm wide and up to 20 mm long, micro, 2% of area, very few, weakly horizontal oriented.
channels; clear channels, partly with loose discontinuous infillings of excremental material (micro), round to elongate, size 200-1000 µm, very fine, 2% of area, very few, walls undulating to rough.
chambers; one chamber of 1.5 mm, connected with a very fine channel, undulating walls, no infillings.
intra-aggregate voids:
compound packing voids; between partially fused aggregates within peds, irregular shape, ≤ 200 µm; and vughs; within peds, irregular shape, < 100 µm; 3% of area, very few to few; packing void/vugh distinction is not obvious.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare intrapedal clay nodules (possible weathered minerals), 100µm, limpid b-fabric.
FABRIC PEDOFEATURES:
bow-like features: none
passage features:
closer packed fabric along channels, common, thickness 1-2 mm, external cylindrical or vermiform shaped with a diffuse boundary, internal very dense crumb, faint contrast, distribution related to channels, strongly fragmented, no intact pores.
EXCREMENT PEDOFEATURES:
few excrements; mainly not fragmented or deformed; red ellipsoidal mite excrements, 2-20 µm, micro, in plant remnants; dark-brown, mammilated earthworm excrements, 1-2 mm, fine, and other ellipsoidal excrements; dense internal ageing, strong coalescence (formation of granulars) and a weak disintegration, undulating surface roughness and a random basic distribution, composed of org. fine material with clay and tissue fragments.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.129
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 7 july 1987
horizon: AB/Bw1
depth: 7.5-15 cm

MICROSTRUCTURE:
very porous crumb structure
TYPES:
mainly crumbs, in the upper part coarse granular peds and fine and medium subangular blocks, in the lower part fine and medium crumbs.

PEDS: types with intergrades:
crumbs; strongly developed; very dominant, mainly 2-5 mm, medium; rough surfaces; random distribution; porous.
granules; strongly developed; few, mainly 5-10 mm, coarse, undulating surfaces; random distribution; very dense, but with a porous fringe.
subangular blocks; strongly and moderately developed; few, mainly clustered with crumbs, range from 1-10 mm, very fine and fine.
microaggregates; clustered subangular blocks and crumbs.

VOIDS:
total estimated porosity: approx. 60 %
inter-aggregate voids:
compound packing voids; between crumbs, granules, subangular blocks and plant fragments, wide range of sizes, 50% of area, very dominant, irregular shapes, rough walls, interconnected, random distribution.
intra-aggregate voids:
compound packing voids; between the clustered microaggregates, irregular shape; and vughs; irregular shape; and channels, 100 µm, micro, within peds.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:

rare intrapedal micro clay nodules.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant, vermiform, 200-500 µm, very fine, dense crumb structure with a distinct contrast, low variability and strongly fragmented.
EXCREMENT PEDOFEATURES:
many types; ellipsoidal to mammilated excrements, dense internal ageing, moderately coalescence, weakly in some crumbs, wide size range, fine and medium, very dominant, undulating to rough surfaces, darkbrown, infillings and clustered into peds.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.130
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 22 june 1987
horizon: Bw1
depth: 15-22.5 cm

MICROSTRUCTURE:
very porous crumb structure, very open.
TYPES: Mainly strongly developed porous crumbs and dense granules.

PEDS: types with intergrades:
crumbs; strongly developed, common: few coarse, >5 mm; very few fine and medium, 1-5 mm; and frequent very fine, 200-1000 µm; total size range, 50 µm-10 mm, fine ones are referred to channels, very fine ones random distributed or clustered together; all with rough surfaces, porous to very porous.
granules; strongly developed; dominant, mainly 1-5 mm, fine and medium; whole range of 100 µm-5 mm is present, usually subrounded to subangular; rough surfaces, except for the medium granules, distribution pattern of medium granulas related to the channels, very fine to medium granules are random distributed; microgranules are moderately clustered; dense to very dense.
subangular blocks: present as an integrate of granules; strongly developed; few, 1-5 mm, very fine; undulating surface; dense to very dense; random basic distribution.

VOIDS:
total estimated porosity: approx. 55 %
inter-aggregate voids:
compound packing voids; very dominant; between crumbs, granules and plant fragments;wide range of sizes; irregular shapes; rough walls; random arrangement and interconnected.
channels; very few; 50-100 µm, micro, round to elongate; length 40 mm.
intra aggregate voids:
compound packing voids and vughs; irregular shapes; size ≤200 µm, few in coarse crumbs, very few in other crumbs and granules.
trans-aggregate voids:
planar voids; ≤50 µm, micro; occurence in fine and medium peds.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare intrapedal clay nodules, yellow colour, isotropic.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
along channels; frequent; 500-1000 µm, very fine; external vermiform to cylindrical with a clear boundary; rough inner wals and a porous internal structure; faint to distinct contrast with adjecent material; maderate variability; mainly strongly fragmented, but with a wide range; very few intact pores.
EXCREMENT PEDOFEATURES:
very dominant; but very few intact excrements (some mite and earthworm exc. recognizable), forming very dense microaggregates coalesced into porous crumbs and dense granules.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.131
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 7 july 1987
horizon: Bw2
depth: 22.5-30 cm

MICROSTRUCTURE:
very porous to porous crumb structure
TYPES: Mainly medium porous crumbs and very fine and fine granules.

PEDS: types with intergrades:
crumbs; strongly developed; common to dominant; mainly 2-5 mm, medium common porous crumb; few crumb microaggregates; 50-200 µm, micro, rough surfaces; random distribution.
granules; strongly developed; common; mainly 200 µm-2mm, very fine and fine; undulating to smooth; random distribution; subrounded; dense; granular microaggregates.
subangular blocks; strongly developed; few; mainly 500-1000 µm; undulating surface; random distribution; very dense.

VOIDS:
total estimated porosity: approx. 50 %
inter-aggregate voids:
compound packing voids; between crumbs, granules and subangular blocks; very dominant, 45% of area; wide range of sizes; irregular shapes; rough walls; partially interconnected; random distribution.
intra-aggregate voids:
compound packing voids and vughs between partially fused aggregates within peds.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant to very dominant; 200-1000 µm, very fine; external vermiform; diffuse sharpness; undulating inner walls; internal very dense; prominentcontrast; medium variability; moderate to strongly fragmented.
EXCREMENT PEDOFEATURES:
dominant; many recognizable excrements; internal ageing dense; weakly to moderately coalesced; mainly ≤200 µm, micro; medium brown; large amounts as porous continuous infilings in fine pores.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.132
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 22 june 1987
horizon: Bw2
depth: 30-37.5 cm

MICROSTRUCTURE:
porous crumb structure, open to close.
TYPES: Strongly developed medium crumbs and very fine granules.

PEDS: types with intergrades:
crumbs; strongly developed; very dominant, mainly 2-5 mm, medium, range from 100 µm-7 mm; rough surfaces; dense; random distribution; distribution of few coarse crumbs related to channels; microaggregates clustered.
granules; strongly developed; frequent, mainly 200-1000 µm, very fine; wide range from 200 µm-5 mm; undulating surfaces; random distribution; (sub)rounded.

VOIDS: not described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant; lesser passage f. in de lower denser part; 200-1000 µm; external vermiform; clear sharpness; undulating to rough inner walls; internal dense crumb structure; distinct contrast with adjecent matrix; high variability; moderately to strongly fragmented; few intact channels.
EXCREMENT PEDOFEATURES:
frequent; very few intact excrements; internal very dense; moderately coalesced into porous to dense crumbs.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.133
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw2
depth: 37.5-45 cm

MICROSTRUCTURE:
very porous to dense crumb structure
TYPES: crumbs and granules; wide range of sizes

PEDS: not described in detail.

VOIDS:
inter-aggregate voids:
channel; 8 mm, coarse; possibly a wormchannel.
other voids not described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; 200-500 µm; external vermiform; difuse sharpness; internal very dense crumb structure; distinct to prominent contrast; high variability; moderately to strongly fragmented.
EXCREMENT PEDOFEATURES:
common; internal dense; moderately coalesced; rough; some occurence as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.134
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: 25 june 1987
horizon: Bw2
depth: 45-52.5 cm

MICROSTRUCTURE:
porous to dense crumb structure, transition to vughy structure, closed.
TYPES: Mainly apedal soil material; a aggregated crumb mass with a vughy structure, smaller micropeds are recognizable in this apedal soil material because of their denser internal porosity and dark brown colour.

PEDS: types with intergrades:
crumbs; strongly developed; few, mainly 1-2 mm, fine, smooth to rough; and 200-500 µm, very fine, rough; unaccomodated; random distribution; fine crumbs slightly related to channels; porous.
granules; strongly developed; mainly 200-1000 µm, very fine, wide size range, 20 µm-5 mm; rough; subrounded; very dense; fine granules are smooth, subangular, very dense; random distribution.

VOIDS:
total estimated porosity: approx. 45 %
inter-aggregate voids:
compound packing voids; between crumbs and granules; dominant; 30% of area; rough; irregular; 100-1000 µm; micro and very fine; partially interconnected.
vughs; few; 200-1000 µm; rough walls; random distrbution; unconnected.
channels; few intact; 200-1000 µm; smooth walls.
intra-aggregate voids:
vughs; within the apedal soil material; 10% of area; micro; irregular rough walls; random distribution.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
few; 200-1000 µm; external vermiform; clear sharpness; smooth to undulating walls; internal very dense structure; birefringence in intact channels; faint contrast with adjecent material in very dense parts; distinct contrast in porous parts; weakly fragmented.
EXCREMENT PEDOFEATURES:
common; but very few intact excrements; internal dense to very dense; moderately coalesced; some occur as discontinuous, incomplete infilings of earthworm and mite excrements.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.135
profile: NEG 9
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw2
depth: 52.5-60 cm

MICROSTRUCTURE:
porous crumb structure
TYPES: Compound structure of very fine and fine very dense granules and subangular blocks and very porous microcrumb.

PEDS: types with intergrades:
crumbs; strongly developed; frequent; usually ≤500 µm, micro; rough surfaces; unaccomodated; clustered; mainly as infillings and along channels; porous.
granules; strongly developed; dominant; range of sizes 500 µm- 2 mm, very fine and fine; undulating surfaces; random distribution; very dense.
subangular blocks; moderately developed; few; 1-5 mm; very fine; smooth to undulating; unaccomodated; random distributed; very dense.

VOIDS:
total estimated porosity: approx. 50 %
inter-aggregate voids:
compound packing voids; between crumbs, granules and subangular blocks; very dominant; 45% of area; irregular shape; rough walls; random distribution; partialy interconnected.
channels; few; mainly 200 µm, very fine, wide range of sizes 50 µm- 2 mm, usually with infillings and smooth walls.
chambers; very few; 1-2 mm, fine, connected with very fine channels; 200-500 µm, very fine, connected with a micro channel; smooth walls.
intra-aggregate voids:
vughs; within crumbs and granules; very few; 100-500 µm; iregular shape; rough walls; clustered;unconnected.
trans-aggregate voids:
planar voids; very few; ≤50 µm, micro; smooth walls; zig-zag orientation.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
AMORPHOUS PEDOFEATURES:
very few; (hypo)coatings of ferrogunious material.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
frequent; ≤500µm; external vermiform with diffuse boundary; rough to undulating inner walls; medium variability; moderately fragmented.
EXCREMENT PEDOFEATURES:
dominant; internal very dense; moderately coalesced; rough; occur as porous continuous and discontinuous infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

NEG 10 - MAIZE

GENERAL:
thin section number: 87.136
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: 10 june 1987
horizon: Au3/AB
depth: 15-22.5 cm

MICROSTRUCTURE:
crack structure/angular structure.
TYPES: Mainly coarse angular blocky structure, frequent very fine subangular blocks.

PEDS: types with intergrades:
subangular blocks; moderately developed; frequent; 2-5 mm, very fine; undulating surfaces; partially accommodated; clustered; internal very dense.
angular blocks; moderately and strongly developed; dominant; mainly ≥20 mm; coarse; range 5-30 mm; smooth surfaces; partially accomodated; clustered; internal very dense; compounded of smaller micropeds as granules and subangular blocks; only recognizable by their darker colour.

VOIDS:
total estimated porosity: approx. 20 %
inter-aggregate voids:
planar voids; separating the angular blocks; dominant; 14% of area; 200-500 µm; very fine; range ≤500 µm; undulating vals; moderately oriented; perpendicular to each other; interconnected.
intra-aggregate voids:
vughs;within peds; few, 2% of area; 50-100 µm; irregular walls; rough; random distributed; unconnected.
channels;few, 2% of area; 100-200 µm; smooth walls; random distributed; partially with infillings of excrements.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
dusty clay and clay & silt; rare to occasional; thickness mainly 20 µm, with a range of 20-150 µm; coating; yellow to orange colour; white to yellow birefringence colours; few birefringence; strong birefringence of external boundary, inner walls birefringence absent, microlaminated; clay & silt p.f. parallel layered; interpedal distribution in planar voids.
AMORPHOUS PEDOFEATURES:
frequent; ferrogineous mottles.
FABRIC PEDOFEATURES: because of the very dense soil material, fabric p.f. are absent.
EXCREMENT PEDOFEATURES:
very few to few; mayor part are mite excrements; porous internal ageing; moderately coalesced; ≤50 µm; ellipsoidal; smooth; dark brown; org.matter and clay; occurrence as porous discontinuous infillings in channels.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.137
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: AB
depth: 22.5-30 cm

MICROSTRUCTURE:
vughy to spongy microstructure
TYPES: The mainly apedal material shows a vughy to sponghy microstructure, the pedality of this structure is only showed by rustbands, which deliniate coarse angular blocks, there is no evidence of discrete aggregates.

PEDS: none; the soil material is apedal.

VOIDS:
total estimated porosity: approx. 12 %
intra-aggregate voids:
vughs; common; 4% of area; 200-500µm, very fine; irregular; rough walls; random distributed; unconnected.
channels; very few; 1% of area; 10 mm, coarse; cylindrical; smooth walls; probably of dung beetle.
planar voids; dominant; 8% of area; thickness 500-1000 µm, very fine; smooth walls; moderately oriented; parallel to inclined; weakly accomodated; interconnected.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
dusty clay in coatings; rare; thickness 20-50 µm; yellow to orange colour; mainly isotropic; on inner wall with a white to orange birefringence colour; microlaminated; occurence along coarse channel walls.
AMORPHOUS PEDOFEATURES:
frequent; ferrogineous hypocoatings on ex-ped faces of angular blocks.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
few; 50-500µm; external vermiform; diffuse; smooth to undulating inner wall; faint contrast; low variability; weakly fragmented; some cemented with iron oxyde.
EXCREMENT PEDOFEATURES:
very few; mite excrements recognizable; porous to dense internal ageing; weakly coalesced; 50µm; smooth; brown; occurrence as porous continuous infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.138
profile: NEG 10

location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 30-37.5 cm

MICROSTRUCTURE:
weakly developed subangular blocky.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features:
very few; 500-1000 µm, very fine; cylindrical external shape; clear boundary; porous crumb internal structure; no birefringence; distinct contrast.
passage features:
frequent; thickness 200-1000 µm, very fine; range 200 µm-2 mm; vermiform; diffuse boundary; undulating inner wall; very dense crumb microstructure; distinct to faint contrast; high variability; weakly fragmented.
EXCREMENT PEDOFEATURES:
common; not equal distributed, in upper part frequent and very dense, in lower part dominant and dense; strongly coalesced; <50 µm; ellipsoidal; org.matter/clay; random distribution; some recognizable mite excrements as channel infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.139
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 37.5-45 cm

MICROSTRUCTURE:
dense crumb to vughy microstructure
TYPES: Apedal soil material, showing a dense crumb to vughy microstructure, no discrete aggregates recognizable.

PEDS: none; the soil material is apedal.

VOIDS:
total estimated porosity: approx. 25 %
intra-aggregate voids:
vughs; very dominant; micro; and channels; very few; cylindrical; 10-20 mm, very coarse; smooth walls; probably of a dung beetle.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare; coating; on fringe with channel wall; consisting of micro-laminated dusty clay; with parallel birefringence; thicknes 30-60 µm; inner side of clay & silt; layered; isotropic; thickness 30-60 µm; total thickness coating 60-120 µm; moderately fragmented; high variability.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
frequent; vermiform; clear boundary; smooth inner wall; very dense internal microstructure; distinct contrast; medium variability; weally to moderately fragmented.
EXCREMENT PEDOFEATURES:
common; very few recognizable excrements; very dense internal ageing; moderately coalesced; rounded; smooth; brown; random distribution; occur as discontinuous porous infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.140
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 45-52.5 cm

MICROSTRUCTURE:
vughy to spongy.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare; typic coating; 20-50 µm; dusty clay; yellow colour; low birefringence; microlaminated; low variability.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant; 200-500 µm; range from 50-500 µm; vermiform; clear boundary; smooth to undulating inner wall; low birefringence; distict contrast; medium variability; moderately fragmented.
EXCREMENT PEDOFEATURES:
very dominant; mite and earthworm excrements recognizable; very dense internal ageing; strongly coalesced; 20-1000 µm; rough; mite excrements occur as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.141
profile: NEG 10
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 52.5-60 cm

MICROSTRUCTURE:
porous crumb structure
TYPES: Mainly micro crumbs, frequent very fine granules.

PEDS:
crumbs; strongly developed; dominant; 50-200 µm, micro; rough surfaces; unaccomodated; random distribution; porous to dense internal porosity.
granules; strongly developed; frequent; mainly 200-1000 µm, very fine; undulating to smooth surface; unaccomodated; random distribution; dark brown; very dense internal porosity.

VOIDS:
total estimated porosity: approx. 55 %
inter-aggregate voids:
compound packing voids; between crumbs and granules; few, 5% of area; 200-500 µm, very fine; irregular; random distribution; partially interconnected.
channels; separating the aggregates; frequent, 8% of area; 200-600 µm, very fine; range from 200-1000 µm; cylindrical; smooth walls; random distribution; interconnected; some with infillings.
chambers; connected with channels of 200 µm wide; very few; cylindrical; very fine; random distribution.
intra-aggregate voids:
compound packing voids; between distinctable granules in aggregates; few, 5% of area; 100-200 µm, micro; irregular; rough walls; random distribution; partially interconnected.
vughs; in crumbs; common, 20%of area; ≤100 µm; irregular shape; random distribution; unconnected.
trans-aggregate voids:
planar voids; very few; ≤50 µm; smooth walls; random distribution; partially interconnected.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare; infillings of silty material; discontinuous; non-laminated; isotropic.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; 200-500 µm, very fine; diffuse boundary; faint to distinct contrast; medium variability; weakly fragmented.
EXCREMENT PEDOFEATURES:
dominant; moderately deformed; very dense internal ageing; moderately coalesced; subrounded; rough; random distribution; many mamillated earthworm excrements.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

NEG 102 - FOREST

GENERAL:
thin section number: 87.142
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: 17 june 1987
horizon: Au1/Au2
depth: 0-7.5 cm

MICROSTRUCTURE:
very porous crumbstructure, very open.

PEDOFEATURES: not described.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.143
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: 17 june 1987
horizon: Au2/Au3
depth: 7.5-15 cm

MICROSTRUCTURE:
very porous crumb structure
TYPES: Mainly very fine dense granules with common porous crumb.

PEDS:
crumbs; strongly developed; common, 15% of area; mainly 2-7 mm, medium and coarse; and 500-1000 µm, very fine; total range 200 µm-10 mm; rough mamillated surface; unaccomodated; random distribution; porous internal porosity; the very fine crumbs are weakly clustered.
granules; strongly developed; dominant; mainly 200-1000 µm, very fine; wide range 50 µm-5 mm; undulating; unaccomodated; weakly clustered; dense internal porosity.

VOIDS:
total estimated porosity: approx. 60 %
inter-aggregate voids:
compound packing voids; between crumbs, granules and plant fragments; very dominant, 50% of area; micro and very fine; rough walls; random distribution; interconnected.
channels; few, 5% of area; subrounded; 2-5 mm, medium; rough walls; weakly oriented, horizontal; partially interconnected; strongly fragmented; with infillings.
chambers; very few, 1% of area; 5-10 mm, coarse; rough walls; random distribution; interconnected; strongly fragmented.
intra-aggregate voids:
vughs; few, 3% of area; irregular; elongated; 50-200 µm, micro; rough; random distribution; mainly referred to medium and coarse aggregates; partially interconnected.

vesicles; very few, 1% of area; rounded; 50-100 µm; smooth; random distribution; mainly referred to granules.
channels; very few, 1% of area; rounded; 1-5 mm, fine and medium; smooth walls; unconnected; with infillings.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
CRYSTALLINE PEDOFEATURES:
nibbsitic features:
occasional; mainly 2-7 mm, medium and coarse; range 1-10 mm; as typic coating and as infilling; random distribution.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
very few; vermiform; rough inner wall; strongly fragmented.
EXCREMENT PEDOFEATURES:
dominant; excrements hardly recognizable; mainly 200-500 µm, very fine; but total range present; very dense intenal ageing; strongly coalesced into crumbs; rough; occur occasional as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.144
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: 17 june 1987
horizon: Au3
depth: 15-22.5 cm

MICROSTRUCTURE:
very fine porous crumb microstructure, open.
TYPES: Mainly very fine and fine dense granules with common medium porous crumbs.

PEDS:
crumbs; strongly developed; common; mainly 2-6 mm, medium; range 500 µm-10 mm; rough mamillated; unaccomodated; random distribution; porous internal porosity; some small crumb microaggregates.
granules; strongly developed; very dominant; mainly 200 µm-2 mm, very fine and fine; vide range 50 µm-2 mm; (very) dense internal porosity; fine granules subangular; microgranules clustered.

VOIDS:
total estimated porosity: approx. 55 %
inter-aggregate voids:
compound packing voids; between crumbs and granules; very dominant, 50% of area; irregular; rough walls; random distribution; interconnected.
channels; few; usually 5-10 mm, coarse; subrounded; rough walls; partially interconnected; random distribution; strongly fragmented; some infillings.
chambers; very few; 10-20 mm, very coarse; rounded; smooth walls; random distribution; interconnected.
intra-aggregate voids:
very few in total, majority occurs in crumbs.
vughs; 100-200 µm, micro; range 50-500 µm; irregular; rough; random distribution.
vesicles; 50-100 µm, micro; irregular; rounded; occurrence mainly in very dense granules.
channels; 200-500 µm, very fine; rounded; smooth; random distribution.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare, limpid clay nodules, non laminated, intrapedal, yellow-orange colour, isotropic.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.145
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: AB
depth: 22.5-30 cm

MICROSTRUCTURE:
very porous to porous crumb structure
TYPES: Frequent medium porous crumb and very dominant very fine granules.

PEDS:
crumbs; strongly developed; frequent; mainly 2-5 mm, medium; range from 1-7 mm; rough mamillated surface; unaccomodated; random distribution; porous internal porosity.
granules; strongly developed; very dominant; mainly 200-1000 µm, very fine; with a wide range of 100 µm-5 mm; undulating; unaccomodated; random distribution; very dense internal porosity; microaggregates show a more clustered distribution.

VOIDS:
total estimated porosity: approx. 55 %
inter-aggregate voids:
compound packing voids; very dominant, 42% of area; between crumbs and granules; irregular shape; rough walls; random distribution; interconnected.
channels; frequent, 10% of area; mainly 4-6 mm, medium; with a range 2-10 mm; smooth walls; random distribution; weakly fragmented; many infillings.
intra-aggregate voids:
vughs; very few; 200-500 µm, very fine; range 100-500 µm; irregular; rough; random distribution; occurrence mainly in crumbs.
vesicles; very few; 100-200 µm, micro; rounded; smooth; random distribution.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
few; vermiform; clear; rough inner walls; distinct contrast; high variability; strongly fragmented.
EXCREMENT PEDOFEATURES:
very dominant; porous internal ageing; moderately coalesced; rough; random distribution; occur as infillings; mite excrements recognizable.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.146
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: june 1987
horizon: AB
depth: 30-37.5 cm

MICROSTRUCTURE:
porous crumb to sponghy structure, closed.
TYPES: Very fine crumbs and medium and fine granules welded together into a apedal crumb mass. Compacted by biological activity.

PEDS:
crumbs; moderately developed; common, mainly 200-1000 µm, very fine; and ≥5 mm, coarse; range 200 µm-10 mm; rough mamillated; unaccomodated; dense internal porosity; the coarse crumbs are porous and subangular.
granules; strongly developed; common; mainly 1-5 mm, fine and medium; range 50 µm-5 mm; undulating; unaccomodated; random distribution; partially referred to channels; dense; the very fine granules are very dense and smooth.

VOIDS:
total estimated porosity: approx. 30 %
inter-aggregate voids:
compound packing voids; very dominant, 27% of area; irregular; rough walls; random distribution; partially interconnected.
channels; few, 2% of area; 500 µm- 5 mm; culindrical; smooth walls; random distribution; partially interconnected.
intra-aggregate voids:
vughs; very few, 1% of area; irregular; micro.
trans-aggregate voids: none.

PEDOFEATURES: not described.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.147
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: june 1987
horizon: Bw1
depth: 37.5-45 cm

MICROSTRUCTURE:
porous crumb structure

TYPES: A crumb mass, hardly pedal, mainly consisting of dominant fine and medium crumb and common very fine granules.

PEDS:
crumbs; strongly developed; dominant, mainly 1-5 mm, fine and medium; range 200 µm-10 mm; rough; unaccomodated; random distribution, smooth dense parts referred to channels; porous to dense internal porosity.
granules; strongly developed; common; mainly 200-1000 µm, very fine; range 50 µm-2 mm; rounded to subangular; undulating; unaccomodated; random distribution; microgranules clustered; very dense internal porosity.

VOIDS:
total estimated porosity: approx. 40 %
inter-aggregate voids:
compound packing voids; dominant; irregular.
vughs; very few; and channels; very few, 3-5 mm, medium; and chambers; very few, 10 mm, coarse.
intra-aggregate voids:
very few in total.
vughs; 100-200 µm, micro; and vesicles; 50-100 µm, micro; and channels; 300 µm, very fine.
trans-aggregate voids:
planar voids; ≤50 µm, micro.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
frequent; vermiform; undulating inner walls; very dense structure; distinct contrast; medium variability; strongly fragmented.
EXCREMENT PEDOFEATURES:
very dominant; dense to very dense internal ageing; moderately coalesced; rough; some occur as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.148
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: june 1987
horizon: Bw1
depth: 45-52.5 cm

MICROSTRUCTURE:
crumb mass, almost a apedal structure, closed to very closed.
TYPES: Mainly a apedal structure, only strongly developed peds are recognizable.

PEDS:
crumbs; strongly developed; dominant; mainly 1-10 mm, fine, medium and coarse; range 500 µm-10 mm; undulating to rough; unaccomodated; mainly referred to channels; high variability; porous.
granules; strongly developed; common; mainly 200-1000 µm, very fine; range 50 µm-5 mm; subrounded; smooth; unaccomodated; random distribution; very dense.

VOIDS:
total estimated porosity: approx. 45 %
inter-aggregate voids:
compound packing voids; very dominant; between crumbs and granules; irregular; partially interconnected; rough walls.
vughs; very few; irregular.
channels; very few; 2-5 mm, medium.
intra-aggregate voids:
very few in total.
vughs; 50-200 µm, micro; and channels; 200-500 µm, very fine.
trans-aggregate voids:
planar voids; 50 µm; parallel and inclined.

PEDOFEATURES:
CRYSTALLINE PEDOFEATURES:
gibbsitic features:
rare; occurence as coatings and infillings.

Other pedofeatures are not described.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.149
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 52.5-60 cm

MICROSTRUCTURE:
porous crumb structure; not further described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bowlii- features: none.
passage features:
dominant; vermiform; diffuse; dense crumb microstructure; distinct to faint contrast; medium variability; moderately fragmented.
EXCREMENT PEDOFEATURES:
very dominant; dense internal ageing; moderately coalesced; rough; few occur as discontinuous infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

NEG 106 - PASTURE

GENERAL:
thin section number: 87.150
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Au1
depth: 0-7.5 cm

MICROSTRUCTURE:
upper part: crack structure
lower part: moderate subangular blocky
TYPES: Dominant moderate (sub)angular blocks, frequent very fine to medium granules and very few very fine crumbs.

PEDS: types with intergrades :
crumbs; strongly developed; very few; mainly 200-1000 µm, very fine; rough, unaccomodated; clustered in the lower part; porous internal porosity.
granules; strongly developed; frequent; mainly 500 µm - 5 mm, very fine to medium; subangular; undularing; unaccomodated; clustered in the lower part; dense internal porisity.
(Sub)angular blocks; dominant; moderately to strongly developed; mainly 10-20 mm, medium, with a range 5-50 mm; smooth; accomodated; random distribution; very dense internal porosity.

VOIDS:
total estimated porosity: approx. 25 %
inter-aggregate voids:
planar voids; frequent; 8 % of area, mainly 100-200 µm; separating the (sub)angular blocks; smooth; random distribution; interconnected.
intra-aggregate voids:
vughs; common, 14 % of area; mainly 50-500 µm; irregular, rough walls; random distribution; unconnected.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare, limpid clay nodules; low variability; random distribution.
AMORPHOUS PEDOFEATURES:
ferroginious mottles; orange; 2-5 mm.
FABRIC PEDOFEATURES:
bow-like features:
very few; usually 1-2 mm; cylindrical; claer; vughy to dense crumb microstructure; no birefrngence; faint contrast; low variability; random distribution; moderately fragmented.
passage features:
frequent; mainly 200-500 µm, with a range 200 µm - 2 mm; vermiform; diffuse; smooth innerwall; very dense crumb microstructure; high variability; faint contrast; weakly fragmented.
EXCREMENT PEDOFEATURES:
frequent excrements, but not very recognizable (very few intact mite excrements, few intact earthworm excrements); dense internal aging; strongly coalesced; 50 µm - 2 mm; subrounded; rough brown, but worm excrements dark brown; interpedal; random distribution; medium variability.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.151
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Au2
depth: 7.5-15 cm

MICROSTRUCTURE:
vughy or dense crumb structure.
TYPES:
mainly fine subangular blocky
PEDS:
(Sub)angular blocks; very dominant; mainly 5-10 mm, with a range 500 µm - 15 mm; undulating; moderately developed; random distribution; partially accomodated; very dense internal porosity.
VOIDS:
total estimated porosity: approx. 20 %
inter-aggregate voids:
planes; frequent; 4 % of area; separating the (sub)angular bloks mainly 100-200 µm, with a range 50-500 µm; smooth walls; moderately orientated; perpendicular; interconnected.
intra-aggregate voids:
channels; frequent; 7 % of area; mainly 50-100 µm, with a range 50-1000 µm; smooth; random distribution; partially interconnected; occur with infillings.
vughs; dominant; 10 % of area; 200-1000 µm; irregular; rough walls; random distribution; unconnected.
vesicles & compound packing voids; very few.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare, limpid clay nodules; non laminated; intrapedal; low variability.
AMORPHOUS PEDOFEATURES:
occasional, charcoal fragments and few ferrogenious mottles.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
few; vermiform; 200-1000 µm; clear; smooth innerwalls; faint contrast; high variability; weakly fragmented.
EXCREMENT PEDOFEATURES:
few intact mite excrements, no intact earthworm excrements; common; dense to very dense internal ageing; strongly coalesced; mainly 100-500 µm; rough; random distribution; intrapedal; (incorporated in soil matrix).

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL
thin section number: 87.152
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: AB
depth: 15-22,5 cm

MICROSTRUCTURE:
vughy to spongy microstructure.
TYPES:
The mainly apedal material shows a vughy to spongy microstructure. There is no evidence of discrete aggregates.

PEDS: none, the soil is apedal.

VOIDS: not described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; veriform; irregular; diffuse boundary; smooth innnervalls; faint contrast; moderately fragmented.
EXCREMENT PEDOFEATURES:
few mite excrements, no earthworm excrements recognizable; dominant ≤ 2 mm; dense internal ageing; moderately coalesced; rough; few as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.153
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: AB
depth: 22.5-30 cm

MICROSTRUCTURE:
spongy microstructure.
TYPES:
the mainly apedal material shows a spongy microstructure. There is no evidence of discrete aggregates.

PEDS: none; the soil material is apedal.

VOIDS:
total estimated porosity: approx. 20 %
inter aggregate voids: none.
intra-aggregate voids:
vughs; very dominant; 10 % of area; mainly 200-500 µm, with a range 50-1000 µm; irregular; rough; random distribution; some larger vughs partially interconnected.
channels; very few; 1 % of area; mainly 200-500 µm, but one 25 mm channel; cylindrical; smooth; random distribution; unconnected.
chambers; very few; 1-2 mm; smooth, random distribution; interconnected with very fine channels.
planes; very few; 1 % of area; 50-100 µm; smooth; moderately orientated; radial referred to coarse channel.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare, limpid clay nodules; not laminated; intrapedal; low variability.
AMORPHOUS PEDOFEATURES:
very few ferrogenious mottles.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; vermiform; mainly 200-500 µm; diffuse boundary; undulating innervalls; very dense crumb microstructure; distinct to faint contrast; high variability moderately fragmented (a few intact pores).
EXCREMENT PEDOFEATURES:
very few mite excrements; common; dense internal ageing; strongly coalesced; mainly 200-500 µm; rough; yellow brown; some as loose discontinuous infillings

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.154
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw2
depth: 30-37.5 cm

MICROSTRUCTURE:
porous, dense crumb microstructure, closed, transition to vughy microstructure. No futher description.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features: very few; hardly recognizable because of loose arrangement of aggregates; diffuse boundary; porous crumb structure; faint contrast; low variability; strongly fragmented.
passage features:
common; vermiform; 200-500 µm, with a wide range; diffuse boundary;undulating innvralls; dense crumb microstructure; no birefringence; faint contrast; medium variability;random distribution; strongly fragmented.

EXCREMENT PEDOFEATURES:

very few intact mite and earthworm excrements; very dominant; dense to very dense internal ageing; moderately coalesced; ≤ 5 mm; rough; yellow brown, earthworm excrements are dark brown; random distribution.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.155
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw2
depth: 37.5-45 cm

MICROSTRUCTURE:
spongy microstructure (open)
TYPES:
the mainly apedal material shows a spongy microstructure. Discrete aggregates are moderately to stronly recognizable.

PEDS: none; the soil material is apedal.

VOIDS:
total estimated porosity: approx. 30 %
inter-aggregate voids: none.
intra-aggregate voids:
vughs; very dominant; 30 % of area; irregular; mainly 200-500 µm, with a wide range 50-1000 µm; rough; random distribution; partially interconnected.
channels; very few; 100-200 µm; smooth; random distribution.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant; veriform; 50-100 µm; diffuse boundary; rough innervalls; dense internal microstructure; no birefringence; faint contrast; medium variability; strongly fragmented.

EXCREMENT PEDOFEATURES:
very dominant; dense internal ageing; weakly to moderately coalesced; size 100-1000 µm; rough; random distribution; no infillings occur.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.156
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw3
depth: 45-52.5 cm

MICROSTRUCTURE:
very closed crumb mass, transition to sponghy microstructure.
TYPES:
the mainly apedal material shows a very porous to dense vughy microstructure. There is no evidence of discrete aggregates.

PEDS: none; the soil material is apedal.

VOIDS: not described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features: none.

passage features:
common; vermiform; 200-500 µm; clear to diffuse; undulating to rough innervalls; high variability; moderately fragmented.

EXCREMENT PEDOFEATURES:
very dominant; ≤ 2 mm; dense internal ageing; moderately coalesced; rough; light brown; some occur as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.157
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw3
depth: 52.5-60 cm

MICROSTRUCTURE:
dense crumb structure
TYPES:
pedal structure, but nearly apedal.

PEDS:
crumbs; strongly developed; dominant; 35 % of area; mainly 50-200 µm; rough surface; unaccomodated; random distribution; very porous internal porosity.
granules; strongly developed; common; 20 % of area; mainly 200-500 µm, range 100-1000 µm; undulating; unaccomodated; dense internal porosity.

VOIDS:
total estimated porosity: approx. 45 %
inter-aggregate voids:
compound packing voids, dominant; 30 %of area; wide range of sizes; irregular; rough walls; random distribution; interconnected.
channels; frequent; 10 % of area; mainly 200-500 µm, with a wide range 200 µm - 5 mm, length 20-50 mm; undulating walls; random distribution; partially interconnected; occur with crumb infillings.
intra-aggregate voids:
vughs; few; 5 % of area; 50-100 µm; mainly in crumbs; irregular; random distribution; unconnected.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

AMORPHOUS PEDOFEATURES:
some manganese and ferroginous nodules.

FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; vermiform; 500-1000 µm; clear boundary; smooth inner-walls; distinct contrast; high variability; random distribution; weakly to moderately fragmented.

EXCREMENT PEDOFEATURES:
very few recognizable excrements; dominant; very dense internal ageing; moderately coalesced; rough; brown, some dark brown; occur as infillings.

APPENDIX C. CHEMICAL DATA

Profile: NEG 3 - FOREST

horizons:	A	Bw1	Bw2	Bw3
upper boundary, cm:	0	5	15	55
lower boundary, cm:	5	15	55	120
texture:	cl	cl	cl	cl
sand, %:	42	32	16	12
silt, %:	25	19	31	25
clay, %:	33	49	53	63
org. matter, %:	11.9	7.5	2.2	1.5
C, %:	6.9	4.3	1.3	0.9
N, %:				
C/N :				
pH-H_2O:	5.5	4.5	5.0	5.3
pH-KCl:	3.8	3.7	3.9	4.0
Δ pH :	-0.7	-0.8	-1.1	-1.3
exchangeable cations, (meq/100g):				
Ca :	1.56	0.75	0.88	1.00
Mg :	0.84	0.41	0.59	0.85
K :	0.45	0.32	0.12	0.13
Na :	*	*	*	*
Sum cations:	*	*	*	*
exchangeable acid, (meq/100g):	*	*	*	*
E-CEC (meq/100g):	*	*	*	*
CEC (pH 7)(meq/100g):	35.2	29.7	26.4	23.7
BS (sum cations), %:	*	*	*	*
BS (pH 7), %:	28	25	26	28
nutrients (µg/ml):				
P :	12.0	7.0	6.0	11.0
S :	12.2	7.0	3.0	6.0
Cu :	9.0	11.0	9.0	8.0
Zn :	5.0	4.8	4.0	3.6
Mn :	25.0	15.0	14.0	7.0

* = not determined

Profile: NEG 4 - MIXED CROPPING

horizons:	Au1	Au2	AR	Bw1	Bw2	Bw3	C
upper boundary, cm:	0	4	10	22	50	70	100
lower boundary, cm:	4	10	22	50	70	100	210
texture:	cl	cl	cl	cl	cl	cl	silo
sand, %:	23	15	15	15	11	13	32
silt, %:	24	30	26	26	26	24	51
clay, %:	53	55	59	59	63	63	17
org. matter, %:	1.7	0.9	0.4	9.5	4.6	1.5	0.9
C, %:	1.0	0.5	0.2	5.5	2.7	0.9	0.6
N, %:	0.42	0.33	0.24	0.11	0.14	0.09	0.04
C/N :	2.4	1.5	0.8	50	19	10	15
pH-H_2O:	5.1	4.7	4.5	4.6	4.8	4.7	5.0
pH-KCl:	4.5	4.3	4.4	4.7	4.9	4.9	5.2
Δ pH :	-0.6	-0.4	-0.1	0.1	0.1	0.2	0.2
exchangeable cations, (meq/100g):							
Ca :	2.94	0.94	0.41	0.65	0.58	0.32	0.14
Mg :	1.72	0.62	0.30	0.37	0.56	0.30	0.18
K :	0.31	0.19	0.12	0.11	0.26	0.18	0.29
Na :	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Sum cations:	5.04	1.82	0.89	1.20	1.47	0.87	0.68
exchangeable acid, (meq/100g):	0.45	0.95	0.60	0.30	0.25	0.25	0.15
E-CEC (meq/100g):	5.49	2.77	1.49	1.50	1.72	1.12	0.83
CEC (pH 7), (meq/100g):	26.4	23.0	20.2	16.8	15.8	14.9	14.9
BS (sum cations) %:	92	66	60	80	85	78	82
BS (pH 7), %:	19	8	4	7	9	6	5
nutrients (µg/ml):							
P :	10.7	7.3	5.1	3.0	5.1	5.1	11.1
S :	46.2	66.8	57.4	121.6	130.5	117.2	210.5
Cu :	14.2	15.9	10.6	6.1	7.5	10.4	4.6
Zn :	3.16	2.67	1.38	1.07	1.52	2.32	1.23
Mn :	94.3	77.0	44.6	21.6	24.9	15.0	6.7

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
few; vermiform; clear; rough inner walls; distinct contrast; high variability; strongly fragmented.
EXCREMENT PEDOFEATURES:
very dominant; porous internal ageing; moderately coalesced; rough; random distribution; occur as infillings; mite excrements recognizable.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.146
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: june 1987
horizon: AB
depth: 30-37.5 cm

MICROSTRUCTURE:
porous crumb to sponghy structure, closed.
TYPES: Very fine crumbs and medium and fine granules welded together into a apedal crumb mass. Compacted by biological activity.

PEDS:
crumbs; moderately developed; common, mainly 200-1000 µm, very fine; and ≥5 mm, coarse; range 200 µm-10 mm; rough mamillated; unaccomodated; dense internal porosity; the coarse crumbs are porous and subangular.
granules; strongly developed; common; mainly 1-5 mm, fine and medium; range 50 µm-5 mm; undulating; unaccomodated; random distribution; partially referred to channels; dense; the very fine granules are very dense and smooth.

VOIDS:
total estimated porosity: approx. 30 %
inter-aggregate voids:
compound packing voids; very dominant, 27% of area; irregular; rough walls; random distribution; partially interconnected.
channels; few, 2% of area; 500 µm- 5 mm; culindrical; smooth walls; random distribution; partially interconnected.
intra-aggregate voids:
vughs; very few, 1% of area; irregular; micro.
trans-aggregate voids: none.

PEDOFEATURES: not described.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.147
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: june 1987
horizon: Bw1
depth: 37.5-45 cm

MICROSTRUCTURE:
porous crumb structure

TYPES: A crumb mass, hardly pedal, mainly consisting of dominant fine and medium crumb and common very fine granules.

PEDS:
crumbs; strongly developed; dominant, mainly 1-5 mm, fine and medium; range 200 µm-10 mm; rough; unaccomodated; random distribution, smooth dense parts referred to channels; porous to dense internal porosity.
granules; strongly developed; common; mainly 200-1000 µm, very fine; range 50 µm-2 mm; rounded to subangular; undulating; unaccomodated; random distribution; microgranules clustered; very dense internal porosity.

VOIDS:
total estimated porosity: approx. 40 %
inter-aggregate voids:
compound packing voids; dominant; irregular.
vughs; very few; and channels; very few, 3-5 mm, medium; and chambers; very few, 10 mm, coarse.
intra-aggregate voids:
very few in total.
vughs; 100-200 µm, micro; and vesicles; 50-100 µm, micro; and channels; 300 µm, very fine.
trans-aggregate voids:
planar voids; ≤50 µm, micro.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
frequent; vermiform; undulating inner walls; very dense structure; distinct contrast; medium variability; strongly fragmented.
EXCREMENT PEDOFEATURES:
very dominant; dense to very dense internal ageing; moderately coalesced; rough; some occur as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.148
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: june 1987
horizon: Bw1
depth: 45-52.5 cm

MICROSTRUCTURE:
crumb mass, almost a apedal structure, closed to very closed.
TYPES: Mainly a apedal structure, only strongly developed peds are recognizable.

PEDS:
crumbs; strongly developed; dominant; mainly 1-10 mm, fine, medium and coarse; range 500 µm-10 mm; undulating to rough; unaccomodated; mainly referred to channels; high variability; porous.
granules; strongly developed; common; mainly 200-1000 µm, very fine; range 50 µm-5 mm; subrounded; smooth; unaccomodated; random distribution; very dense.

VOIDS:
total estimated porosity: approx. 45 %
inter-aggregate voids:
compound packing voids; very dominant; between crumbs and granules; irregular; partially interconnected; rough walls.
vughs; very few; irregular.
channels; very few; 2-5 mm, medium.
intra-aggregate voids:
very few in total.
vughs; 50-200 µm, micro; and channels; 200-500 µm, very fine.
trans-aggregate voids:
planar voids; 50 µm; parallel and inclined.

PEDOFEATURES:
CRYSTALLINE PEDOFEATURES:
gibbsitic features:
rare; occurence as coatings and infillings.

Other pedofeatures are not described.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.149
profile: NEG 102
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw1
depth: 52.5-60 cm

MICROSTRUCTURE:
porous crumb structure; not further described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.
FABRIC PEDOFEATURES:
brown-ish features: none.
passage features:
dominant; vermiform; diffuse; dense crumb microstructure; distinct to faint contrast; medium variability; moderately fragmented.
EXCREMENT PEDOFEATURES:
very dominant; dense internal ageing; moderately coalesced; rough; few occur as discontinuous infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

NEG 106 - PASTURE

GENERAL:
thin section number: 87.150
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Au1
depth: 0-7.5 cm

MICROSTRUCTURE:
upper part: crack structure
lower part: moderate subangular blocky
TYPES: Dominant moderate (sub)angular blocks, frequent very fine to medium granules and very few very fine crumbs.

PEDS: types with intergrades :
crumbs; strongly developed; very few; mainly 200-1000 µm, very fine; rough, unaccomodated; clustered in the lower part; porous internal porosity.
granules; strongly developed; frequent; mainly 500 µm - 5 mm, very fine to medium; subangular; undularing; unaccomodated; clustered in the lower part; dense internal porisity.
(Sub)angular blocks; dominant; moderately to strongly developed; mainly 10-20 mm, medium, with a range 5-50 mm; smooth; accomodated; random distribution; very dense internal porosity.

VOIDS:
total estimated porosity: approx. 25 %
inter-aggregate voids:
planar voids; frequent; 8 % of area, mainly 100-200 µm; separating the (sub)angular blocks; smooth; random distribution; interconnected.
intra-aggregate voids:
vughs; common, 14 % of area; mainly 50-500 µm; irregular, rough walls; random distribution; unconnected.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare, limpid clay nodules; low variability; random distribution.
AMORPHOUS PEDOFEATURES:
ferroginious mottles; orange; 2-5 mm.
FABRIC PEDOFEATURES:
bow-like features: none.
very few; usually 1-2 mm; cylindrical; claer; vughy to dense crumb microstructure; no birefrngence; faint contrast; low variability; random distribution; moderately fragmented.
passage features:
frequent; mainly 200-500 µm, with a range 200 µm - 2 mm; vermiform; diffuse; smooth innervall; very dense crumb microstructure; high variability; faint contrast; weakly fragmented.
EXCREMENT PEDOFEATURES:
frequent excrements, but not very recognizable (very few intact mite excrements, few intact earthworm excrements); dense internal aging; strongly coalesced; 50 µm - 2 mm; subrounded; rough brown, but worm excrements dark brown; interpedal; random distribution; medium variability.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.151
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Au2
depth: 7.5-15 cm

MICROSTRUCTURE:
vughy or dense crumb structure.
TYPES:
mainly fine subangular blocky
PEDS:
(Sub)angular blocks; very dominant; mainly 5-10 mm, with a range 500 µm - 15 mm; undulating; moderately developed; random distribution; partially accomodated; very dense internal porosity.
VOIDS:
total estimated porosity: approx. 20 %
inter-aggregate voids:
planes; frequent; 4 % of area; separating the (sub)angular bloks mainly 100-200 µm, with a range 50-500 µm; smooth walls; moderately orientated; perpendicular; interconnected.
intra-aggregate voids:
channels; frequent; 7 % of area; mainly 50-100 µm, with a range 50-1000 µm; smooth; random distribution; partially interconnected; occur with infillings.
vughs; dominant; 10 % of area; 200-1000 µm; irregular; rough walls; random distribution; unconnected.
vesicles & compound packing voids; very few.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare, limpid clay nodules; non laminated; intrapedal; low variability.
AMORPHOUS PEDOFEATURES:
occasional, charcoal fragments and few ferrogenious mottles.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
few; vermiform; 200-1000 µm; clear; smooth innervalls; faint contrast; high variability; weakly fragmented.
EXCREMENT PEDOFEATURES:
few intact mite excrements, no intact earthworm excrements; common; dense to very dense internal ageing; strongly coalesced; mainly 100-500 µm; rough; random distribution; intrapedal; (incorporated in soil matrix).

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL
thin section number: 87.152
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: AB
depth: 15-22,5 cm

MICROSTRUCTURE:
vughy to spongy microstructure.
TYPES:
The mainly apedal material shows a vughy to spongy microstructure. There is no evidence of discrete aggregates.

PEDS: none, the soil is apedal.

VOIDS: not described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; veriform; irregular; diffuse boundary; smooth innnervalls; faint contrast; moderately fragmented.
EXCREMENT PEDOFEATURES:
few mite excrements, no earthworm excrements recognizable; dominant ≤ 2 mm; dense internal ageing; moderately coalesced; rough; few as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.153
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: AB
depth: 22.5-30 cm

MICROSTRUCTURE:
spongy microstructure.
TYPES:
the mainly apedal material shows a spongy microstructure. There is no evidence of discrete aggregates.

PEDS: none; the soil material is apedal.

VOIDS:
total estimated porosity: approx. 20 %
inter-aggregate voids: none.
intra-aggregate voids:
vughs; very dominant; 10 % of area; mainly 200-500 µm, with a range 50-1000 µm; irregular; rough; random distribution; some larger vughs partially interconnected.
channels; very few; 1 % of area; mainly 200-500 µm, but one 25 mm channel; cylindrical; smooth; random distribution; unconnected.
chambers; very few; 1-2 mm; smooth, random distribution; interconnected with very fine channels.
planes; very few; 1 % of area; 50-100 µm; smooth; moderately orientated; radial referred to coarse channel.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES:
rare, limpid clay nodules; not laminated; intrapedal; low variability.
AMORPHOUS PEDOFEATURES:
very few ferrogenious mottles.
FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; vermiform; mainly 200-500 µm; diffuse boundary; undulating innervalls; very dense crumb microstructure; distinct to faint contrast; high variability moderately fragmented (a few intact pores).
EXCREMENT PEDOFEATURES:
very few mite excrements; common; dense internal ageing; strongly coalesced; mainly 200-500 µm; rough; yellow brown; some as loose discontinuous infillings

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.154
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bv2
depth: 30-37.5 cm

MICROSTRUCTURE:
porous, dense crumb microstructure, closed, transition to vughy microstructure. No futher description.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features: very few; hardly recognizable because of loose arrangement of aggregates; diffuse boundary; porous crumb structure; faint contrast; low variability; strongly fragmented.
passage features:
common; vermiform; 200-500 µm, with a wide range; diffuse boundary;undulating innrualls; dense crumb microstructure; no birefringence; faint contrast; medium variability;random distribution; strongly fragmented.

EXCREMENT PEDOFEATURES:

very few intact mite and earthworm excrements; very dominant; dense to very dense internal ageing; moderately coalesced; ≤ 5 mm; rough; yellow brown, earthworm excrements are dark brown; random distribution.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.155
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw2
depth: 37.5-45 cm

MICROSTRUCTURE:
spongy microstructure (open)
TYPES:
the mainly apedal material shows a spongy microstructure. Discrete aggregates are moderately to stronly recognizable.

PEDS: none; the soil material is apedal.

VOIDS:
total estimated porosity: approx. 30 %
inter-aggregate voids: none.
intra-aggregate voids:
vughs; very dominant; 30 % of area; irregular; mainly 200-500 µm, with a wide range 50-1000 µm; rough; random distribution; partially interconnected.
channels; very few; 100-200 µm; smooth; random distribution.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
dominant; veriform; 50-100 µm; diffuse boundary; rough innerwalls; dense internal microstructure; no birefringence; faint contrast; medium variability; strongly fragmented.

EXCREMENT PEDOFEATURES:
very dominant; dense internal ageing; weakly to moderately coalesced; size 100-1000 µm; rough; random distribution; no infillings occur.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.156
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw3
depth: 45-52.5 cm

MICROSTRUCTURE:
very closed crumb mass, transition to sponghy microstructure.
TYPES:
the mainly apedal material shows a very porous to dense vughy microstructure. There is no evidence of discrete aggregates.

PEDS: none; the soil material is apedal.

VOIDS: not described.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

FABRIC PEDOFEATURES:
bow-like features: none.

passage features:
common; vermiform; 200-500 µm; clear to diffuse; undulating to rough innervalls; high variability; moderately fragmented.

EXCREMENT PEDOFEATURES:
very dominant; ≤ 2 mm; dense internal ageing; moderately coalesced; rough; light brown; some occur as infillings.

DETAILED MICROMORPHOLOGICAL DESCRIPTION

GENERAL:
thin section number: 87.157
profile: NEG 106
location: Provincia de Limón, Costa Rica
date: july 1987
horizon: Bw3
depth: 52.5-60 cm

MICROSTRUCTURE:
dense crumb structure
TYPES:
pedal structure, but nearly apedal.

PEDS:
crumbs; strongly developed; dominant; 35 % of area; mainly 50-200 µm; rough surface; unaccomodated; random distribution; very porous internal porosity.
granules; strongly developed; common; 20 % of area; mainly 200-500 µm, range 100-1000 µm; undulating; unaccomodated; dense internal porosity.

VOIDS:
total estimated porosity: approx. 45 %
inter-aggregate voids:
compound packing voids, dominant; 30 %of area; wide range of sizes; irregular; rough walls; random distribution; interconnected.
channels; frequent; 10 % of area; mainly 200-500 µm, with a wide range 200 µm - 5 mm, length 20-50 mm; undulating walls; random distribution; partially interconnected; occur with crumb infillings.
intra-aggregate voids:
vughs; few; 5 % of area; 50-100 µm; mainly in crumbs; irregular; random distribution; unconnected.
trans-aggregate voids: none.

PEDOFEATURES:

TEXTURAL PEDOFEATURES: none.

AMORPHOUS PEDOFEATURES:
some manganese and ferroginous nodules.

FABRIC PEDOFEATURES:
bow-like features: none.
passage features:
common; vermiform; 500-1000 µm; clear boundary; smooth inner-walls; distinct contrast; high variability; random distribution; weakly to moderately fragmented.

EXCREMENT PEDOFEATURES:
very few recognizable excrements; dominant; very dense internal ageing; moderately coalesced; rough; brown, some dark brown; occur as infillings.

APPENDIX C. CHEMICAL DATA

Profile: NEG 3 - FOREST

horizons:	A	Bw1	Bw2	Bw3
upper boundary, cm:	0	5	15	55
lower boundary, cm:	5	15	55	120
texture:	cl	cl	cl	cl
sand, %:	42	32	16	12
silt, %:	25	19	31	25
clay, %:	33	49	53	63
org. matter, %:	11.9	7.5	2.2	1.5
C, %:	6.9	4.3	1.3	0.9
N, %:				
C/N :				
pH-H_2O:	5.5	4.5	5.0	5.3
pH-KCl:	3.8	3.7	3.9	4.0
Δ pH :	-0.7	-0.8	-1.1	-1.3
exchangeable cations, (meq/100g):				
Ca :	1.56	0.75	0.88	1.00
Mg :	0.84	0.41	0.59	0.85
K :	0.45	0.32	0.12	0.13
Na :	*	*	*	*
Sum cations:	*	*	*	*
exchangeable acid, (meq/100g):	*	*	*	*
E-CEC (meq/100g):	*	*	*	*
CEC (pH 7)(meq/100g):	35.2	29.7	26.4	23.7
BS (sum cations), %:	*	*	*	*
BS (pH 7), %:	28	25	26	28
nutrients (µg/ml):				
P :	12.0	7.0	6.0	11.0
S :	12.2	7.0	3.0	6.0
Cu :	9.0	11.0	9.0	8.0
Zn :	5.0	4.8	4.0	3.6
Mn :	25.0	15.0	14.0	7.0

* = not determined

Profile: NEG 4 - MIXED CROPPING

horizons:	Au1	Au2	AR	Bw1	Bw2	Bw3	C
upper boundary, cm:	0	4	10	22	50	70	100
lower boundary, cm:	4	10	22	50	70	100	210
texture:	cl	cl	cl	cl	cl	cl	silo
sand, %:	23	15	15	15	11	13	32
silt, %:	24	30	26	26	26	24	51
clay, %:	53	55	59	59	63	63	17
org. matter, %:	1.7	0.9	0.4	9.5	4.6	1.5	0.9
C, %:	1.0	0.5	0.2	5.5	2.7	0.9	0.6
N, %:	0.42	0.33	0.24	0.11	0.14	0.09	0.04
C/N :	2.4	1.5	0.8	50	19	10	15
pH-H_2O:	5.1	4.7	4.5	4.6	4.8	4.7	5.0
pH-KCl:	4.5	4.3	4.4	4.7	4.9	4.9	5.2
Δ pH :	-0.6	-0.4	-0.1	0.1	0.1	0.2	0.2
exchangeable cations, (meq/100g):							
Ca :	2.94	0.94	0.41	0.65	0.58	0.32	0.14
Mg :	1.72	0.62	0.30	0.37	0.56	0.30	0.18
K :	0.31	0.19	0.12	0.11	0.26	0.18	0.29
Na :	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Sum cations:	5.04	1.82	0.89	1.20	1.47	0.87	0.68
exchangeable acid, (meq/100g):	0.45	0.95	0.60	0.30	0.25	0.25	0.15
E-CEC (meq/100g):	5.49	2.77	1.49	1.50	1.72	1.12	0.83
CEC (pH 7), (meq/100g):	26.4	23.0	20.2	16.8	15.8	14.9	14.9
BS (sum cations) %:	92	66	60	80	85	78	82
BS (pH 7), %:	19	8	4	7	9	6	5
nutrients (µg/ml):							
P :	10.7	7.3	5.1	3.0	5.1	5.1	11.1
S :	46.2	66.8	57.4	121.6	130.5	117.2	210.5
Cu :	14.2	15.9	10.6	6.1	7.5	10.4	4.6
Zn :	3.16	2.67	1.38	1.07	1.52	2.32	1.23
Mn :	94.3	77.0	44.6	21.6	24.9	15.0	6.7

Profile: NEG 9 - MIXED CROPPING

horizons:	Au1	Au2	AB	Bw1	Bw2	Bw3
upper boundary, cm:	0	2	7	12	24	61
lower boundary, cm:	2	7	12	24	61	117
texture:	cl	cl	cl	cl	cl	cl
sand, %:	36	30	12	16	6	10
silt, %:	18	22	20	18	18	16
clay, %:	46	48	68	66	76	74
org. matter, %:	9.9	6.6	4.8	3.0	1.5	0.7
C, %:	5.6	3.9	2.8	1.9	0.9	0.4
N, %:	0.62	0.34	0.37	0.19	0.04	0.09
C/N :	9.0	11.5	7.6	10	23	4
pH-H_2O:	4.0	3.9	3.9	4.2	4.1	4.3
pH-KCl:	3.8	3.7	3.7	3.8	3.9	4.0
Δ pH :	-0.2	-0.2	-0.2	-0.4	-0.2	-0.3
exchangeable cations, (meq/100g):						
Ca :	2.52	1.43	0.78	0.85	0.72	0.45
Mg :	1.40	0.65	0.28	0.22	0.17	0.24
K :	0.60	0.36	0.23	0.19	0.13	0.05
Na :	0.12	0.20	0.20	0.20	0.11	0.20
Sum cations:	4.64	2.64	1.49	1.46	1.13	0.94
exchangeable acid, (meq/100g):	2.15	4.50	4.90	4.75	3.60	3.20
E-CEC (meq/100g):	6.79	7.14	6.39	6.21	4.73	4.14
CEC (pH 7)(meq/100g):	29.3	28.1	26.6	23.0	25.7	29.3
BS (sum cations), %:	68	37	23	24	24	23
BS (pH 7), %:	16	9	6	6	4	3
nutrients (µg/ml):						
P :	11.9	7.0	5.5	4.5	4.1	4.5
S :	35.8	56.4	72.5	91.4	70.6	55.3
Cu :	18.7	27.6	31.6	35.3	27.1	28.9
Zn :	7.3	11.7	15.2	13.7	5.3	7.5
Mn :	80.9	79.3	58.2	71.7	65.9	26.1

Profile: NEG 10 - MAIZE

horizons:	Au1	Au2	Au3	AB	Bw1	Bw2	BC
upper boundary, cm:	0	8	14	17	30	66	115
lower boundary, cm:	8	14	17	30	66	115	137
texture:	cl	cllo	cl	cl	cl	cl	cl
sand, %:	14	28	13	11	9	4	7
silt, %:	30	36	30	26	28	38	26
clay, %:	56	36	56	62	62	58	67
org. matter, %:	7.6	3.6	5.8	2.2	1.3	0.3	1.1
C, %:	4.4	5.7	3.4	1.3	0.8	0.2	0.9
N, %:	0.47	0.50	0.39	0.18	0.12	0.09	0.09
C/N :	9.4	11.4	8.7	7.2	7	2	10
pH-H_2O:	4.8	5.5	5.8	5.3	5.0	4.5	4.2
pH-KCl:	4.2	4.9	5.0	4.8	4.5	4.2	4.1
Δ pH :	-0.6	-0.6	-0.8	-0.5	-0.5	-0.3	-0.1
exchangeable cations, (meq/100g):							
Ca :	2.93	8.81	7.81	2.56	1.38	0.47	0.32
Mg :	2.13	4.99	3.53	1.17	0.62	0.16	0.04
K :	1.20	1.86	2.49	2.29	2.32	1.79	1.11
Na :	0.22	0.25	0.14	0.23	0.18	0.20	0.11
Sum cations:	6.48	15.91	13.91	6.25	4.50	2.62	1.58
exchangeable acid, (meq/100g):	1.20	0.30	0.20	0.20	0.45	1.90	2.10
E-CEC (meq/100g):	7.68	16.21	14.17	6.45	4.95	4.52	3.68
CEC (pH 7), (meq/100g):	23.3	36.0	30.5	22.6	20.2	23.5	24.5
BS (sum cations),%:	84	98	99	97	91	58	43
BS (pH 7), %:	28	44	46	28	22	11	6
nutrients (µg/ml):							
P :	31.0	36.4	22.6	27.4	12.7	11.9	16.8
S :	61.7	45.2	37.7	153.1	210.1	157.8	99.9
Cu :	26.3	22.7	26.4	27.6	34.3	28.2	30.9
Zn :	6.6	6.7	7.7	5.1	5.7	5.0	5.7
Mn :	79.4	60.3	42.3	19.2	21.3	17.3	15.8

Profile: NEG 102 - FOREST

horizons:	Au1	Au2	Au3	AB	Bu1	Bu2
upper boundary, cm:	0	4	9	23	35	82
lower boundary, cm:	4	9	23	35	82	103+
texture:	cl	cl	cl	cl	cl	cl
sand, %:	31	13	17	9	11	5
silt, %:	26	28	26	24	22	20
clay, %:	42	58	56	66	66	74
org. matter, %:	9.8	5.4	3.3	1.7	1.0	0.5
C, %:	5.7	3.1	1.9	1.0	0.6	0.3
N, %:	0.55	0.37	0.25	0.15	0.09	0.01
C/N :	10	8.4	7.6	6.7	7	30
pH-H_2O:	4.1	4.1	4.1	4.2	4.3	4.4
pH-KCl:	3.8	3.8	3.9	4.0	4.1	4.0
Δ pH :	-0.3	-0.3	-0.2	-0.2	-0.2	-0.4
exchangeable cations, (meq/100g):						
Ca :	2.42	0.96	0.46	0.25	0.15	0.10
Mg :	0.89	0.30	0.17	0.07	0.10	0.22
K :	0.35	0.19	0.12	0.07	0.04	0.04
Na :	0.22	0.19	0.22	0.12	0.20	0.21
Sum cations:	3.88	1.64	0.97	0.51	0.49	0.57
exchangeable acid, (meq/100g):	3.10	3.80	3.50	3.10	2.75	3.25
E-CEC (meq/100g):	6.98	5.44	4.47	3.61	3.24	3.82
CEC (pH 7)(meq/100g):	25.4	31.4	22.8	20.6	22.3	21.4
BS (sum cations), %:	56	30	22	14	15	15
BS (pH 7), %:	15	5	4	2	2	3
nutrients (µg/ml):						
P :	9.6	7.0	7.7	6.6	5.5	5.9
S :	42.2	48.2	87.2	63.9	57.4	59.5
Cu :	17.4	21.8	23.2	26.0	26.8	31.4
Zn :	2.9	2.8	3.5	4.8	4.8	12.2
Mn :	111.3	84.2	72.1	55.0	29.9	19.4

Profile: NEG 106 - PASTURE

horizons:	Au1	Au2	AB	Bw	BC
upper boundary, cm:	0	6	14	29	64
lower boundary, cm:	6	14	29	64	89+
texture:	cl	cl	cl	cl	cl
sand, %:	27	11	15	7	10
silt, %:	30	22	24	22	18
clay, %:	42	66	60	70	72
org. matter, %:	8.9	5.0	2.9	1.1	0.7
C, %:	5.1	2.9	1.7	0.6	0.4
N, %:	0.52	0.32	0.17	0.11	0.08
C/N :	9.8	9.1	10	5.5	5
pH-H_2O:	4.7	4.2	4.2	3.5	3.8
pH-KCl:	4.0	3.8	3.9	3.9	3.9
Δ pH :	-0.7	-0.4	-0.3	0.4	0.1
exchangeable cations, (meq/100g):					
Ca :	1.17	0.99	1.91	0.48	0.29
Mg :	2.45	0.52	0.33	0.22	0.08
K :	1.90	0.74	0.66	0.22	0.05
Na :	0.29	0.18	0.21	0.26	0.25
Sum cations:	5.81	2.43	3.11	1.18	0.67
exchangeable acid, (meq/100g):	1.75	4.75	4.00	3.95	4.20
E-CEC (meq/100g):	7.56	7.18	7.11	5.13	4.87
CEC (pH 7)(meq/100g):	31.9	27.6	25.0	24.7	26.6
BS (sum cations), %:	77	34	44	23	14
BS (pH 7), %:	18	9	12	5	3
nutrients (µg/ml):					
P :	18.5	7.4	4.8	4.5	5.2
S :	108.5	32.3	60.6	82.2	48.2
Cu :	22.2	25.7	23.9	22.2	23.0
Zn :	4.4	2.4	3.2	4.4	6.9
Mn :	77.8	52.8	46.9	23.1	12.9