NATIONAL SOIL REFERENCE COLLECTION
COLOMBIA

Final Report

by

W. Siderius

Directorate General for
Technical Cooperation (DGIS)
Ministry of Foreign Affairs
P.O.Box 20061
2500 EB The Hague
The Netherlands

International Soil Museum
P.O.Box 353
6700 AJ Wageningen
The Netherlands

January 1982

ISN 6605 db

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1 INTRODUCTION

A programme of cooperation for the establishment of a national soil reference collection in Colombia commenced on 16th April 1981 and was terminated on 31st of December 1981.
It was executed on behalf of the Minister for Development Cooperation in the Netherlands by the International Soil Museum (ISM) and in Colombia by the Instituto Geografico Agustin Codazzi (IGAC) in Bogota.

2 ACCOMPLISHMENTS

The goals and purpose of the programme are outlined in the original Project Document of January 1981, page 3 and 4 (DGIS, 1981).

2.1 Long term objectives

The modest collection of soil monoliths at present available at the IGAC has increased the general knowledge about Colombian soils in general and that of the Amazone region in particular. Secondly, dissemination of this knowledge may ultimately lead to a better land utilization of the Project areas concerned. Thirdly the application of the FAO/Unesco terminology and the USDA Soil Taxonomy has increased the possibility for a national and international soil correlation programme.

2.2 Immediate objectives

These were outlined in Section 2.3 of the Project Document and are reported on in detail in Section 3 of this Report.

3 ACTIVITIES

During the execution of the programme the following activities were carried out:

- Training of a Colombian soil scientist in the establishment and use of a national soil reference collection, from 6th April to 14th May 1981 at the ISM, Wageningen. The following subjects were dealt with during the training course:
  1) the collection, impregnation and ways of display of a loamy soil, a sandy soil, a clay soil and a peat soil;
  2) the preparation of an alluvial soil;
  3) lectures in soil science and soil classification;
  4) the study of the ISM facilities, viz. offices, exhibition room, workshop, laboratories, library, lecture hall, drawing room, dark room, store, materials and means for display of soil monoliths;
  5) visits to STIBOKA, Agricultural University in Wageningen, Soils Laboratory in Oosterbeek, Rijksdienst for Ijsselmeerpolders in Lelystad;
  6) preparation of the Colombian programme.
- A Dutch expert was made available by the Directorate General for Development Cooperation for the period 15th April to 31st December 1981. His activities concerned the coordination and execution of the various programme points.

During the period two visits were made to Colombia, viz. 18th June to 7th August and 25th September to 6th November 1981.

- Available soil information on the Project areas was gathered and studied in collaboration with personnel from IGAC, CIAF, CIAT, DAINCO; this led to the compilation of maps and reports of the Project areas, while personal contacts in the field ensured the proper location of the soil sampling sites.
- During five fieldtrips in Colombia a total of 18 monoliths were collected for the IGAC from the following areas:
  Villaviciencio/Puerto Lopez: 3 profiles
  San Jose del Guaviare : 4 profiles
  Araracuara : 4 profiles
  Leticia : 3 profiles
  Pasto : 4 profiles
- At the IGAC soil laboratory space was made available for 1) reception of the field samples in the basement, 2) preparation of the soil monoliths at the second floor and 3) exhibition of the soil monoliths and additional field and laboratory data of the ground floor.
- Seven soil monoliths were completed for exhibition at the beginning of November and a display was organized on the 5th November 1981.
- A total of 114 soil samples for routine analysis were taken. On the 1st November the laboratory data of profiles CO.1 to CO.14 had been received from the IGAC; in August 1981 soil samples from the profiles CO.1 to CO.6 were also submitted to the ISM laboratory to obtain comparative data.
- In addition samples were taken for the determination of the soil moisture and bulk density; for microscopic determination 41 small thin sections were prepared, while the preparation of 20 mammoth thin sections will be undertaken at the ISM.
- Colour photographs of the soil, vegetation, and land use accompany the display of soil monoliths 1-14. In addition explanatory text was prepared.

4 CONTRIBUTIONS

4.1 Netherlands contribution

Details of this aspect of the programme are outlined in Section 3.1 of the Project Document, and were met satisfactorily. The visit of a second Colombian soil scientist to the Netherlands for participation of the ISM training course is in preparation (sub. a).
Because of the extensive field programme the time for reporting in the Netherlands was extended with six weeks (sub. b).
A total of about Fl. 10,000.- was spent on materials and equipment in the Netherlands packed into the two containers which arrived safely but late in Bogota. Their contents were put to good use during the interim period and second visit. Their return in the Netherlands with a number of duplo soil monoliths taken for the ISM is expected in January 1982. During their preparation close contact will be kept with the IGAC on methods and technology.

4.2 Colombian contribution

These are presented in Section 3.2 of the Project Document and were fulfilled satisfactorily. They concern:

a) The availability of a Colombian soil scientist for training in the Netherlands from 6th April to 14th May 1981;

Fig. 1 Location map

b) The availability of working space and facilities at the soils laboratory of the IGAC viz. reception room ,workshop and exhibition room,
c) Transport facilities from Bogota to the Project areas by car and/or plane;
d) Costs for technical assistants, drivers and labourers; ;
e) Assistance with the import and export of the two containers in close cooperation with the Royal Netherlands Embassy in Bogota and the transport company Aviomar;
f) Office facilities, made available inclusive typing, map reproduction, etc.
g) Costs of analysis of the soil samples at IGAC, financed out of the current funds for the soil laboratory;
h) Local materials, purchased (wooden boxes and tools) for the collection of some soil monoliths in the field; in addition research is carried out to obtain similar lacquers and thinners in Colombia as are in use at the ISM.

5 CONCLUSIONS

The long term and immediate objectives of the programme have been met and a proper foundation has been laid for the further expansion of the national soil reference collection of Colombia.
The organization of the programme was satisfactory and provides sufficient scope and strength for the continuation of the Colombian side of the programme. The incorporation of the project activities as a yearly component on the budget of the soil laboratory of the IGAC is considered very positive and ensures the continuity of the national soil reference collection and the dissemination of the associated information.

6 RECOMMENDATIONS

The recommendations as stated in the second Mission Report were re-endorsed and elaborated. It is recommended:
1) To continue and strengthen the funding of the "Museo Edafologico";
2) To expand the activities to other areas in the country;
3) To consolidate the staffing of the "Museo" and to procure at least one technician for the collection, preparation and display of the soil monoliths;
4) To liaise with other institutions in Colombia concerning the collection of soil monoliths in other parts of the country (viz. IGAC, ORSTOM, CIAF, CIAT, DAINCO, Royal Netherlands Embassy, etc.).
5) To disseminate the available soil information to as many people as possible by means of reports, displays, visits and regional subcollections;
6) To organize a permanent, open exhibition of soil monoliths at the Soils Laboratory of IGAC;
7) To promote the awareness and study of important differences in soil conditions among farmers, agriculturalists, planners, politicians, students, etc.

7 ACKNOWLEDGEMENTS

During the execution of the Programme the valuable assistance of staff from the Royal Netherlands Embassy in Bogota, the International Soil Museum (ISM) and the Directorate General for Technical Cooperation (DGIS) is greatly

appreciated. In addition much appreciation is due to personnel of the Instituto Geografico Agustin Codazzi (IGAC), the Centro Interamericano de Fotointerpretacion (CIAF) and the Departamento Administrativo de Intendencias y Comisarias (DAINCO) inclusive of the Corporacion Araracuara.

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APPENDIX 1
Characterization of the Project areas

The areas are dealt with according to geographical order and not chronologically, viz. Villaviciencio/Puerto Lopez, San Jose del Guaviare, Araracuara, Leticia and Pasto (see Figure 1).
For each area the following parameters are discussed shortly: climate, physiography, geology, vegetation, land use and land evaluation. Subsequently the soil profile description and analytical data for each area are presented.

1A Villaviciencio/Puerto Lopez area (Llanos)

Climate

The climate of the area is characterized by a long wet season and a short but very pronounced dry season (December-January-February).
It is classified as savanna climate (Aw) according to Köppen-Geiger (1954) and as semi-hot equatorial by Papadakis (1961), quoted by Goosen (1972).
The data of La Libertad apply to CO.1, while those of Puerto Lopez concern CO.2 and CO.3.
Rainfall and evaporation of the Western Llanos are illustrated in Figure 2 and Table 1 for three stations.

Table 1. Rainfall and evaporation in the western Llanos

Month	Villavi-ciencio	La Liber-tad	Puerto Lopez	Villavi-ciencio	La Liber-tad	Puerto Lopez
	rainfall in mm			evaporation in mm		
Jan.	58,0	25,6	29,0	197,0	158,6	155,5
Feb.	99,5	60,2	24,8	156,2	161,6	164,2
March	163,8	122,0	154,7	157,6	160,5	165,6
April	449,8	299,0	317,7	128,2	133,4	126,0
May	463,0	377,3	360,4	124,2	127,7	129,4
June	599,0	375,2	416,8	114,9	120,1	117,4
July	542,4	309,1	347,3	111,9	115,9	107,3
Aug.	319,6	249,2	322,3	123,4	121,5	120,3
Sept.	228,2	229,6	277,5	121,8	122,6	123,7
Oct.	256,1	230,9	268,4	129,0	121,8	125,9
Nov.	200,3	134,6	142,7	127,3	129,6	129,2
Dec.	110,0	65,5	66,3	134,9	138,8	137,5
Year	3078,7	2478,4	2727,9	1586,4	1612,1	1602,0
Period	1968-1977	1945-1978		1972-1977		
altitude	423	336		182		

Source: HIMAT, 1981

The rainfall contribution is similar in the area, however the intensity varies from West to East. The length of the dry season is more pronounced going eastwards. According to Goosen (1972), months with less than 50 mm rainfall are considered "dry months".

Fig. 2a Climatic graph Villaviciencio

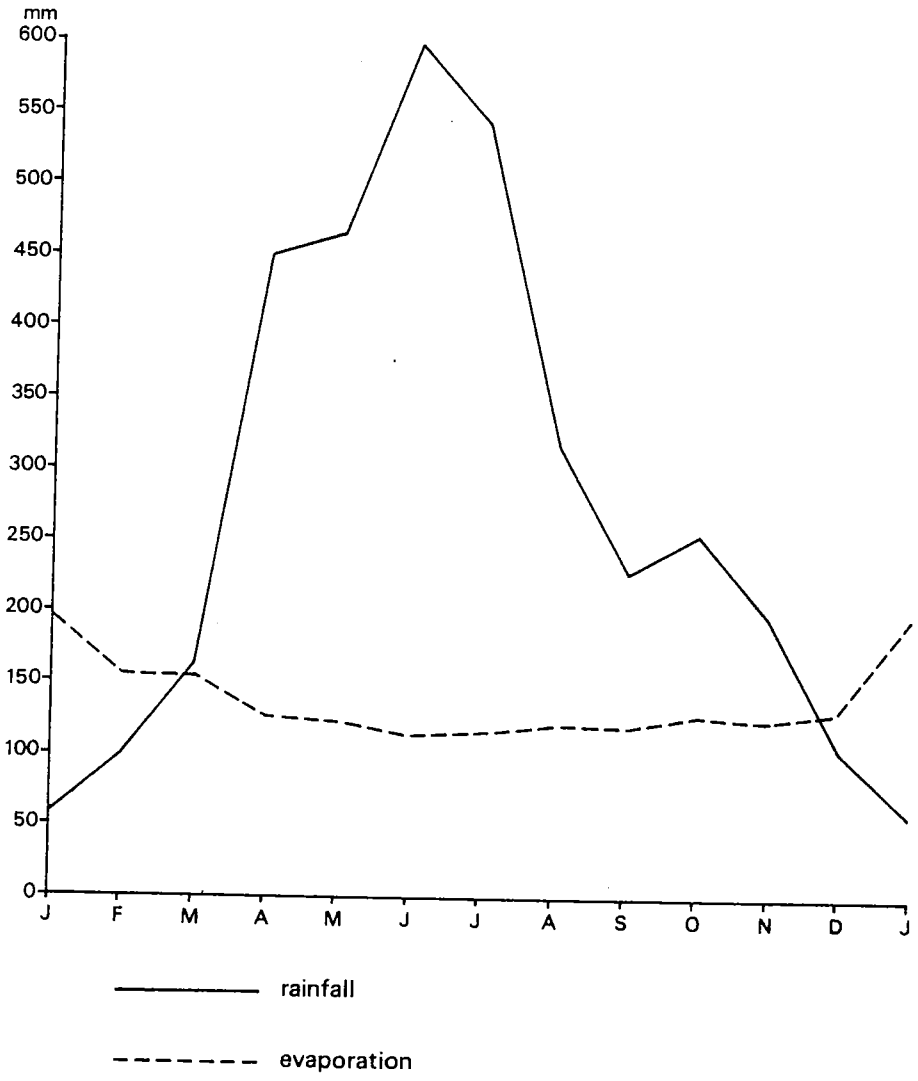


Fig. 2b Climatic graph La Libertad

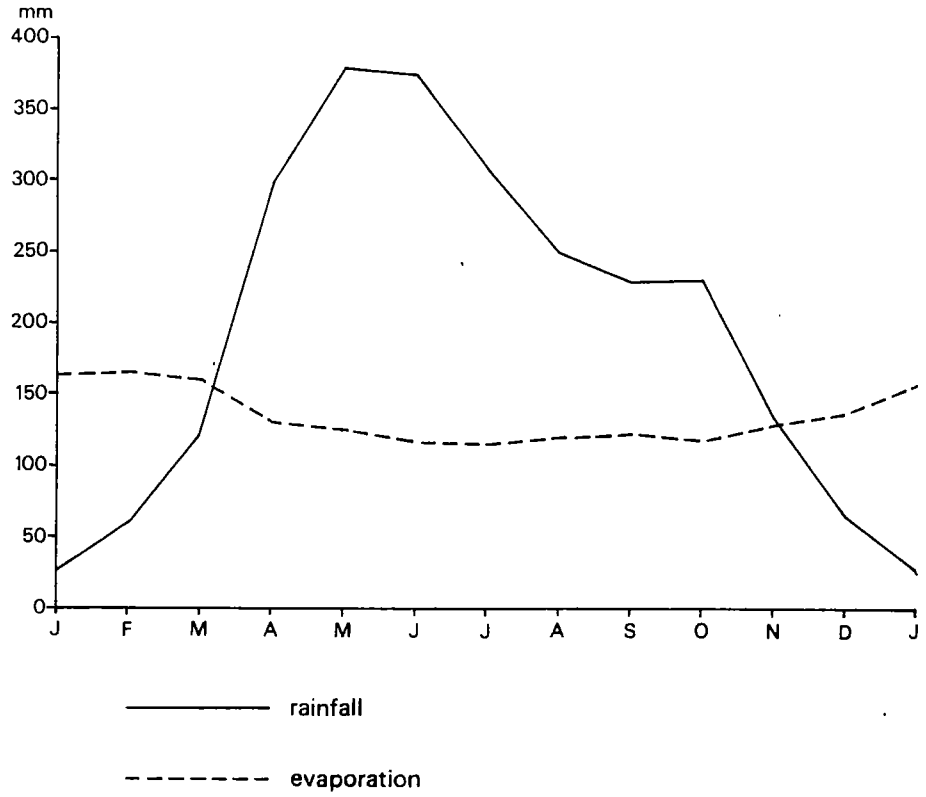
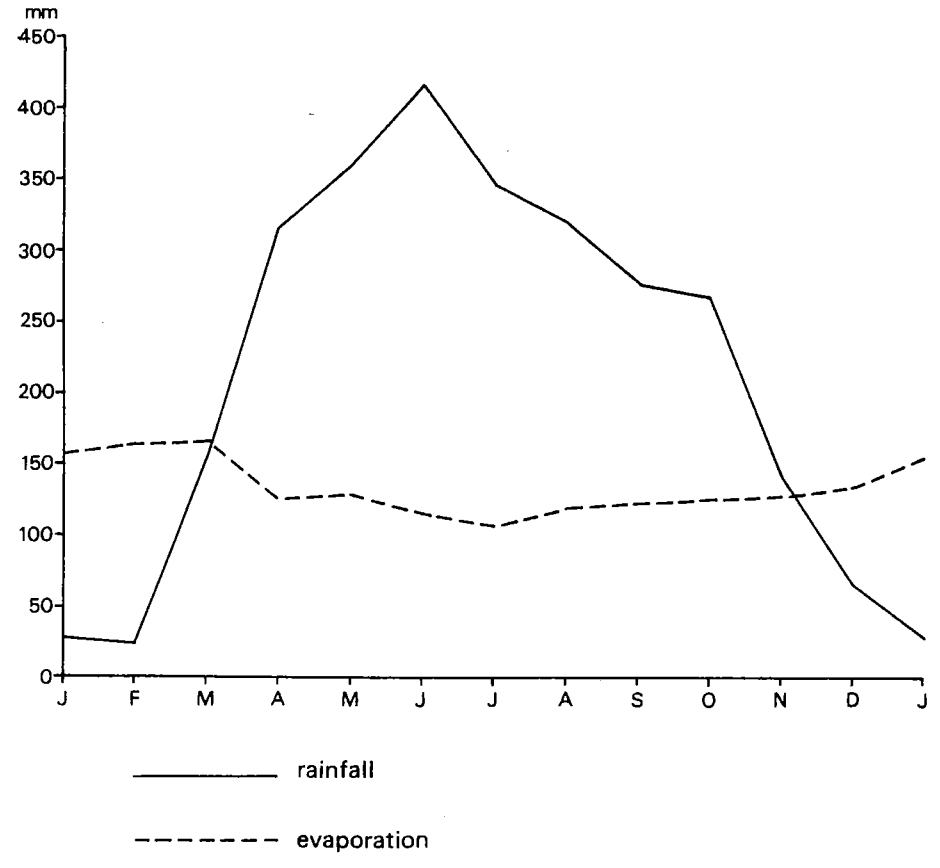


Fig. 2c Climatic graph Puerto Lopez



The mean annual air temperature at Villaviciencio varies between 24.3°C and 26.8°C respectively in July and January. Variations between the daily maximum and minimum tend to be larger than fluctuations in the mean annual temperature.
The relative humidity in Villaviciencio has a yearly mean of 75% and attains its maximum in July (81%) and minimum in January (68%). Similar values correlate with the wet and the dry seasons occur in the eastern part.
In terms of the Soil Taxonomy (1975) the soil moisture regime of the area is classified as *ustic*, although it approaches *udic* in the area associated with the eastern Cordillera (CO.1). The ustic moisture regime implies sufficient moisture present at a time when conditions are suitable for plant growth as the mean annual soil temperature is considered to be 22°C or higher and mean annual soil temperature at 50 cm depth differ by less than 5°C, the soil moisture control section (0-30 cm) is dry in some or all parts for 90 or more cumulative days in most years. The soil temperature regime is classified as isohyperthermic meaning the mean annual soil temperature is 22°C or higher and the difference between mean summer and mean winter soil temperature is less than 5°C.

Physiography

The physiography of the three sites is described as follows: CO.1 structural terraces, CO.2 level well drained high plains and CO.3 dissected high plains. Details are presented in the following Table.

Table 2. Physiographic parameters of sites CO.1, CO.2 and CO.3

Physiography	CO.1	CO.2	CO.3
altitude	336	200	180
slope	1%	2%	15%
local relief	none	0-20 cm	10-20 cm
land form	structural terrace	level well drained high plains	dissected high plains
erosion	none	none	none to severe
age	Holocene	Late Pleistocene to early Holocene	Early to middle Pleistocene, locally Late Tertiairy

Geology

Sedimentary rocks from the late Tertiairy to Holocene era constitute the parent material for the soils and underlay the area. The sediments tend to become finer going eastwards. The main source is the Andean region where erosion of the various mountain ranges proved a continuous supply of sediments. Some of these did undergo previous erosion cycles, thus causing an impoverishment of the material.

In the Holocene the admixture of volcanic ash with the soil material may not be excluded (Elbersen, 1982). It can still be detected by the presence of volcanic grass (or other allochthone minerals) in the sand fraction. Upon weathering it may cause an increase of the CEC by the formation of amorphous compounds or the formation of vermiculite type clay minerals (see also Goosen, 1972).

Vegetation

On all site a grass vegetation is encountered. On the piedmont and associated terraces (CO.1) the savanna vegetation is characterized by *Melinis minuti flora* which at the site has been cleared. On the well drained parts of the high plains (CO.2) an association of *Trachypogon vessitus* and *Paspalum pectinatum* is typical, while the dissected high plains carry mainly *Paspalum pectinatum* savanna (Goosen, 1972).

Land use

At all sites grazing is the dominant land utilization type. However at CO.1 the original grass cover has been renoved and reseeded with "Kikuyu" grass. Upon these conditions of improved grass management two (2) head of cattle per one hectare up to 4 s.u./ha. is achieved. Under natural conditions and low input extensive grazing supports 1 stock when for every 4-10 ha. In the dissected high plains this acreage may be up to 20 ha per 1 s.u.

Land evaluation

According to the soil derived land qualities as outlined by the ISM (1981) the evaluation of the soils is given in Table 3. Key on page 55.

Table 3. Rating of soil derived land qualities of profiles CO.1 - CO.3

Soil derived land quality	CO.1	CO.2	CO.3	Remarks
moisture	2	2	3	Soil chemical factors pose
oxygen	1	1	2	the most serious limitations.
flooding	1	1	1	If no vegetation is present
nutrients	5	5	5	puddling of the topsoil may
toxicity	1	1	1	lead to erosion by decreasing
stability	3	3	4	permeability of the surface
arability	1	2	4	horizons
tilth	2	2	3	
foothold	1	1	4	

CO.1 poses serious estimations concerning the extremely low base saturation and moderate to low stability. The very low status of exchangeable nutrients is partly offset by the favourable %C in the top 50 cm. However for sustained agricultural production high inputs are necessary viz. liming and P and K fertilizers.
The present condition warrants the production of beef cattle, which under improved grass management can be held at 4 s.u. per ha.

The suitability of CO.2 for agricultural production is similar to CO.1 However in the former the %C is less and also limited in depth to the topsoil. In addition structural development is not as strong in the top and the subsoil. The carrying capacity of the soil could be improved upon by introducing better range management.
Under present extensive pasturism the s.u. density is low, about 10-20 ha for one animal.

The soil at site CO.3 has a number of limiting soil derived land qualities. The most important ones are: 1) occurrence of gravel in the topsoil (45%), 2) extremely low CEC and base saturation, 3) unfavourable stability, 4) limited arability.
This renders the soil not suitable for cultivation. It is used for extensive range, but poses serious liability to drought in the dry season because of limited moisture storage capacity.

Soil Profile Description CO. 01 (x)

Date	: 1 july 1981
Location	: 28 km East of Villavicencio on the road to Port Lopez, in a field opposite the HIMAT station Libertad
Physiography	: slightly undulating, in places dissected, piedmont
Altitude	: 325 m
Geology	: Quaternary sedimentary rocks
Parent material	: colluvium derived from weathered grès arenisca
Vegetation/Land use	: the original vegetation has been cleared and replaced by grasses/Land use is exclusively for grazing, density 1 s.u. per 3/4 ha; the land capability class is IV, because of very low soil fertility level
Soil climate	: SMR is ustic, STR is hyperthermic (iso)
Ecological zone	: Dh-T, bosque húmedo tropical
Drainage	: well drained
Moisture conditions	: moist throughout

Soil Field Description

Horizon	Depth cm	Description
Ap	0- 24	Dark brown (7.5 YR 3/2) moist, clay loam; weak fine subangular blocky to granular; slightly hard dry, friable moist, slightly sticky and plastic wet; common fine pores; common fine and medium roots; few fecal pellets; pH 6,0; gradual smooth boundary to
AB	24- 27	Dark brown (7.5 YR 3/4) moist, clay; weak to moderate fine subangular blocky; slightly hard dry, friable moist, slightly sticky and plastic wet; common fine pores; common fine and medium roots; few krotovina and fecal pellets; pH 5,5; gradual smooth boundary to
Bt1	47-74	Brown (7.5 YR 4/4) moist, clay; moderate to strong fine to medium angular blocky; slightly hard dry, friable moist, slightly sticky and plastic wet; few thin cutans; few fine pores; few fine roots; few small krotovina (Ø 5 cm); pH 5,0; diffuse smooth boundary to
Bt2	74-100	strong brown (7.5 YR 5/6) moist, clay; moderate to strong fine angular blocky; slightly hard dry, friable moist, slightly sticky and plastic wet; few to common thin cutans; few fine pores; few fine roots; pH 4,8; diffuse smooth boundary to
BC	100-150	Yellowish red (5 YR 5/8) moist, clay; moderate to strong fine angular blocky; slightly hard dry, friable moist, slightly sticky and plastic wet; few to common thin cutans; few fine pores; very few fine roots; few small krotovina (Ø 5 cm); pH 6,0
BC	150-180	by auger; as above
C	180+	strongly mottled yellowish red (5 YR 5/8), dark yellowish brown (10 YR 4/6) and red (2.5 YR 4/8) weathered grès

Remarks: The soil has a "nitic" appearance below 100 cm depth; the soil T at 50 cm depth is 31°C, the air T is 25°C.

(x) profile descriptions according to FAO,1977
colour notation according to Munsell,1971
vegetation according to IGAC,1977 and PRORADAM,1979
land capability according to IGAC,1978

Table 4. Laboratory data of CO.1 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	%
		sand	silt	clay	gravel	1:1	moisture
Ap	0- 24	56	22	22		4.2	1.0
AB	24- 47	48	26	26		4.1	2.0
Bt1	47- 74	40	20	40		3.9	1.0
Bt2	74-100	36	18	46		4.0	1.0
BC	100-150	36	18	46		3.9	1.0

Depth cm	Exchangeable cations (me/100g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 24	0.2	0.2	0.1	0.1	0.6	14.1	4.3	64.1
24- 47	0.2	0.2	0.1	0.1	0.6	13.5	4.4	51.9
47- 74	0.2	0.2	0.1	0.1	0.6	9.7	6.2	24.3
74-100	0.2	0.2	0.1	0.1	0.6	8.7	6.9	18.9
100-150	0.2	0.2	0.1	0.1	0.6	8.5	7.1	18.5

Depth cm	Organic matter			P	Exchangeable me/100g			Cation saturation			
	%C	%N	C/N	ppm	Al	H	total	Ca	Mg	K	Na
0- 24	2.49	0.14	18	2	2.4	0.4	2.8	1.4	1.4	0.7	0.7
24- 47	1.70	0.09	19	1	2.4	0.5	2.9	1.5	1.5	0.7	0.7
47- 74	0.88	0.06	15	1	2.1	0.3	2.4	2.1	2.1	1.0	1.0
74-100	0.68	0.05	14	1	1.9	0.3	2.2	2.3	2.3	1.1	1.1
100-150	0.27	0.05	5	1	1.8	0.3	2.1	2.4	2.4	1.2	1.2

Table 5. Laboratory data of CO.1 (by ISM)

Horizon	Depth cm	Texture (µm in weight %)							
		sand					silt		clay
		2000-1000	1000-500	500-250	250-100	100-50	50-20	20-2	<2
Ap	0- 24	0.0	4.3	12.8	18.3	7.0	6.5	9.0	42.1
AB	24- 47	0.5	4.1	12.4	17.3	7.7	8.9	15.0	34.0
Bt1	47- 74	0.7	3.3	10.4	16.1	7.4	6.7	9.4	46.1
Bt2	74-100	0.8	3.5	9.9	15.3	7.7	8.1	7.1	47.5
BC	100-150	0.6	3.5	9.3	14.1	7.7	8.3	8.4	48.1

Depth cm	Exchangeable cations (me/100g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 24	0	0.1	0.2	0.3	0.6	14.8	4.1	11.5
24- 47	0	0	0.1	0.3	0.4	13.2	3.0	18.8
47- 74	0	0	0.1	0.2	0.3	10.6	1.9	15.4
74-100	0	0	0	0.1	0.1	9.7	1.0	14.5
100-150	0	0	0	0.1	0.1	9.6	1.0	17.8

Depth cm	clay minerals			non clay minerals				
	Kaol	Chl/Verm	P.Phyll	Quar	Feld	Gibb	Goeth	Hem
0- 24	+++	+	tr		tr		x	
24- 47	+++	+	tr		tr		x	
47- 74	+++	+	tr		tr		x	
74-100	+++	+	tr		tr		x	
100-150	+++	+	tr		tr		x	

key clay minerals
+ minor (<10%)
++ subordinate (10-40%)
+++ dominant (>50%)
tr trace

key non clay minerals
x minor (<10%)
xx subordinate (10-20%)
xxx dominant (>20%)
tr trace

Soil Profile Description CO. 02

Date	: 4 July 1981
Location	: 17 km NE of Porto Lopez on the road to Porto Gaitan; 300 m West in a meadow
Physiography	: non-dissected sedimentary plain
Altitude	: 225 m
Geology	: sedimentary rocks of Plio-Pleistocene age
Parent material	: grès
Vegetation/Land Use	: various grasses (100% cover); land is exclusively for grazing, 1 s.u. for every 25 ha; land capability class IV
Soil climate	: SMR is ustic, STR is hyperthermic (iso)
Ecological zone	: DhT, bosque hûmedo tropical
Drainage	: well drained
Moisture conditions	: moist throughout

Soil Field Description

Horizon	Depth cm	Description
Ap	0- 12	Dark brown (7.5 YR 3/4) moist, brown (7.5 YR 4/2) dry, clay; weak fine to medium subangular blocky; slightly hard dry, friable moist, slightly sticky and plastic wet; common fine and medium pores; common fine and medium roots; pH 5,0; gradual smooth boundary to
AB	12- 32	Brown (7.5 YR 4/4), moist clay; weak fine to medium subangular blocky structure; hard dry, friable moist, slightly sticky and plastic wet; common fine and medium pores; few fine and medium roots; pH 4,5; diffuse smooth boundary to
Bw1	32- 61	Yellowish red (5 YR 4/6) moist, clay; weak to moderate fine angular blocky; hard dry, friable moist, slightly sticky and plastic wet; very few thin cutans; common fine pores; few fine roots; few small krotovina's (Ø 5 cm); pH 5,0; diffuse smooth boundary to
Bw2	61-100	Yellowish red (5 YR 5/8) moist, clay; weak fine angular blocky; consistence, cutans, pores and roots as Bs1; common fecal pellets; pH 5,0; diffuse smooth boundary to
Bws	100-170	Yellowish red (5 YR 5/8) moist, with few fine faint reddish yellow (7.5 YR 6/8) mottles; clay; weak fine (sub)angular blocky structure; hard dry, friable moist, slightly sticky and plastic wet; few fine soft lithorelicts;
BC	170-250	by auger; red (2.5 YR 4/6) moist, clay; common soft lithorelicts of various colours.

Remarks: the soil material may have been influenced by loess and/or volcanic ash.

Table 6. Laboratory data of CO.2 (by ISM)

Horizon	Depth cm	Texture (µm in weight %)							
		sand					silt		clay
		2000-1000	1000-500	500-250	250-100	100-50	50-20	20-2	<2
Ap	0- 12	0.1	0.9	4.2	5.0	3.2	13.3	10.0	63.4
AB	12- 32	0.1	1.1	4.4	5.7	3.8	15.3	9.9	59.8
Bw1	32- 61	0.1	1.2	4.9	5.0	3.0	13.6	10.4	61.8
Bw2	61-100	0.1	1.1	5.3	5.8	3.4	14.4	10.8	59.2
Bws	100-170	0.1	1.3	6.2	6.7	3.3	16.8	11.0	54.5
BC	170-250	0.1	0.5	3.2	5.0	3.1	11.7	7.8	67.6

Depth cm	Exchangeable cations (me/100g)					CEC soil	CEC clay	Base sat.%
	Ca	Mg	K	Na	sum			
0- 12	0	0	0	0	0	9.2	14.5	0
12- 32	0	0	0	0.1	0.1	9.2	15.4	1.1
32- 61	0	0	0	0	0	10.8	17.5	0
61-100	0	0	0	0	0	13.1	22.1	0
100-170	1.7	0	0.1	0	1.8	15.2	27.9	1.2
170-250	0	0	0	0.2	0.2	8.5	12.6	4.0

Depth cm	clay minerals			non clay minerals				
	Kaol	Chl/Verm	P.Phyll	Quar	Feld	Gibb	Goeth	Hem
0- 12	+++	+	tr - +		tr		x	
12- 32	+++	+	tr - +		tr		x	
32- 61	+++	+	tr - +		tr		x	
61-100	+++	+	tr - +		tr		x	
100-170	+++	+	tr - +		tr		x	
170-250	+++	+	tr - +		tr		x	

Soil Field Description CO. 03

Date	: 4 July 1981
Location	: 16 km E of Porto Lopez
Altitude	: 250 m
Physiography	: strongly dissected sedimentary plain
Geology	: sedimentary rocks of Plio-Pleistocene age
Parent material	: clayey sediments of fluvio-lacustrite origin
Vegetation/Land Use	: grasses, dominantly Quantara and Hydropogon/extensive range, land capability class IV
Soil climate	: SMR is ustic, STR is hyperthermic (iso)
Ecological zone	: Dh-T, bosque húmedo tropical
Drainage	: moderately well drained
Moisture conditions	: moist throughout

Soil Field Description

Horizon	Depth cm	Description
Ap	0- 16	Brown (7.5 YR 4/4) moist, slightly gravely sandy loam; very weak medium subangular blocky; slightly hard dry, friable moist, slightly sticky and slightly plastic wet; common fine pores common fine and meduim roots; few small soft concretions; pH 5,0; clear wavy boundary to
Bt1	16- 40	Yellowish red (5 YR 5/8) moist, with few to common, fine to medium sharp brownish yellow (10 YR 6/8) and dark red (10 R 3/6) mottles; slightly gravely sandy clay; massive; hard dry, friable moist, slightly sticky and very plastic wet; few fine pores; few fine roots; few medium soft concretions; pH 4,5; clear wavy boundary to
Bt2	40- 60	Yellowish red (5 YR 5/8) moist, with few to common, fine to large, sharp reddish yellow (7.5 YR 6/8) and dark red (10 R 3/6) mottles; slightly gravely clay; massive; hard dry, friable moist, sticky and very plastic wet; common medium soft concretions; pH 4,5; gradual wavy boundary to
BCs	60- 90	Red (10 R 5/6); with abundant medium and large, sharp dark red (10 R3/6) and reddish yellow (7.5 YR 6/8) mottles; clay; massive; hard dry, friable moist, sticky and very plastic wet; pH 4,0; diffuse wavy boundary to
C	90-150	Strongly mottled red (10 R 4/6 and 10 R 5/6), grey (10 YR 7/2) and brownish yellow (10 YR 6/8) clay; massive; very hard dry, friable moist, very sticky and very plastic wet; pH 5,0

Remark: the mottling is for the larger part due to weathering of the parent material, e.g. lithogenic mottles .

Table 7. Laboratory data of CO.3 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	%
		sand	silt	clay	gravel	1:1	moisture
Ap	0- 16	54	32	14	45	4.0	1.0
Bt1	16- 40	46	34	20		4.0	1.0
Bt2	40- 60	40	38	22	28	4.0	1.0
BCs	60- 90	24	44	32		3.9	1.0
C	90-150	24	46	30		4.0	1.0

Depth cm	Exchangeable cations (me/100g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 16	0.2	0.2	0.1	0.1	0.6	4.8	12.5	34.3
16- 40	0.2	0.2	0.1	0.1	0.6	3.2	18.8	16.0
40- 60	0.2	0.2	0.1	0.1	0.6	4.8	12.5	21.8
60- 90	0.2	0.2	0.1	0.1	0.6	4.0	15.0	12.5
90-150	0.2	0.2	0.1	0.1	0.6	5.3	11.3	17.7

Depth cm	Organic matter			P	Exchangeable me/100g			Cation saturation			
	%C	%N	C/N	ppm	Al	H	total	Ca	Mg	K	Na
0- 16	1.21	0.07	17	1	0.9	0.3	1.2	4.2	4.2	2.1	2.1
16- 40	0.40	0.03	13	1	0.8	0.5	1.3	6.3	6.3	3.1	3.1
40- 60	0.40	0.02	20	1	0.8	0.4	1.2	4.2	4.2	2.1	2.1
60- 90	0.33	0.02	17	1	1.3	0.3	1.6	5.0	5.0	2.5	2.5
90-150	0.33	0.02	17	1	1.4	0.4	1.8	3.8	3.8	1.9	1.9

Table 8. Laboratory data of CO.3 (by ISM)

Horizon	Depth cm	Texture (μm in weight %)							
		sand					silt		clay
		2000-1000	1000-500	500-250	250-100	100-50	50-20	20-2	<2
Ap	0- 16	6.9	3.9	9.5	25.6	13.7	17.9	9.0	13.5
Bt1	16- 40	2.0	2.4	9.1	23.8	12.8	20.5	11.6	18.0
Bt2	40- 60	3.0	4.0	10.0	19.2	10.3	16.2	18.1	19.3
BCs	60- 90	0.7	2.2	4.7	8.8	11.5	22.8	21.4	28.1
C	90-150	0.7	1.1	2.2	4.2	10.6	26.3	27.2	27.7

Depth cm	Exchangeable cations (me/100g)					CEC	CEC	Base
	Ca	Mg	K	Na	sum	soil	clay	sat.%
0- 16	0	0	0	0	0	4.5	33.3	0
16- 40	1.0	0	0	0.1	1.1	2.7	15.0	4.1
40- 60	3.6	0	0	0	3.6	3.3	17.1	10.9
60- 90	0	0	0	0.1	0.1	3.7	13.2	2.7
90-150	0	0	0	0	0	3.8	13.7	0

Depth cm	clay minerals				non clay minerals				
	Kaol	Verm	Chl/Verm	Il/verm	Quar	Feld	Gibb	Goeth	Hem
0- 16	+++	-	+	-				x	
16- 40	+++	-	+ - ++	-				x	
40- 60	+++	-	+ - ++	-				x	
60- 90	+++	+	+	-				x	
90-150	+++	-	-	+				x	

IB San Jose area (transitional Llanos to Amazonia)

Climate

The climate in the San Jose area is transitional between that of the North-eastern Llanos and the Amazonia. The pronounced dry season from December to March is only partly offset by the abundance of precipitation in the remaining part of the year. A maximum of rainfall occurs during July.
Evaporation follows closely the rainfall regime with a maximum from January to March and a minimum during July and June (see Figure 3).
The mean annual temperature is 25.6°C with a maximum in February and a minimum in July.
In terms of the USDA Soil Taxonomy (1975) the soil moisture regime is ustic, as the soil moisture control section is considered to dry out in some or all parts for 90 or more cumulative days in most years.
The soil temperature regime is isohyperthermic, e.g. the mean annual soil temperature is 22°C or higher, where the difference between the mean summer and winter soil temperature at 50 cm depth differ by less than 5°C. Climatic parameters are presented in Table 9 and cover an eight year period (1968-1975).
Evaporation data for the year 1980 (HIMAT, 1981) show an increase of 63 mm as compared to the eight year mean.
The relative humidity is high throughout the year, while an average of 5 hours sunshine/day are recorded (1700 hrs annually).

Table 9. Climatic data for San Jose del Guaviare (1968-1975)

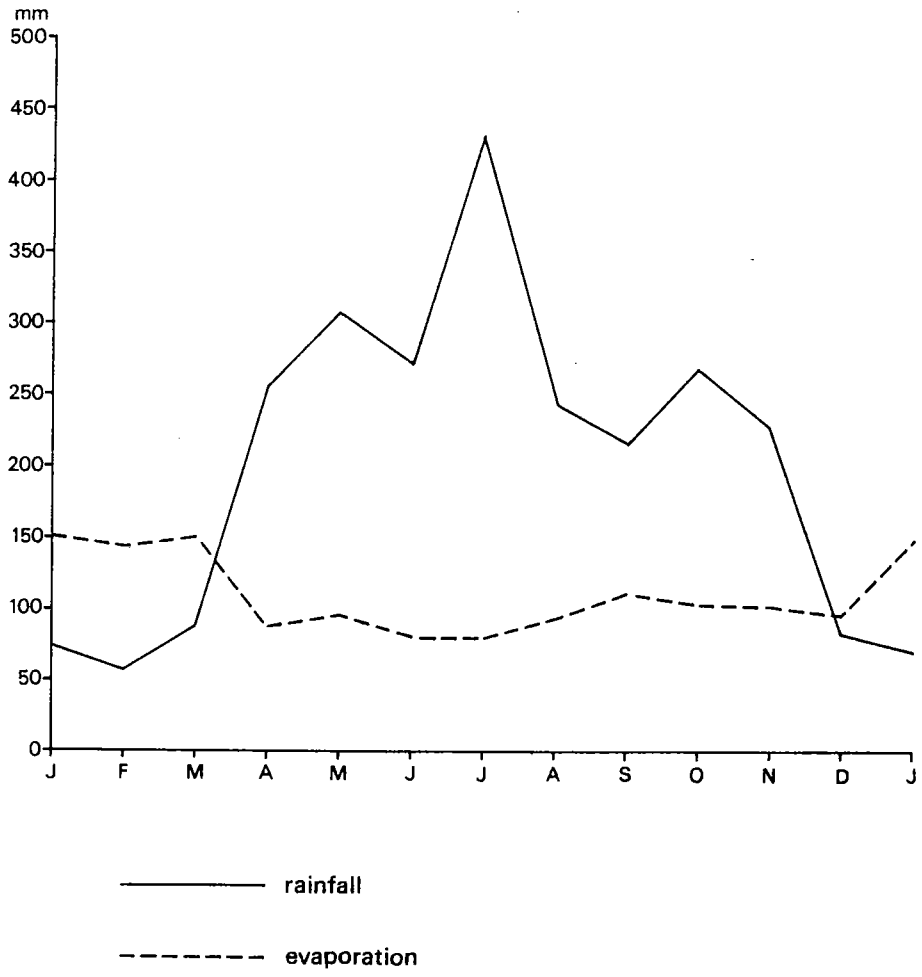
elevation 260 m Month	Rainfall mm	Evaporation mm	Temperature °C	rel. humidity %
Jan	73.4	150.1	26.5	77
Feb	55.7	145.1	28.2	65
Mar	87.5	151.0	27.1	76
Apr	257.8	90.2	25.2	78
May	303.9	98,5	24.8	88
June	272.0	82.3	24.5	89
July	431.5	82.5	23.8	88
Aug	243.6	95.0	24.6	87
Sep	217.2	113.1	25.5	85
Oct	269.0	104.7	25.3	88
Nov	225.9	102.2	25.9	85
Dec	82.5	99.3	25.2	86
Year	2520.0	1314.0	25.6	83

Source: M.M. Gutiérrez (1980)

Physiography

The area south of the Guaviare river is physiographically divided into 1) the alluvial plain del Guaviare (CO.17), 2) the denudation surfaces (CO. 15, 16, 18) and 3) structural forms (IGAC, in preparation).
Relief differences in the alluvial plain are between 10-20 m and slopes are usually between 0-3%.

Fig. 3 Climatic graph San Jose del Guaviare



A special feature is the occurrence of a stone - or gravel - line. Initially parallel to the weathering rock surface, but on slopes it comforms to the topography. Gravel tends to be encountered higher in the soil profile at higher elevation.
Relief in the denudational plain is more pronounced upto 50 m, with slopes ranging from 0% to more than 15%.

Geology

The alluvial plain consists of holocene to recent loamy to clayey non consolidated sediments.
Those areas subject to annual flooding experience continued sedimentation, which depending on river load and stream velocity, usually causes banded sediments. The materials are derived from weathering rocks of the Andes as well as from eroded lands bordering the Guaviare river upstreams and along its banks.

Sediments of the denudational plain are of Paleocene-Oligocene age. They may be of fluviatile-deltaic source and consists of non- to partly consolidated conglomerates, sands and clays.
This material has gone through at least two erosion cycles and is not considered rich in plant nutrients.

Vegetation

The original wet tropical rain forest vegetation has been cleared in many areas to make way for shifting cultivation or recently, (semi) permanent pasture. New crops and trees are presently introduced to counteract erosion on cleared land.

Land use

At the alluvial plain a variety of crops are grown, but livestock is being raised also. Crops include rice and maize, respectively on poorer and better drained sites. At the site of the experimental farm "El Granja", monocultures, intercropping and agroforestry are tried out.
Main crops include yuca, peanuts, and maize. Cacao is introduced in partly cleared forest areas to study the effect of sombrage and soil type.

Land evaluation

Four soils were described and sampled but no laboratory results are as yet available(Profiles CO 15,16,17 and 18).
However four individual soil samples (no's 1-4) were collected previously and analysis results thereof are presented in the following Table.

Table 10. Site and soil characteristics of some soil samples at El Granja

Sample	1	2	3	4
depth in cm	0-20	0-20	0-20	20-40
surface area	0.5 ha	0.5 ha		
elevation	200 m	200 m	± 180 m	± 180 m
drainage	well	well	well	well
topography	undulating	undulating	sl.undulating	sl.undulating
land use	maize	maize	cacao	cacao

Note: Sites 1 and 2 may be compared with CO.16
Sites 3 and 4 may be compared with CO.18

Table 11. Soil characteristics of some soil samples at El Granja

				meq/100g soil							
Sample	Text.	pH	%C	Pppm	Al	Ca	Mg	K	Na	CEC	ECc
1	SCl	4.4	2.8	3.0	6.5	1.7	0.43	0.15	0.19	8.9	0.53
2	SCl	4.6	3.1	3.0	6.1	1.9	0.72	0.32	0.23	9.3	0.50
3	Sl	4.6	3.2	0.90	1.7	1.6	0.35	0.14	0.03	3.8	-
4	Sl	4.7	2.1	0.50	3.2	0.4	0.38	0.08	0.03	4.1	-

The data indicate particularly the low pH, very low base status and high exchangeable aluminium.
The percent organic carbon is relatively high in the topsoil. Nevertheless for sustained optimum fields the application of fertilizer is a necessity. The following recommendations were made for maize: 150-200 kg/ha (10-30-10) with 50 kg/ha of well crushed gypsum.

In terms of soil derived land qualities the following preliminary rating may be applied (Table 12). Key on page 55.

Table 12. Preliminary rating of soil derived land qualities of some soil samples at El Granja (ISM method) ,no 1-4.

Land quality	1	2	3	4
moisture	3	3	3	3
oxygen	1	1	1	1
flooding	1	1	1	1
nutrients	3/4	3/4	3/4	3/4
toxicity	Al	Al	Al	Al
stability	?	?	?	?
arability	?	?	1	1
tilth	?	?	1	1
foothold	1/2	?	1	1

In terms of the PRORADAM rating system the following evaluation is obtained:

Table 13. Preliminary rating of soil derived land qualities of some soil samples at El Granja (PRORADAM method) , no. 1-4.

Land quality	1	2	3	4
av.nutrients	2	2	2	2
moisture	2	2	2	2
oxygen	1	1	1	1
flooding	1	1	1	1
erosion	(1)	(1)	(1)	(1)
agric.impl.	(1)	(1)	(1)	(1)
soil assoc.	a1	a1	a1	a1
input	(3)	(3)	(3)	(3)

With sufficient fertilization the soils are capable to sustain extensive annual and perennial cultivation.

Soil Profile Description CO.15

Date : 25 October 1981.

Location : 20 km South of San José del Guaviare, at the turnof El Granja.

Physiography : dissected sedimentary plain; slope 3% but up to 8% in places; exposure North; site just below crest of interfluve.

Altitude : appr. 250 m.

Geology : Plio-Pleistocene continental sedimentary rock of mainly clayey textures with lenses of coarser material.

Parent material : clayey non consolidated sedimentary rock.

Vegetation : original bosque humido tropical cleared for pasture.

Land use : pasture, extensive range.

Soil climate : SMR is udic, STR is isohyperthermic.

Ecological Zone : bhT (bosque humido tropical).

Drainage : moderately well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth in cm	Description
Ah	0-10	Dark brown (7.5YR3/2) moist, gravelly sandy clay loam; very weak fine crumb; friable moist, sticky and plastic wet; common fine and medium tubular pores; common fine, medium and coarse roots; few medium weathered rock fragments; clear smooth boundary to
B1	10-40	yellowish red (5YR4/6) moist gravelly clay loam; weak to moderate, fine to medium subangular blocky; friable moist, very sticky and very plastic wet; pores and roots as Ah; frequent, dark red (10R3/6) and strong brown (7.5YR5/8) medium weathered rock fragments; clear wavy boundary to
Bs	40-77	yellowish red (5YR4/8) moist, gravelly silty clay loam; weak to moderate medium (sub) angular blocky; friable moist, very sticky and very plastic wet; common fine and medium tubular pores; few fine and medium roots; few thin cutans; common fine and medium dark red (10R3/6) and strong brown (7.5YR5/8) angular rock fragments; gradual wavy boundary to

Horizon	Depth in cm	Description
BCs	77-108	red (2.5YR5/6) moist with common, medium distinct clear red (10R4/8) and light grey (10YR7/2) mottles; silty clay; weak fine subangular blocky; friable moist, very sticky and very plastic wet; few to common fine tubular pores; few coarse and medium roots; very few thin cutans; gradual wavy boundary to
C	108-144	pale brown (10YR6/3), red (10R4/8), red (2.5YR5/6) sandy clay loam; moderate rock structure; friable to firm moist very sticky and very plastic wet; medium weathered rock fragments; few fine tubular pores.
R	144+	Slightly consolidated sedimentary rock with a mixture of colours.

Remarks: the C material is varied and consists of rather sandy sedimentary rock, non consolidated , in places concretionary forms; in the B1 platy 3 mm thick rock fragments hard to very hard throughout.

Samples	Depth	pF rings
	0-10	899,902, 910
	10-40	893, 901, 909
	40-77	892, 900, 908
	77-108	891, 899, 907

Micromorphology: 0-15 cm, 20-35 ", 45-60 ", 80- 98 cm, 110-125 "

Soil Profile Description CO.16

Date : 26 October 1981.

Location : at El Granja, appr. 100 m West of office.

Physiography : rolling to undulating sedimentary plain, partly dissected denudation surface; slope 3%, exposure South; slope variation 3,5 to 10%; site at highest terrain.

Altitude : appr. 250 m.

Geology : Plio-Pleistocene continental sedimentary rock, mainly of clayey texture but with lenses of coarser material.

Parent material : clayey non consolidated sediments.

Vegetation : bosque humido tropical.

Land use : forest reserve.

Soil climate : SMR is udic, STR is isohyperthermic.

Ecological zone : bhT (bosque humido Tropical).

Drainage : well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth	Description
Ah	0-5	Reddish grey (5YR5/2) moist, sandy loam; weak fine crumb; friable moist, slightly sticky and slightly plastic wet; common fine, medium and coarse pores; many fine, medium and coarse roots; clear smooth boundary to
AB	5-25	yellowish red (5YR4/6) moist, loam; weak fine subangular blocky; friable moist, sticky and slightly plastic wet; pores and roots as Ah; gradual smooth boundary to
Bw1	25-37	yellowish red (5YR4/8) moist, loam; weak fine, subangular blocky to porous massive; friable moist, sticky and slightly plastic wet; few fine charcoal fragments; common fine, medium and coarse pores; common fine, medium and coarse roots; clear smooth boundary to

Horizon	Depth	Description
Bw2	37-65	yellowish red (5YR5/6) moist, gravelly loam; porous massive in parts single grain; friable moist, slightly sticky and slightly plastic wet; frequent medium to large reddish black (10R2.5/1) and very dusky red (10R2.5/2) rock fragments; clear smooth boundary to
Bw3	65-87	yellowish red (5YR5/6) moist, sandy clay loam; weak fine angular blocky; friable to firm moist, sticky and plastic wet; common fine and medium pores, few coarse pores; common medium and coarse roots; clear smooth boundary to
BC	87-108	red (2.5YR5/6) moist with common fine distinct clear yellow (10YR7/6) mottles; clay; weak fine angular blocky; friable moist, slightly sticky and plastic wet; common fine and medium pores; few fine roots; clear smooth boundary to
C	108-120	reddish brown (5YR5/4), yellowish red (5YR5/6), strong brown (7.5YR5/8), red (2.5YR4/8) and yellow (10YR7/6) sandy clay; massive, very hard dry, firm moist, sticky and plastic wet; few small weathered rock fragments.
R	120-170	Fresh to slightly weathered sedimentary rock (by auger).

Remarks: a gravelly layer is encountered between 37-65 cm depth; however its occurrence is variable and may be found between 20-60 cm at higher sites.

Samples

Depth	pF rings
0-5	329, 921, 913
5-25	928, 920, 912
25-37	327, 919, 911

Micromorphology

0-15 cm	70-85 cm
20-35 "	100-115 "
40-55 "	

Soil Profile Description CO.17

Date : 27 October 1981.

Location : on an island in the Guaviare river, appr. 8 km downstreams of San José.

Physiography : island in river, site ± 4 m above river-level; exposure NW; slope 0%; subject to flooding once every year.

Altitude : 250 m.

Geology : recent loamy alluvium of Guaviare River.

Parent material : very soft loamy alluvium.

Vegetation : original riverine tropical rainforest cleared for cultivation.

Land use : rainfed cultivation of maize, yuca, bixa, cacao, coffee, platana; no fertilizers, low management level, low input.

Soil climate : SMR is udic, STR is isohyperthermic.

Ecological zone : bosque humido tropical (bhT).

Drainage : moderately well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth	Description
Ap	0-12	Weak red (2.5YR4/2) moist, with few fine faint sharp yellowish red (5YR4/6) mottles; loamy sand; weak single grain; loose moist non sticky non plastic wet; many medium and coarse pores; many fine and medium roots; few coarse roots; abrupt wavy boundary to
A11	12-19	dark greyish brown (10YR4/2) moist, with common fine distinct sharp yellowish red (5YR4/6) mottles; silt loam; very weak fine crumb to porous massive; very friable moist, sticky and plastic wet; pores and roots as Ap; abrupt wavy boundary to
A12	19-43	dark greyish brown (10YR4/2) moist, with common medium faint sharp greyish brown (10YR5/2) mottles; loam; single grain; loose moist, sticky and very plastic wet; many medium and coarse pores; many fine and medium roots; abrupt wavy boundary to

A13	43-54	greyish brown (10YR5/2) moist, with common medium faint sharp brown (10YR5/3) mottles; silty clay loam; very weak fine crumb to porous massive; very friable, moist, sticky and plastic wet; common to many medium and coarse pores; common fine and medium roots; abrupt wavy boundary to
A14	54-79	brown (10YR5/3) moist with common medium faint sharp grey (10YR5/1) mottles; sandy loam; single grain; loose moist, non sticky and non plastic wet; pores and roots as A14; abrupt wavy boundary to
AC11	79-86	dark greyish brown (10YR4/2) moist with common fine to medium distinct sharp dark brown (7.5YR4/4) mottles; silty clay loam; very weak crumb to porous massive; very friable moist, sticky and plastic wet; common to many coarse and medium pores; common fine and medium roots; abrupt wavy boundary to
AC12	86-100	brown (10YR5/3) moist with common medium distinct sharp grey (10YR6/1) mottles; sandy loam; single grain; loose moist, non sticky and non plastic wet; common medium pores; few fine and medium roots; abrupt wavy boundary to
AC13	100-103	brown (10YR5/3) moist, with common medium distinct sharp light grey (10YR6/1) mottles; loam; porous massive; very friable loose, sticky and plastic wet; pores and roots as AC12; abrupt wavy boundary to
AC14	103-117	greyish brown (10YR5/2) moist, with common medium distinct sharp strong brown (7.5YR5/6) mottles; sandy loam; single grain; loose moist, non sticky and non plastic wet; abrupt wavy boundary to
AC15	117-121	loam (10YR5/3)
AC16	121-134	sandy loam (10YR5/2)
AC17	134-138	loam (10YR5/3)

Remarks:

Samples

Depth	pF rings	Micromorphology
0- 12	890, 898, 906	0- 15 cm
19- 43	889, 897, 905,	25- 40 "
54- 79	888, 896, 904	45- 60 "
103-117	887, 895, 903	95-110 "
		120-135 "

Soil Profile Description CO.18

Date : 28 October 1981.

Location : El Granja, 20 km South of San Jose, in cacao plot no. 1.

Physiography : undulating sedimentary plain subject to denudation; site at 2% slope in slight depression; exposure South.

Altitude : 220 m.

Geology : Plio-Pleistocene continental sedimentary rock, mainly of clayey textures but with lenses of coarser material.

Parent material : clayey sedimentary rock.

Vegetation : bosque humido tropical.

Land use : cacao interplanted with the forest, undergrowth cleared to limited extent.

Soil climate : SMR is udic, STR is hyperthermic.

Ecological zone : bhT (bosque humido tropical).

Drainage : well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth in cm	Description
Ah	0-5	Dark greyish brown (10YR4/2) moist, sandy loam; weak fine subangular blocky; friable moist, slightly sticky and slightly plastic wet; many fine and medium continuous pores; many fine medium and coarse roots; clear smooth boundary to
A1	5-15	brown (10YR4/3) moist, sandy loam; weak fine subangular blocky; friable moist, slightly sticky and plastic wet; pores and roots as Ah; clear smooth boundary to
Ah_b	15-35	dark brown (7.5YR3/2) moist, sandy loam to loam; very weak fine subangular blocky; friable moist, slightly sticky and plastic wet; pores and roots as Ah; clear smooth boundary to
AB	35-59	brown (7.5YR4/4) moist, with very faint slightly lighter in colour mottles; sandy loam; very weak fine subangular blocky to porous massive; friable moist, slightly sticky and plastic wet; common fine and medium pores; common fine and medium roots; gradual smooth boundary to

Horizon	Depth in cm	Description
Bs1	59-86	strong brown (7.5YR5/6) moist with common medium faint sharp strong brown (7.5YR4/4) mottles; sandy clay loam; porous massive; firm moist, slightly sticky and slightly plastic wet; few fine, common medium pores; few fine and medium roots; gradual smooth boundary to
Bs2	86-112	yellowish red (5YR5/6) moist, with common medium distinct diffuse yellowish brown (10YR5/6) mottles; sandy clay loam to sandy clay; porous massive; firm moist, slightly sticky and slightly plastic wet; few fine, common medium continuous pores; few fine and medium roots; gradual smooth boundary to
BC	112-145	yellowish red (5YR5/8) moist, with common medium and coarse distinct diffuse yellowish brown (10YR5/8) mottles; sandy clay, porous massive; firm moist, slightly sticky and plastic wet; few fine, medium and coarse pores; few fine roots; gradual smooth boundary to
C1	145-180	yellowish red (5YR5/8) moist, with common medium and coarse distinct sharp reddish brown (2.5YR5/4) mottles; sandy clay to clay; porous massive; firm moist, slightly sticky and plastic wet; few fine and medium pores; gradual smooth boundary to
C2	180-210	red (10R4/8) and 2.5YR5/8), strong brown (7.5YR5/8) and light grey (10YR7/2) clay; porous massive; firm moist slightly sticky and plastic wet.

Remarks: from 105-110 cm in places gravelly sandy clay loam.

Samples

Depth	pF rings
5-15	934, 926, 918
15-35	933, 925, 957
35-59	932, 924, 916,
59-86	931, 923, 915
86-112	930, 922, 914

Micromorphology: 0-15 cm, 15-30 ", 45-60 ", 70- 85 cm, 95-110 "

IC Araracuara area (Amazonia)

Climate

The available climatic data of the Araracuara area are incomplete and cover a rather short period as until recently no records were made. Statements on the climate in the PRORADAM report (1979) are therefore of a general nature and are of little relevance for detailed land use planning of the area.

The rainfall is estimated between 3000-3500 mm/year, closer to the 3000 mm isohyet.
A minimum occurs in January between 150-200 mm (closer to the 150 mm isohyet).
A maximum is recorded in July, between 200-250 mm (closer to the 250 mm isohyet).
The evaporation is estimated to be about half of the precipitation, e.g. about 1600 mm a year.

According to the USDA Soil Taxonomy the soil moisture regime is considered udic. This regime implies that in most years the soil moisture control section is not dry in any part for as long as 90 days (cumulative).
The soil temperature regime is considered isohyperthermic. The soil temperature (mean annual soil temperature at 50 cm depth) is estimated to be more than 24°C, and the difference between the mean summer and the mean winter temperature is considered less than 5°C.
Daily fluctuations of the air temperature may be considerable.
The relative humidity is more than 75%, with a maximum occurring during January and February.

Physiography

Data on the physiography are summarized in the following Table, which includes also references to the PRORADAM report.

Table 14. Physiographic parameters for CO. 7, 8, 9, and 10

Parameter	CO.7	CO.8	CO.9	CO.10
altitude	200 m	230 m	290 m	340 m
slope	2%	1%	15%	1%
local relief	1 m	10-15 m	100 m	0-2 m
erosion	none	none	severe in places	none
landform	flat to slightly undulating alluvial terrace	undulating denudational sedimentary plain	footslope/ piedmont	slightly undulating plateau
parent material	clayey alluvial sediments	unconsolidated clayey sediment rock	clayey occ. stony colluvium	non- slightly consolidated sandstone
corr.PR.unit	(T1) ABab*	(S1) TAc	(P12) CRab	(P11) CRab
corr.PR.soils	Ar 4, Ar. 5	P55, P57, P58	P13, P62, P63	P28, P29, P40

* between brackets unit indication by CIAF (1981)

Geology

The geology varies from Holocene to recent alluvium to Precambrian metamorphous sedimentary rock. Details are given in Table 15.

Table 15. Geology of the four sites at Araracuara

Site	Geology
CO.7	Holocene to recent unconsolidated clayey alluvial sediments
CO.8	Plio-Pleistocene clayey sedimentary rock
CO.9	Colluvium derived from quartzite with lenses of clayey material
CO.10	Hard in places softer Precambrian metamorphic rock (mainly quartzites with horizontal bedding)

Vegetation

The original vegetation at all sites is classified as a tropical rain forest (bosque humido tropical). However, there are differences in species composition due to local factors as parent material and drainage.
Much forest, even at the site of CO.8, has been subject to burning, as can be witnessed from charcoal fragments occurring usually in the top 50 cm.

At the site of CO.7 the forest has not been cleared. However at an associated area for cacao experiments some undergrowth has been removed. At a nearby site all forest has been cut and/or burnt to make way for the cultivation of annual crops.
At CO.8 no disturbance of vegetation has occurred. The type of forest is described as mature dense tropical rainforest on erosional sedimentary surfaces (B3, PRORADAM, 1979).
At the site of CO.9 the forest was cleared about 50 years ago and pasture was introduced. In some areas an invasion of shrub is observed.

No disturbance has occurred at CO.10. The forest is somewhat comparable to that at CO.8 but contains less palms.

Details may be obtained from the PRORADAM report (1979, p. 231).

Land use

About 20 m from CO.7 cacao has been introduced in the partly cleared forest. After one year of growth the trees seem well established but 4 additional years are needed to assess the value.
The introduction of cacao in the forest environment is aimed at a better utilization of the forest without complete destruction of the original vegetation. At a nearby site the vegetation was cleared by cutting and burning. Much organic debris is left but yuca, maize and peas respond reasonable.
At the site of CO.9 the land is used for extensive grazing. Although strongly sloping, no erosion was observed and the grassmat seems well established. No data on stock density and past use of the area could be obtained.
The land at CO.10 is not used for any particular purpose. The exposed quartzite is occasionally used for road building purposes.

Land evaluation

The site of CO.7 is located at "Las Penas", some 10 minutes downstreams the Caqueta river from Araracuara. In the past it was used as a detention camp and as such the land has a varied history. Some parts were cleared and put under cultivation a long time ago, other have been put to use very recently. Additional data obtained from fields now under yuca and cacao confirm some of the major soil limitations, e.g. low pH, high exchangeable aluminium, very low in P and K and exchangeable Ca and Mg.
Application of fertilizers is necessary to obtain and sustain optimum yields. For cacao the following recommended applications are: 100 kg N/ha, 150 Kg P_2O_5/ha and 100 kg K_2O/ha.

No cultivation has taken place at CO.8 in memorable time, but the presence of charcoal in the top 20 cm indicates burning of the vegetation at some stage.

The site at CO.9 was cleared many years previously and mainly used as pasture. Conservation measures should be enforced when introducing arable cropping on these steep slopes. No data on stock density, etc. are available.

Table 16. Preliminary rating of soil derived land qualities (ISM method)

Land quality	CO.7	CO.8	CO.9	CO.10
moisture	2	2	2	4
oxygen	2	1	1	1
flooding	1	1	1	1
nutrients	5	5	5	5
toxicity	(A1)	(A1)	(A1)	(A1)
stability	(5)	(3)	(4)	(5)
arability	(3)	(3)	(3)	(1)
tilth	3	2	2	4
foothold	1	1	1	4

A comparison is made with the evaluation as derived at according to the PRORADAM method (Table 17).

Table 17. Preliminary rating of soil derived land qualities of profiles CO.7, 8, 9 and 10 (PRORADAM method)

Land quality	CO.7	CO.8	CO.9	CO.10
av. nutrients	3	3	3	3
moisture	1	1	1	1
oxygen	1	1	1	1
flooding	1	1	1	1
erosion	1	1	3	3
agric. impl.	1	1	1	4
soil assoc.	a1	a1	a1	a1
input	3	3	3	3

The main difference is related to the availability of nutrients.
In the PRORADAM methodology the CEC and base saturation criteria are more adapted to the local conditions with regard to the qualitative approach. However, both methodologies emphasize the poor chemical status of the soils. High input levels are necessary to induce and maintain high yields of the envisaged crops. In addition, the sandy soil at CO.10 possesses additional physical limitations by its sandy texture and variable depth.

The key for Tables 16 and 17 is given on page 55.

Soil Profile Description CO.07

Date	:	17 July 1981.
Location	:	Las Peñas Experimental site, 10 min. downstream by boat from Araracuara (Caqueta).
Physiography	:	flat to gently undulating terrace; slope 2%.
Altitude	:	200 m.
Geology	:	Holocene to recent unconsolidated clayey sediments.
Parent material	:	clayey alluvial sediments.
Vegetation	:	tropical rain forest.
Land use	:	none, but 20 m. from partly cleared forest in which experiments with cacao trees.
Soil climate	:	SMR is udic, STR is isohyperthermic. [1]
Ecological zone	:	bh-T; bosque húmido tropical.
Drainage	:	moderately well drained.
Moisture conditions:		moist throughout.

Soil Field Description

Horizon	Depth in cm	Description
Ah	0-20	Dark brown (7.5YR3/2) moist, sandy clay loam; weak fine to medium subangular blocky; friable moist, sticky and plastic wet; many fine and medium tubular pores; many fine, medium and coarse roots; gradual smooth boundary to
AB	20-43	dark brown (7.5YR3/4) moist, sandy clay loam; weak fine to medium (sub) to angular blocky; friable moist, sticky and plastic wet; few thin cutans; pores and roots as Ah; clear smooth boundary to
B_{t1}	43-60	brown (7.5YR4/4) moist with common medium faint diffuse strong brown[x] mottles, clay loam, moderate to strong fine to medium angular blocky; friable moist, sticky and plastic wet; few thin to moderately thick cutans; few to common medium pores; few medium and coarse roots; gradual wavy boundary to

[x] 7.5YR5/6

[1] SMR = soil moisture regime
STR = soil temperature regime } according to USDA-SSS, 1975

Horizon	Depth in cm	Description
Bt2	60-85	strong brown (7.5YR5/6) moist, with common fine distinct clear strong brown (7.5YR5/8) mottles, clay; strong fine angular blocky; firm moist, sticky and very plastic wet; common moderately thick cutans; few medium pores; few fine and medium roots; common tubules; gradual wavy boundary to
Bt3	85-125	yellowish brown (10YR5/8) moist with common medium distinct clear strong brown (7.5YR5/8) mottles; clay; strong fine angular blocky; firm moist, sticky and very plastic wet; common to abundant moderately thick cutans; few medium pores; few fine roots; common tubules; gradual wavy boundary to
BC	125-185	yellowish brown (10YR5/8) moist, with many medium to coarse prominent clear yellowish red (5YR5/8) mottles;* strong fine angular blocky; friable moist, sticky and very plastic wet; common to abundant moderately thick cutans, common tubules. *clay

Remarks: in comparison with the Co.04 profile also developed on a terrace near Leticia, this soil (CO.07) has a much thicker epipedon overlying a yellow AB and mottled B horizon. The soil belongs to map unit T1, as mapped by CIAF.

Table 18. Laboratory data of CO.7 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	%
		sand	silt	clay	gravel	1:1	moisture
Ah	0- 20	48	38	14		4.2	1.0
AB	20- 43	44	34	22		4.7	1.0
Bt1	43- 60	30	26	44		4.6	2.0
Bt2	60- 85	26	24	50		4.8	1.0
Bt3	85-125	30	22	48		5.0	2.0
BC	125-185	30	30	40		5.0	2.0

Depth cm	Exchangeable cations (me/100g)					CEC	Base	Al	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	sat.%	clay
0- 20	0.2	0.2	0.2	0.1	0.7	12.1	5.8	26	86.4
20- 43	0.2	0.2	0.1	0.1	0.6	9.3	6.5	28	42.3
43- 60	0.2	0.2	0.1	0.1	0.6	9.0	6.7	41	20.5
60- 85	0.2	0.2	0.1	0.1	0.6	8.9	6.7	36	17.8
85-125	0.2	0.2	0.1	0.1	0.6	8.9	6.7	37	18.5
125-185	0.2	0.2	0.1	0.1	0.6	8.9	6.7	48	22.3

Depth cm	Organic matter			P	Exchangeable	Cation saturation			
	%C	%N	C/N	ppm	Al me/100	Ca	Mg	K	Na
0 - 20	2.29			1	3.2	1.7	1.7	1.7	0.8
20- 43	1.21			1	2.6	2.2	2.2	1.1	1.1
43- 60	0.41			1	3.7	2.2	2.2	1.1	1.1
60- 85	0.40			1	3.2	2.2	2.2	1.1	1.1
85-125	0.20			1	3.3	2.2	2.2	1.1	1.1
125-185	0.20			1	4.3	2.2	2.2	1.1	1.1

The data of CO.7 compare well with information obtained from two other profiles of the same map unit (Ar4 and Ar5 in CIAF, 1981).
Some more values are summarized in Table 19.

Table 19. Some soil properties of two profiles of map units (T1) mean values

Horizon	Depth cm	% clay	CEC soil	Base sat.%	%C	%Al sat.	CEC clay
Ah	0- 22	14	19.2	4	3.28	21	137.1
AB	22- 41	24	11.9	7	1.16	36	49.6
BA	41- 62	32	9.2	8	0.44	47	28.8
Bt1	62- 90	39	11.9	6	0.41	48	30.5
Bt2	90-131	44	12.2	7	0.28	51	27.7
BC	131-180	39	12.7	7	0.24	51	32.6

Soil Profile Description CO.08

Date : 18 July 1981.

Location : appr. 10 km NE from Araracuara (Caqueta).

Physiography : undulating degradational sedimentary plain; slope 1%.

Altitude : 230 m.

Geology : Plio-Pleistocene clayey sediments (TS4).

Parent Material : non-consolidated clayey sedimentary rock.

Vegetation : amazonian tropical rain forest, common palms.

Land use : hunting, food gathering.

Soil climate : SMR is udic, STR is isohyperthermic.

Ecological zone : bh-T; bosque húmido Tropical.

Drainage : well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth in cm	Description
Ah	0-8	Dark brown (7.5YR3/2) moist, sandy clay loam; weak fine subangular blocky; soft dry, friable moist, slightly sticky and slightly plastic wet; many fine, medium and coarse tubular pores; many fine, medium and coarse roots; gradual smooth boundary to
AB	8-21	brown (7.5YR4/4) moist, sandy clay loam; weak fine subangular blocky; slightly hard dry, friable moist, sticky and plastic wet; common to many fine, medium and coarse tubular pores; common to many fine, medium and coarse roots; few small charcoal fragments; common fauna activity as fecal pellets; gradual smooth boundary to
Bt1	21-50	reddish brown (5YR4/4) moist, clay; moderate fine (sub) angular blocky; friable moist, sticky and plastic wet; few moderately thick cutans; common pedotubules and some charcoal fragments; common fine and medium tubular pores; few fine and medium roots; gradual smooth boundary to

Horizon	Depth in cm	Description
Bt2	50-75	yellowish red ($5^{Y}R4/8$) moist, clay; moderate fine angular blocky; friable moist, sticky and very plastic wet; common moderately thick cutans; common pedotubules; few charcoal fragments; few to common fine to medium tubular pores; few medium roots; gradual smooth boundary to
Bts1	75-100	red (2.5YR4/6) moist, clay; weak to moderate fine angular blocky; friable moist, sticky and very plastic wet; common moderately thick cutans; few to common fine and medium tubular pores; few coarse quartz grains; some pedotubules; diffuse smooth boundary to
Bs	100-150	red (2.5YR4/8) moist, clay; weak to moderate fine angular blocky; consistence, cutans and pores as Bts1.

Remarks: this soil belongs to map unit S1 (CIAF, 1981); the rootmat is expressed from 0-8 cm; all very coarse roots are confined to the top 21 cm.

Table 20. Laboratory data of CO.8 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture			pH	%
		sand	silt	clay	1:1	moisture
Ah	0- 8	70	16	14	3.8	2.0
AB	8- 21	34	24	42	4.4	1.0
Bt1	21- 50	26	22	52	4.7	2.0
Bt2	50- 75	18	18	64	5.0	1.0
Bts1	75-100	16	20	64	5.2	1.0
BS	100-150	18	22	60	5.1	2.0

Depth cm	Exchangeable cations (me/100g)					CEC	Base	CEC	%Al
	Ca	Mg	K	Na	sum	soil	sat.%	clay	sat.
0- 8	0.2	0.2	0.3	0.1	0.8	27.3	2.9	195.0	19
8- 21	0.2	0.2	0.1	0.1	0.6	15.8	3.8	37.6	22
21- 50	0.2	0.2	0.1	0.1	0.6	11.4	5.3	21,9	33
50- 75	0.2	0.2	0.1	0.1	0.6	10.1	2.8	15.8	30
75-100	0.2	0.2	0.1	0.1	0.6	11.3	5.3	17.7	28
100-150	0.2	0.2	0.1	0.1	0.6	11.4	5.3	19.0	36

Depth cm	Organic matter			P	Exch.Al	Cation saturation			
	%C	%N	C/N	ppm	me/100	Ca	Mg	K	Na
0- 8	7.07			2	5.3	0.7	0.7	1.1	0.4
8- 21	1.95			1	3.4	1.3	1.3	0.6	0.6
21- 50	1.09			1	3.7	1.8	1.8	0.9	0.9
50- 75	0.68			1	3.0	0.9	0.9	0.5	0.5
75-100	0.41			1	3.2	1.8	1.8	0.9	0.9
100-150	0.27			1	4.1	1.8	1.8	0.9	0.9

Data from three other profiles of the same mapping unit (S) are available (CIAF, 1981) and summarized as follows.

Table 21. Summarized soil properties of three profiles of map unit S (mean values)

Horizon	Depth cm	% clay	CEC soil	Base sat.%	%C	Al sat.	pH 1:1	CEC clay
A1	0- 7	18	15.4	6	3.34	25	3.6	85.6
B1	7- 35	31	9.8	6	1.13	29	4.1	31.6
B21	35- 65	41	10.3	6	0.55	33	4.4	25.1
B22	65-115	44	10.2	7	0.38	46	4.5	23.2
BC	115-130	47	10.9	6	0.24	50	4.7	23.2

The data support those of profile CO.8 e.g. increase of clay with depth, decreasing CEC soil but constant at depth, very low base saturation, but high Al saturation, high % organic carbon in the A1 decreasing regular but strongly with depth and low pH values in the soil surface but increasing with depth.

Soil Profile Description CO.09

Date : 21 July 1981.

Location : 0.5 km N of the Cooperation Office at the centre of Araracuara (Caqueta).

Physiography : footslope associated with a plateau NE of the village; also called piedmont; slope 15%.

Altitude : 290 m.

Geology : Precambrian metamorphic rock, mainly quarzites

Parent material : clayey unconsolidated colluvium.

Vegetation : grasses, some herbs and shrubs.

Land use : area was cleared 50 years ago from tropical rainforest and was put under pasture; extensive grazing.

Soil climate : SMR is udic, STR is isohyperthermic.

Ecological zone : bh-T; bosque húmido tropical.

Drainage : well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth cm	Description
Ah	0-10	Very dark greyish brown (10YR3/2) moist, sandy clay loam; weak fine subangular blocky to crumb; slightly hard dry, friable moist, slightly sticky and slightly plastic wet; few coarse gravel; many fine, medium and coarse tubular pores; many fine and medium roots; gradual wavy boundary to
ABh	10-20	dark brown (10YR3/3) moist; sandy clay loam; moderate fine subangular blocky to crumb; slightly hard dry, friable moist, slightly sticky and slightly plastic wet; few thin cutans along root channels; few tubules; many fine, medium and coarse tubular pores; many fine and medium roots; common charcoal fragments on the wavy gradual boundary to
AB	20-35	brown (10YR4/3) moist, sandy clay loam; moderate fine subangular blocky; slightly hard dry, friable moist, slightly sticky and slightly plastic wet; few thin cutans along root channels; few to common tubules; few gravel; common fine and medium tubular pores; common fine and medium roots; gradual wavy boundary to

Horizon	Depth cm	Description
Bt1	35-55	brown (7.5YR4/4) moist, clay loam; moderate fine to medium (sub) angular blocky; slightly hard dry, friable moist, sticky and plastic wet; few to common thin to moderately thick cutans; common tubules; common fine to medium tubular pores; few fine and medium roots; gradual wavy boundary to
Bt2	55-95	strong brown (7.5YR5/6) moist, clay; weak to moderate, fine to medium angular blocky; hard dry, friable moist, very sticky and very plastic wet, common moderately thick cutans; few lithorelicts; many tubules; many fine to medium tubular and elipsoidal pores; few fine and medium roots; gradul wavy boundary to
BC	95-130	reddish yellow (5YR6/8) moist, clay; very weak fine angular blocky to porous massive; friable moist, very sticky and very plastic wet; few thin cutans; many tubules; few fine roots; abrupt wavy boundary to
C	130-150	stone and gravel mainly composed of sandstone.

Comparable profiles as CO.9 were described and sampled by CIAF (1981). These soils also show an increase of clay with depth, low pH, low CEC soil, very low base saturation, high exchangeable aluminium and high Al saturation(unit P12).

Table 22. Laboratory data of CO.9 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture			pH	%
		sand	silt	clay	1:1	moisture
Ah	0- 10	64	20	16	4.3	2·0
ABh	10- 20	54	22	24	4.4	1.0
AB	20- 35	44	16	40	4.6	3.1
Bt1	35- 55	34	20	46	4.6	1.0
Bt2	55- 95	34	8	48	4.7	1.0
BC	95-130	34	16	50	4.5	1.0

Depth cm	Exchangeable cations (me/100g)					CEC	Base	Al	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	sat.%	clay
0- 10	0.2	0.2	0.1	0.1	0.6	16.3	3.7	22	101.9
10- 20	0.2	0.2	0.1	0.1	0.6	15.4	3.9	26	64.2
20- 35	0.2	0.2	0.1	0.1	0.6	11.1	5.4	33	27.8
35- 55	0.2	0.2	0.1	0.1	0.6	8.1	7.4	40	17.6
55- 95	0.2	0.2	0.1	0.1	0.6	8.9	6.7	34	18.5
95-130	0.2	0.2	0.1	0.1	0.6	6.5	9.2	40	13.0

Depth cm	Organic matter			P	Exch.Al	Cation saturation			
	%C	%N	C/N	ppm	me/100	Ca	Mg	K	Na
0- 10	3.06			3	3.5	1.2	1.2	0.6	0.6
10- 20	2.29			1	4.0	1.3	1.3	0.6	0.6
20- 35	1.24			1	3.7	1.8	1.8	0.9	0.9
35- 55	0.68			1	3.2	2.5	2.5	1.2	1.2
55- 95	0.40			1	3.0	2.2	2.2	1.1	1.1
95-130	0.27			1	2.6	3.1	3.1	1.5	1.5

Soil Profile Description CO.10

Date	: 21 July 1981.
Location	: 1 km North of the airstrip at Araracuara.
Physiography	: slightly undulating plateau; slope 1%.
Altitude	: 340 m.
Geology	: Precambrian metamorphic rocks, mainly quartzites with amphibolites and migmatites.
Parent material	: Quartzites in almost horizontal bedding.
Vegetation	: tropical rain forest.
Land use	: hunting and fruit gathering.
Soil climate	: SMR is udic, the STR is isohyperthermic.
Ecological zone	: Bh-T; bosque húmido tropical.
Drainage	: well drained.
Moisture conditions	: moist troughout.

Soil Field Description

Horizon	Depth cm	Description
Ah	0-5	Very dark brown (10YR2.5/2) moist, loamy medium and fine sand; moderate single grained; soft dry, loose moist, non sticky and non plastic wet; many fine and medium pores; many fine, medium and coarse roots; abrupt wavy boundary to
AB	5-13	pinkish grey (7.5YR6/2) moist, loamy fine and medium sand; moderate single grained; soft dry loose moist, non sticky and non plastic wet; common fine and medium pores; common fine, medium and coarse roots; gradual wavy boundary to
B1	13-21	dark grey (10YR4/1.5) moist, fine to medium sandy loam; moderate single grained; soft dry, very friable moist, non sticky and non plastic wet; few fine and medium pores; common fine, medium and coarse roots; gradual wavy boundary to
BC	21-50	light grey (10YR7/2) moist, fine sand; structureless single grained; soft dry, very friable moist, non sticky non plastic wet; some sandstone fragments; few fine pores; few to common fine and medium roots; gradual wavy boundary to

Horizon	Depth cm	Description
C	50-130	white (10YR8/2) moist, fine sand; structureless; soft dry, very friable moist, non sticky, non plastic wet; common fine roots.

Remarks: the soil belongs to map unit P11 (CIAF, 1981); the boundary to the C may be abrupt and broken. It may occur at 70 cm but also at 40 cm.

Table 23. Laboratory data of CO.10 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	%
		sand	silt	clay	gravel	1:1	moisture
Ah	0- 5	84	14	2	-	3.6	2.0
AB	5- 13	84	14	2	-	3.8	0.5
B1	13- 21	84	14	2	-	4.1	0.5
BC	21- 50	84	14	2	-	4.3	0.5
C	50-130	80	18	2	43	4.8	0.5

Depth cm	Exchangeable cations (me/100g)					CEC	Base	Al	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	sat.%	clay
0- 5	0.2	0.2	0.5	0.2	1.1	38.4	2.9	8	1920.0
5- 13	0.2	0.2	0.1	0.1	0.6	6.4	9.4	13	320.0
13- 21	0.2	0.2	0.1	0.1	0.6	1.6	37.5	38	80.0
21- 50	0.2	0.2	0.1	0.1	0.6	1.6	37.5	13	80.0
50-130	0.2	0.2	0.1	0.2	0.7	1.2	58.3	17	60.0

Depth cm	Organic matter			P	Exch.Al	Cation saturation			
	%C	%N	C/N	ppm	me/100	Ca	Mg	K	Na
0- 5	10.27			4	3.1	0.5	0.5	1.3	1.3
5- 13	2.61			1	0.8	3.1	3.1	1.6	1.6
13- 21	2.21			1	0.6	12.5	12.5	6.3	6.3
21- 50	0.40			1	0.2	12.5	12.5	6.3	6.3
50-130	0.20			1	0.2	16.7	16.7	6.3	6.3

Similar profiles are not described in the CIAF report. Soils belonging to the loamy family occur however in the same mapping unit.

Mineralogy

Data on the sand and clay mineralogy of representative soils of the map units T1, S, P11 and P12 are given in the following Tables. Only the B horizons were analyse d.

Table 24. Sand mineralogy

Map unit and soil depth		light minerals						heavy minerals				
		quartz	feldspar	physolite	muscovite	biotite	amphibolite	opaque	zircon	tourmaline	alterite	rock.fragm.
T	19-37	100	t	t	t			t	t	t		t
	37-58	99		t	1			t	t	t	t	
S	25- 56	95		2	t			2	t	t	1	
	56-115	100	t	t	t	t	t		t		t	t
P11	47-58	100		t				t	t		t	
	58-75	99	t		1				t			
P12	20-45	100	t	t	t	t	t		t			t
	45-60	98		t	2			t	t		t	
	60-80	96	3		1	t			t	t		

Source: PRORADAM, 1979; CIAF, 1981

Note: light + heavy minerals were determined during the same count of 100 grains,inclusive opaque.

The soil shows only traces of weatherable minerals in the sand fraction, if any.

Table 25. Clay mineralogy

Map unit	Soil depth	Clay minerals				Non-clay minerals		
		Kaol	Montm	Verm/Chl	Pyr	Quartz	Mica	Gibbs
T1	19- 37	+++		+	tr	tr		tr
	37- 58	+++		++	tr	+	+	tr
	58- 90	++		tr		tr	+	tr
S	25- 56	+++	tr	tr	tr	+	++	
	56-115	+++		tr		+	++	
P11	47- 58	+++	tr	++	tr	tr	tr	+
	58- 75	++		+		tr		tr
P12	20- 45	++		++		tr		+
	45- 60	++	tr	++		tr	tr	++
	60- 80	++		++		tr	tr	+

key:
+++ dominant (>50%)
++ subordinate (10-40%)
+ minor (<10%)
tr trace

source: PRORADAM,1979; CIAF,1981.

Although kaolinite is the dominant clay mineral in all horizons, the amount of weatherable clay minerals is not neglectible and in unit P12 equally important. Soils of unit S are considered to contain most low activity clays, followed by those of unit P11 and T1.

ID Leticia area (Amazonia)

Climate

The data are derived from HIMAT (1981). Unfortunately no information on evaporation is available. However it is considered that evaporation is equal or may exceed the precipitation during the drier months July and August (see Table 24 and Figure 4).

Table 26. Climatic data Leticia, altitude 84 m

Month	rainfall in mm	max. in 24 hours	T_{mean}	T_{max}	T_{min}	rel. hum. %
Jan	357,6	144,2	26,1	30,0	19,2	87
Feb	361,6	80,0	26,6	30,4	21,0	86
Mar	315,5	97,5	26,7	30,4	21,3	85
Apr	282,1	76,7	26,2	29,3	21,0	85
May	229,7	116,0	26,2	29,3	21,0	85
June	210,5	102,0	25,8	29,5	22,1	86
July	129,9	46,0	25,4	29,4	19,2	85
Aug	149,1	55,0	26,5	30,5	22,0	81
Sept	226,5	74,5	26,5	31,4	18,8	82
Oct	250,7	170,0	27,0	32,0	21,9	82
Nov	258,8	122,0	26,9	31,7	21,9	84
Dec	206,8	110,0	26,5	31,1	20,5	85
Year	2978,8	170,0	26,4	30,5	20,8	84

The soil moisture regime is considered udic, e.g. the soil moisture control section is not dry in any part for as long as 90 days (cumulative), in most years.
The soil temperature regime is considered isohyperthermic, e.g. the mean annual soil temperature is higher than 22°C, while the difference between mean summer and mean winter temperature is less than 5°C.
The relative humidity is high (>80%) throughout the year, with a maximum in January (87%) and a minimum in August (81%).
The hours of brillant sunshine are estimated at approximately 1700 hours per year, on average five (5) hours daily.

Physiography

Two main physiographic units are distinguished in relation to the sites: 1) terrace of the Amazone river and 2) undulating in parts dissected denudational sedimentary plain.

The topography of the terrace is flat to gently undulating, the higher parts are occasionally flooded, the lower terrace is flooded every year.
The sedimentary plain has a raised relief. Near site 4 the area is moderately dissected, resulting in a interchange of valley (V-shaped) and flat to slightly convex interfluves.
Near site 6 the relief is more subdued and interfluves are broader as are the valley bottoms.

Geology

The geology associated with the Amazone river is described as non consolidated fluviatile sediments usually composed out of silt, clay and gravel with locally quartz sand (eolian origin?).
The dissected sedimentary plain is underlain by coarser sediments of quartz and chert in a matrix of sand and clay. Its composition may vary considerably over relatively short distances.
Both sediments are considered of Quaternary age. However, the lower terrace may receive recents deposits during high floods of the Amazone river.

Vegetation

In some areas the original wet tropical forest vegetation has been cleared to make way for cultivation.
In the riverine areas the vegetation is classified as riverine tropical rainforest (CO.5).
On the dissected areas of the sedimentary plain the vegetation is classified as well developed relatively old tropical rainforest with few palms (CO.4).
Associated with this vegetation are the somewhat less developed forests with abandoned river courses along which a well developed forest occurs with many palms (CO.6). For details see PRORADAM, 1979.

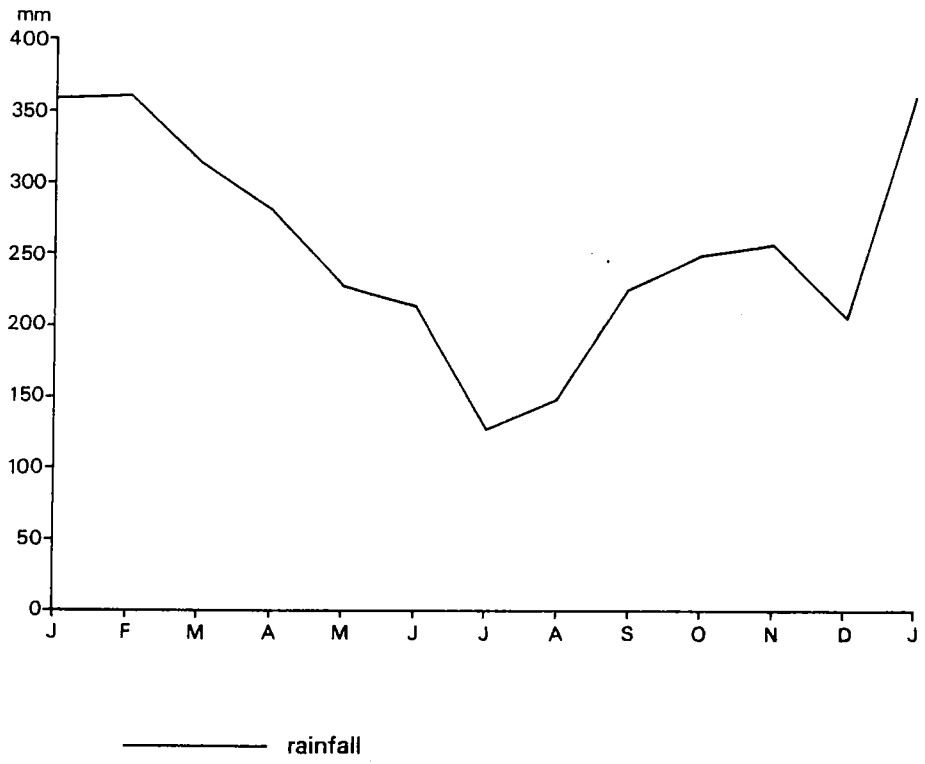
Land use

The original forest is used as a source for wild plants, fruits and animals.
Along tracks small areas (up to 100 ha) may be cleared. The type of cultivation is variable. Often areas are brought under pastures. Without high management and considerable inputs (improving natural grass cover, fertilization) yields are poor and stock density is low.
In some riverine areas foodcrops are being cultivated for sileage (napier grass). Near homesteads and villages foodcrops are grown such as yuca, maize, platanas.
As much of the food in the Leticia area is imported it may be worthwhile to improve the food and vegetable production and increase the meat output.

Land evaluation

The soils are rated according to the ISM system and the PRORADAM method.
According to both evaluations the mean bio-physical limitations concern the low soil fertility and toxicity caused by aluminium.

Fig. 4 Climatic graph Leticia



Soil amelioration is aimed at raising the pH level and conserve the fragile structure of the topsoil, when forests are cleared. Data are summarized in Tables 27 and 28.

Table 27. Soil derived land qualities (ISM method)

Land quality	CO.4	CO.5	CO.6	Remarks
moisture	2	2	2	
oxygen	1	2	1	
flooding	1	2	1	
nutrients	5	5	5	very low base saturation
toxicity	(A1)	(A1)	(A1)	high exchangeable Al
stability	4	4	4	high Si/C ratio; weak structures
arability	3	3	2	consistence
tilth	3	3	2	
foothold	1	1	1	

Table 28. Soil derived land qualities (PRORADAM method)

Land quality	CO.4	CO.5	CO.6	Remarks
av. nutrients	3	3	3	low base saturation
av. water	1	1	1	
av. oxygen	1	1	1	
res. to erosion agric. impl.	3	2	2	slope, topsoil texture
soil ass.	a1	a1	a1	
input level	(3)	(3)	(3)	low fertility
risk of flood.	1	2	1	
res. to erosion	2/3	2	2/3	slopes, susceptibility topsoil

The Key for Tables 27 and 28 is presented on page 55.

Soil Profile Description CO. 04

Date	: 7 July 1981
Location	: 1 km NNE of Arara
Physiography	: dissected sedimentary plain
Altitude	: 210 m
Geology	: Quaternary-Pliocene sedimentary rocks, quartz and chert in matrix of sandy clay
Parent material	: clayey sediment
Vegetation/Land Use	: bosque alto (bien desarrollodo sobre superficies dissectados con poco presencia de palinas)/the tropical rainforest is in parts cleared for the cultivation of cooking banana and casave; a fallow of 1 year is allowed, land classification class VII
Soil climate	: the SMR is perudic, the STR is isohyperthermic
Ecological zone	: Bh-T, bosque hûmedo tropical
Drainage	: well drained
Moisture conditions	: moist throughout

Soil Field Description

Horizon	Depth cm	Description
Ap	0- 10	Brown (10 YR 4/9) moist, clay; weak medium to fine subangular blocky; friable moist, sticky and plastic wet; common fine and medium pores; common fine, medium and coarse roots; pH 5,5; gradual smooth boundary to
AB (E)	10- 35	Brown (7.5 YR 4/4) moist, clay; weak medium and fine subangular blocky; roots and pores as Ap; pH 6,0; gradual smooth boundary to
Bw1 (E)	35- 70	Strong brown (7.5 YR 5/6) moist with few medium distinct sharp red (2.5 YR 5/6) mottles, clay; porous massive; friable moist, sticky and plastic wet; common fine and medium pores; common fine, medium and coarse roots; pH 5,5; gradual smooth boundary to
Bw2	70-100	Reddish yellow (5 YR 6/6) moist, clay; weak fine angular blocky to porous massive; friable moist, sticky and plastic wet; common pores; few fine roots; pH 5,0; gradual smooth boundary to
BC	100-150	Red (2.5 YR 5/6) with common coarse distinct sharp light grey (2.5 Y 7/0) mottles, clay; weak fine angular blocky to porous massive; common pores; very few fine roots

Remarks: according to PRORADAM (1979) the soil belongs to map unit YCde, it occurs on denudation surfaces; e.g. concave-convex strongly dissected plains, compare profile PR 40 - tropeptic Haplortox

Table 29. Laboratory data of CO.4 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture			pH	%
		sand	silt	clay	1:1	moisture
Ap	0- 10	56	30	14	3.8	1.0
AB	10- 35	46	32	22	3.8	1.0
BW1	35- 70	46	24	30	4.2	1.0
BW2	70-100	50	22	28	4.3	1.0
BC	100-150	46	24	30	4.1	1.0

Depth cm	Exchangeable cations (me/100g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 10	0.8	0.2	0.2	0.1	1.3	14.5	9.0	103.6
10- 35	0.2	0.2	0.1	0.1	0.6	12.1	5.0	55.0
35- 70	0.2	0.2	0.1	0.1	0.6	10.1	5.9	33.7
70-100	0.2	0.2	0.1	0.1	0.6	8.1	7.4	28.9
100-150	0.2	0.2	0.1	0.1	0.6	8.9	6.7	29.7

Depth cm	Organic matter			P	Exch.Al	Exch.H	Total	% Al
	%C	%N	C/N	ppm	me/100		ex.acid.	sat.
0- 10	2.35	0.21	11	3	3.9	0.5	4.4	27
10- 35	0.68	0.11	6	1	4.6	0.7	5.3	38
35- 70	0.20	0.05	4	1	4.6	0.5	5.1	51
70-100	0.20	0.03	7	1	4.4	0.5	4.9	54
100-150	0.13	0.03	4	1	5.3	0.4	5.7	60

Table 30. Laboratory data of CO.4 (by ISM)

Horizon	Depth cm	Texture (µm in weight %)							
		sand					silt		clay
		2000-1000	1000-500	500-250	250-100	100-50	50-20	20-2	<2
Ap	0- 10	0.1	0.9	3.7	3.2	2.2	24.1	26.3	39.5
AB	10- 35	0.2	3.2	13.2	14.2	13.3	13.2	14.7	28.1
BW1	35- 70	0.3	3.5	19.4	16.9	12.9	9.7	9.9	31.5
BW2	70-100	0.2	3.8	18.1	19.5	11.0	8.7	10.3	28.5
BC	100-150	0.2	3.5	18.2	21.1	11.0	9.4	7.2	29.5

Depth cm	Exchangeable cations (me/100g)					CEC	CEC	Base
	Ca	Mg	K	Na	sum	soil	clay*	sat.%
0- 10	0	0.3	0.2	0.1	0.6	14.7	13.3	4.1
10- 35	0	0	0.1	0.1	0.2	11.7	32.1	1.7
35- 70	0	0	0.1	0	0.1	9.9	28.4	1.0
70-100	0	0	0	0	0	9.0	28.3	0
100-150	6.3	0	0.1	0	6.4	9.3	29.3	6.9

Depth cm	clay minerals					non clay minerals			
	Kaol	Mont/Ill	Verm	Smec	Mix	Quar	Feld	Gibb	Goeth
0- 10	++	tr - +	tr	tr	+	0 - tr			
10- 35	++	tr - +	tr	tr	+	0 - tr			
35- 70	++	tr - +	tr	tr	+				
70-100	++	tr - +		tr - +	+				
100-150	++	tr - +			+				

* value corrected for presence of organic matter; non corrected values are 37.2, 41.6, 31.4, 31.6 and 31.5

Soil Profile Description CO. 05

Date	: 8 July 1981
Location	: 1 km N of Leticia airport
Physiography	: flat to gently undulating alluvial terrace
Altitude	: 210 m
Geology	: Quaternary sedimentary rocks; mainly fluviatile non consolidated sediments
Parent material	: clayey alluvium
Vegetation/Land Use	: the tropical rainforest was cleared five years previously, presently a grass herbs and some shrub cover/grazing, in some cleared forest foddercrops are grown; land capability class VII
Soil climate	: SMR is perudic, STR is isohyperthermic
Ecological zone	: Bh-T, bosque húmedo tropical
Drainage	: Moderately well drained
Moisture conditions	: moist throughout

Soil Field Description

Horizon	Depth cm	Description
Ap	0-10	Greyish brown (10 YR 5/2) moist with common fine faint smooth yellowish red (5 YR 4/6) mottles, clay; weak fine subangular blocky; very hard dry, friable moist, sticky and plastic wet; common fine and medium pores; many fine and medium roots; pH 5,5; clear wavy boundary to
AB	10- 30	Light yellowish brown (10 YR 6/4) moist with common fine faint sharp yellowish red (5 YR 4/6) mottles, clay; weak fine subangular blocky to porous massive; consistence, pores and roots as Ap; pH 5,0; clear wavy boundary to
Bt1	30- 50	Strong brown (7.5 YR 4/6) moist, with common fine and medium, distinct sharp light yellowish brown (10YR 6/4) mottles, clay; weak fine subangular blocky to porous massive; very hard dry, friable moist, sticky and plastic wet; common fine and medium pores; many fine and medium roots; pH 5,0; gradual smooth boundary to
Bt2	50- 75	Strong brown (7.5 YR 5/6) moist with common medium and coarse distinct clear light yellowish brown (10 YR 6/4) mottles; clay; weak fine subangular blocky to porous massive; few very thin cutans; very hard dry, friable moist, sticky and very plastic wet; few to common fine pores; few fine and medium roots; pH 4,5; gradual smooth boundary to
BC1	75-100	Strong brown (7.5 YR 5/8) moist, with common fine distinct diffuse light red (2.5 YR 6/6) mottles; clay; porous massive; few very thin cutans; very hard dry, friable moist, sticky and very plastic wet; few soft small concretions; few fine and medium roots; pH 4,5; wavy smooth boundary to
BC2	100-150	Mixture of light red (2.5 YR 6/6), red (10 R 4/8), reddish yellow (7.5 YR 6/8) and very pale brown (10 YR 7/4) clay; weak fine (sub)angular blocky; few very thin cutans; very hard dry, friable moist, sticky and very plastic wet; few pores; some coarse quartz grains
	150-250	-as BC2- but material becomes sandier below 200 cm

Remarks: according to PRORADAM the soil belongs to unit PMa, low level, old alluvial terrace soils; compare profile PR-6, oxic Dystropept

Table 31. Laboratory data of CO.5 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture			pH	%
		sand	silt	clay	1:1	moisture
Ap	0- 10	52	40	8	4.5	3.1
AB	10- 30	32	42	26	4.3	1.0
Bt1	30- 50	30	40	30	4.1	2.0
Bt2	50- 75	30	36	34	4.2	1.0
BC1	75-100	30	32	38	4.1	2.0
BC2	100-150	32	30	38	4.4	2.0

Depth cm	Exchangeable cations (me/100g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 10	2.5	0.8	0.4	0.1	3.8	18.1	19.9	226.3
10- 30	0.2	0.2	0.1	0.1	0.6	9.7	6.2	37.3
30- 50	0.2	0.2	0.1	0.1	0.6	9.0	6.7	30.0
50- 75	0.2	0.2	0.1	0.1	0.6	8.9	6.7	26.2
75-100	0.2	0.2	0.1	0.1	0.6	9.8	6.1	25.8
100-150	0.2	0.2	0.1	0.1	0.6	11.4	5.3	30.0

Depth cm	Organic matter			P	Exchangeable (me/100g)			% Al
	%C	%N	C/N	ppm	Al	H	total	sat.
0- 10	5.43	0.38	14	4	1.5	0.6	2.1	8
10- 30	0.94	0.09	10	1	2.7	0.5	3.2	28
30- 50	0.61	0.05	12	1	3.2	0.6	3.8	36
50- 75	0.33	0.05	7	1	4.0	0.7	4.7	45
75-100	0.27	0.03	9	1	4.3	0.6	4.9	44
100-150	0.27	0.02	14	1	6.6	0.6	7.2	58

Table 32. Laboratory data of CO.5 (by ISM)

Horizon	Depth cm	Texture (µm weight %)							
		sand					silt		clay
		2000-1000	1000-500	500-250	250-100	100-50	50-20	20-2	<2
Ap	0- 10	0.1	0.2	1.0	17.4	24.0	18.3	15.5	23.5
AB	10- 30	0.1	0.1	0.5	12.0	23.8	17.6	16.1	29.9
Bt1	30- 50	0.1	0.1	0.5	12.1	23.3	16.5	15.7	31.7
Bt2	50- 75	0.1	0.1	0.5	10.8	21.0	19.2	14.6	33.8
BC1	75-100	0.1	0.1	0.4	9.1	20.8	15.9	17.7	35.9
BC2	100-150	0.1	0.3	0.6	13.8	13.4	13.5	21.8	36.6
C	150-200	0.1	0.1	2.0	27.3	16.4	8.3	22.6	23.3

Depth cm	Exchangeable cations (me/100g)					CEC	CEC	Base
	Ca	Mg	K	Na	sum	soil	clay*	sat.%
0- 10	0.8	1.9	0.6	0.1	3.4	21.2		20.3
10- 30	0	0.1	0.1	0.2	0.4	13.1	31.3	3.1
30- 50	3.5	0.1	0.1	0	3.7	11.8	46.8	31.4
50- 75	0	0.1	0.2	0.5	0.8	12.7	33.5	6.3
75-100	0	0.1	0.2	0.3	0.6	13.1	34.4	4.6
100-150	0	0.1	0.1	0.1	0.3	15.2	38.2	2.0
150-200	0	0.1	0.1	0	0.2	13.3		1.5

* values corrected for organic matter, non corrected values are given top to bottom: 0.2; 43.8; 37.2; 37.6; 36.5; 41.5 and 57.1

Depth cm	Clay minerals			Non-clay minerals
	Kaol*	Chlr/Verm	pyro/phyll	Goeth
0- 10	++	+ - ++	0 - tr	tr
10- 30	++	+ - ++	0 - tr	tr
30- 50	++	+ - ++		tr
50- 75	++	+ - ++		tr
75-100	++	+ - ++		tr - x
100-150	++	+ - ++		tr - x
150-200	++	+ - ++		tr

* poorly crystallized

Soil Profile Description CO. 06

Date	: 9 July 1981
Location	: 24 km N of Leticia, at the end of jungle trail
Physiography	: undulating in places rolling plain
Altitude	: 250 m
Geology	: Tertiary non consolidated sedimentary and volcanic rocks
Parent material	: clayey sediment
Vegetation/Land Use	: tropical rainforest (bosque bajo, poco desarrallado sobre terrases con mal drenaje, presencia de cauces abandonados; sotobosque muy denso con abundancia de palmas - PRORADAM, 1979)/presently no distinct use; land capability class VII; at the end of the trail an area of about 100 ha is being cleared for cultivation
Soil climate	: SMR is perudic, STR is isohyperthermic
Ecological zone	: Bh-T bosque húmedo tropical
Drainage	: well drained
Moisture conditions	: moist throughout

Soil Field description

Horizon	Depth cm	Description
Ah	0- 11	Dark greyish brown (10 YR 4/2) moist, with few fine faint diffuse strong brown (7.5 YR 5/8) mottles, sandy clay; weak fine subangular blocky; hard dry, friable moist, non sticky, non plastic wet; common fine and medium pores; common fine and medium roots; gradual wavy boundary to
AB (E)	11- 29	Brownish yellow (10 YR 6/6) moist, sandy clay; weak fine subangular blocky to porous massive; hard dry, friable moist, non sticky, non plastic wet; common pores; common fine and medium roots; gradual wavy boundary to
BA (E)	29- 50	Brownish yellow (10 YR 6/8) moist, clay; weak fine subangular blocky to porous massive; few thin cutans; hard dry, friable moist, non sticky, non plastic wet; common pores; few fine roots; gradual smooth boundary to
Bw1	50- 70	Strong brown (7.5 YR 5/8) moist, clay; weak fine subangular blocky to porous massive; few thin cutans; hard dry, friable moist, non sticky and plastic wet; common pores; gradual smooth boundary to
Bw2	70-100	Reddish yellow (5 YR 6/8) moist, clay; porous massive; hard dry, friable to firm moist, sticky and very plastic wet; few small soft concretions (lithorelicts); common pores; few roots; gradual smooth boundary to
BC1	100-125	Yellowish red (5 YR 5/8) moist, clay; porous massive; very hard dry, firm moist, sticky and very plastic wet; very few small soft concretions (lithorelicts)
BC2	125-150	Yellowish red (5 YR 5/8) moist with few medium, distinct clear light grey (10 YR 7/2) mottles, clay; porous massive; hard dry, firm moist, sticky and very plastic wet; few weathering rock fragments

Remarks: according to PRORADAM (1979) the soil belongs to map unit YCde, it occurs on denudation surfaces; e.g. concave-convex strongly dissected plains; compare profile PR 40 - tropeptic Haplortox

Table 33. Laboratory data of CO.6 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture			pH	%
		sand	silt	clay	1:1	moisture
Ah	0- 11	70	22	8	3.6	1.0
AB	11- 29	52	26	22	4.2	1.0
BA	29- 50	48	26	26	4.4	1.0
BW1	50- 70	46	24	30	4.3	1.0
BE2	70-100	50	18	32	4.0	1.0
BC1	100-125	48	16	36	4.0	1.0
BC2	125-150	44	16	40	4.2	1.0

Depth cm	Exchangeable cations (me/100g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 11	2.9	1.2	0.2	0.1	4.4	23.4	18.8	292.5
11- 29	0.2	0.2	0.1	0.1	0.6	9.3	6.5	42.3
29- 50	0.2	0.2	0.1	0.1	0.6	7.3	8.2	28.1
50- 70	0.2	0.2	0.1	0.1	0.6	6.9	8.7	23.0
70-100	0.2	0.2	0.1	0.1	0.6	6.9	8.7	21.6
100-125	0.2	0.2	0.1	0.1	0.6	3.2	18.8	8.9
125-150	0.2	0.2	0.1	0.1	0.6	7.7	7.8	19.3

Depth cm	Organic matter			P	Exchangeable (me/100g)			% Al
	%C	%N	C/N	ppm	Al	H	total	sat.
0- 11	6.06	0.35	17	3	2.0	1.3	3.3	8.5
11- 29	1.08	0.09	12	1	2.9	0.3	3.2	31.2
29- 50	0.68	0.06	11	1	2.4	0.1	2.5	32.9
50- 70	0.40	0.05	8	1	2.4	0.2	2.6	34.8
70-100	0.27	0.03	9	1	2.9	0.3	3.2	42.0
100-125	0.20	0.02	10	1	3.0	0.4	3.4	93.8
125-150	0.27	0.03	9	1	3.5	0.3	3.8	45.5

Table 34. Laboratory data of CO.6 (by ISM)

Horizon	Depth cm	Texture (µm weight %)							
		sand					silt		clay
		2000-1000	1000-500	500-250	250-100	100-50	50-20	20-2	<2
Ah	0- 11	0.5	3.6	19.9	32.3	10.6	9.9	7.8	15.5
AB	11- 29	0.3	2.3	13.0	25.5	12.3	9.7	12.5	24.3
BA	29- 50	0.4	2.1	11.5	23.7	11.6	11.3	9.4	30.0
BW1	50- 70	0.3	2.1	11.6	23.6	11.2	14.0	6.8	30.4
BW2	70-100	0.5	2.2	12.1	24.2	11.1	10.8	8.4	30.8
BC1	100-125	0.3	2.0	12.1	22.4	10.7	8.3	7.1	37.2
BC2	125-150	0.3	1.9	11.0	21.0	8.9	9.2	8.2	39.5

Depth cm	Exchangeable cations (me/100g)					CEC soil	CEC clay*	Base sat.%
	Ca	Mg	K	Na	sum			
0- 11	0	0.5	0.2	0	0.7	17.2		4.1
11- 29	0	0.1	0.2	0.2	0.5	11.9	31.6	4.2
29- 50	0	0.1	0.1	0.1	0.3	10.6	26.3	2.8
50- 70	0	0.1	0.2	0.3	0.6	9.9	27.7	6.1
70-100	0	0.1	0.1	0.1	0.3	10.5	30.4	2.9
100-125	0	0.1	0.1	0.1	0.3	10.1	25.1	3.0
125-150	0	0	0.1	0.1	0.2	10.7	24.1	1.9

* values are corrected for organic matter; non corrected values are: 111,0; 49.0; 35.3; 32.6; 34.1; 27.2 and 27.1

Depth cm	Clay minerals			Non-clay minerals
	Kaol	Chl/Verm	Pyro/phyll	Goeth
0- 11	+++	+ - ++	tr	tr
11- 29	+++	+	0 - tr	tr
29- 50	+++	+	tr	tr
50- 70	+++	+	tr	tr
50-100	+++	+	0 - tr	0 - tr
100-125	+++	+	0 - tr	0 - tr
125-150	+++	+	0 - tr	

IE Pasto area (Andes)

This area contrasts strongly with the Llanos and Amazonia with regard to all factors of soil formation and land use. The climate may vary considerably over short distances because of varied topography, while the parent material is strongly influenced by admixtures of volcanic ash or is totally composed by ash and tuff.
Detailed information is available by Calhoun (1971), and Luna & Calhoun (1973).

Climate

Climatic data are derived from Pasto Airport and given in Table 35(& Fig.5).

Table 35. Climatic data Pasto Airport (altitude 1796m; source HIMAT, 1981)

Month	rainfall in mm(P)	T_{mean}	T_{max}	T_{min}	rel. hum.%	evap. (E)	period	max. in 24 hours
Jan	89.5	18.7	29.2	5.0	82	116.3	P 1957-1975	50.0
Feb	83.5	18.8	29.2	5.0	80	107.3	T 1961-1975	50.0
Mar	91.4	18.8	29.2	6.0	81	123.7	E 1972-1975	95.0
Apr	146.7	18.7	29.8	9.0	82	115.4	Hum. 1958-1975	61.0
May	131.5	19.1	29.2	7.0	82	109.4		50.0
June	74.7	19.0	29.2	7.0	80	109.4		48.0
July	20.0	19.5	30.4	8.0	74	123.8		41.0
Aug	22.0	19.4	30.4	7.0	75	119.7		53.0
Sept	45.3	19.5	33.0	7.0	74	116.4		50.0
Oct	155.6	17.8	30.0	7.0	81	124.0		53.1
Nov	150.8	17.7	27.2	6.0	85	112.9		60.0
Dec	117.6	18.0	27.4	8.0	84	107.3		60.0
Year	1128.6	18.8	33.0	5.0	80	1385.6		95.0

According to Calhoen (1971) there is considerable variance in rainfall in relation to altitude, while for every 1000 m rise there is a decline in temperature with 6°C. Data are summarized in the following Table.

Table 36. Altitude, rainfall and temperature in the Pasto Area

altitude	rainfall	temperature
2750 m	781 mm	13°C
2670 m	700 mm	13°C
1400 m	1392 mm	20°C
(0 m	2849 mm	26°C)

Source: Calhoen, 1971

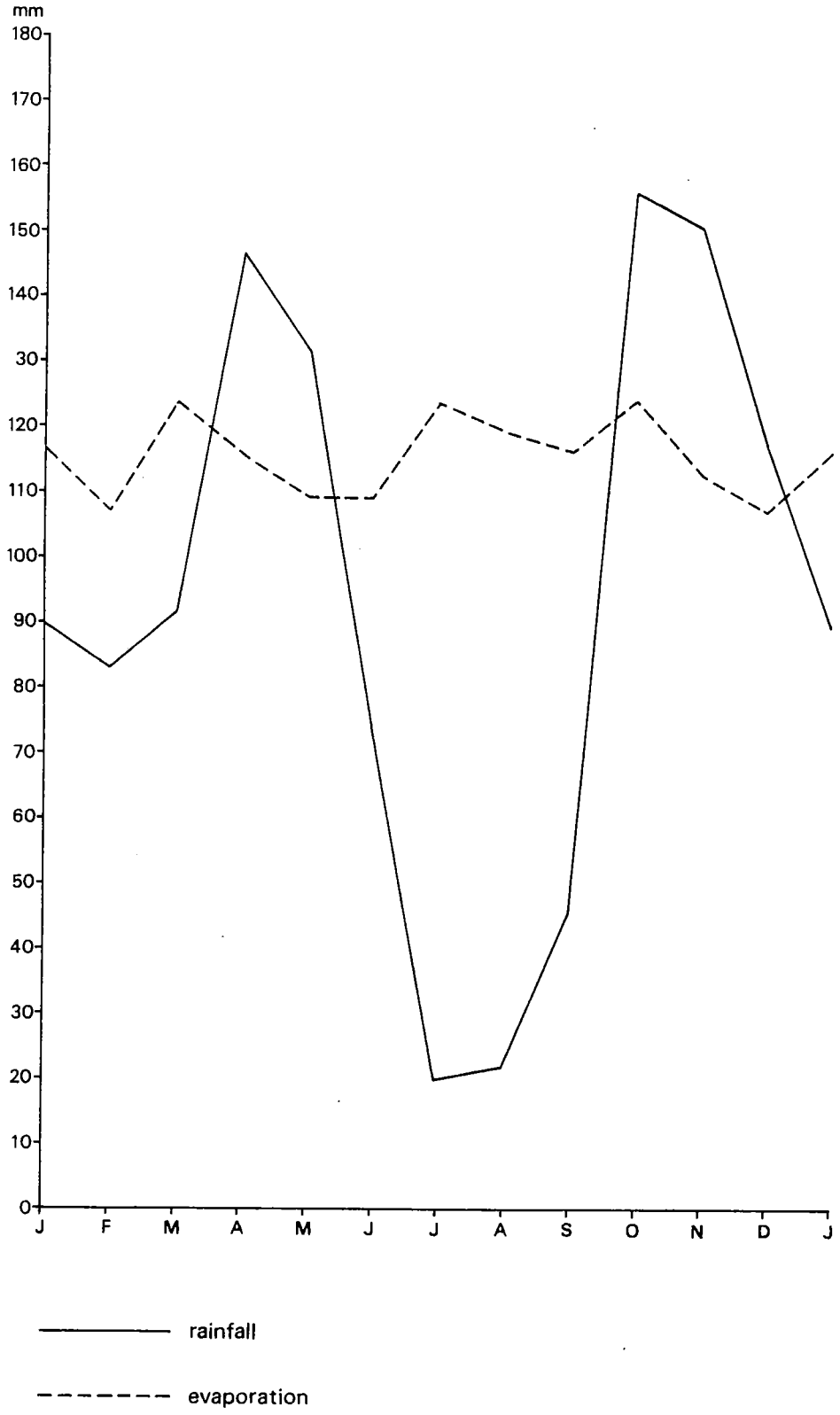
The ecological data of the four profiles taken in the Pasto area are given in Table 37.

Table 37. Ecological data soil monoliths Pasto Area

Altitude	No. profile	Temperature	Ecological zone
2350 m	CO.12	12-18°C	humid forest - lower montane
3100 m	CO.11	9-12°C	humid montane forest
3240 m	CO.13	9-12°C	humid montane forest
3810 m	CO.14	3- 9°C	grassland sub-alpine

Source: Calhoen, 1971

Fig. 5 Climatic graph Pasto



The preliminary soil classification of the four Andosols is presented in Appendix II and Tables 46 and 47.

Land use

Climate and physiography play an important part in the criteria that decide land use.
At medium and lower altitudes a multitude of crops may be grown, in addition to the keeping of livestock and poultry.
At higher elevations grazing is common. Present land use at the four sites is indicated in the following Table.

Table 38. Land use at the four Pasto sites

Profile no.	L U T	Crops grown
CO.11	pasture, intensive grazing	maize, potatoes, beans, pinus
CO.12	sisal, small scale, medium input	eucalipthus, pinus
CO.13	low montane forest	eucalipthus, pinus
CO.14	montane grassland, extensive grazing, with same bushes, low input	eucalipthus, pinus

The soils were also rated according to a recently introduced system at the ISM. Although the rating of the soil derived land qualities is preliminary, it points out the limitations of the soils for agricultural production.
The results are presented in the following Table.

Table 39. Rating of soil derived land qualities profiles CO.11-CO.14 (ISM method)

Soil derived land quality	CO.11	CO.12	CO.13	CO.14	Remarks
moisture	(3)*	(2)	(3)	(4)	
oxygen	1	1	3	1	
flooding	1	1	1	1	
nutrients	5	5	5	5	base saturation is most limiting soil property
toxicity	1	1	1	1	
stability	(5)	(5)	(5)	4	
arability	1	1	1	4	
tilth	1	3	3	5	
foothold	1	1	1	4	

Key:

evaluation	presence/absence of limiting soil characteristics (factor)
1 - very high	absence of any limiting soil characteristics
2 - high	slight limitation by one soil characteristic
3 - moderate	moderate limitation(s) by one or more characteristic(s)
4 - low	serious limitation(s) by one or more characteristic(s)
5 - very low	very serious limitation(s) by one or more characteristic(s)

* more elaborate pretreatment may cause an increase in the clay percentage thus causing different si/c ratio's and % clay

Soil Profile Description CO.11

Date : 28 July 1981.

Location : 15 km South of Pasto; plancha 429, 1:100,000, 1°07 N - 77°22' E (Narino).

Physiography : undulating volcanic plain; slope 8%.

Altitude : 3100 m.

Geology : Tertiary-Quaternary andesitic lava TQ vp.

Parent material : andesitic volcanic ash.

Vegetation : original vegetation of Bosque humido montano Bayo has been cleared for pasture.

Land use : intensive pasture at the site, however in the immediate environment also cultivation of maize, potatoes and beans; also plantations of Eucaliptus and Pinus. In associated lower areas where Alfisols occur the cultivation of cereals is common, like wheat and barley.

Soil climate : SMR is udic, STR is isomesic.

Ecological zone : bh-MB; bosque húmido montano bajo.

Drainage : well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth in cm	Description
Ah1	0-30	Black (10yR2.5/1) moist, loam; strong fine and medium granular; soft dry, friable moist, non sticky and non plastic wet; smeary; many fine medium and coarse pores; many fine and medium roots; reaction to NaF =9.8; pH 6,0; gradual smooth boundary to
Ah2	30-57	black (10YR2.5/1) moist, silt loam; moderate fine and medium subangular blocky; slightly hard dry, friable moist, non sticky and non plastic wet; smeary; few moderately thick organans; few to common small charcoal fragments; many fine medium and coarse tubular pores; common fine and medium roots; pH 5,5; gradual smooth boundary to
AC	57-80	very dark greyish brown (10YR3/2) moist, clay loam; weak fine to medium subangular blocky; slightly hard dry, friable to firm moist, slightly sticky and non plastic wet; common moderately thick organans and cutans;common charcoal fragments; common krotovina Ø 3 cm ellipsoidal; some whitish biological mottles; common fine, medium and coarse pores; common fine and medium roots; pH 5,5; gradual smooth boundary to

Horizon	Depth in cm	Description
C1	80-130	Dark brown (10YR3/3) moist, loam; weak medium to fine subangular blocky; soft dry, friable to firm moist, slightly sticky and non plastic wet; few krotovina's (Ø 3 cm); common fine, medium and coarse pores; common fine and medium roots; pH 5,5; gradual smooth boundary.
C2	130-150+	Brown (7.5YR4/4) moist, loam; porous massive, consistence and pores as C1; few fine roots; pH 5,0.

Remarks: thin Fe fibers occur at 150 cm; but are too deep to be diagnostic for the placic horizon; common earthworm activity from 0-80 cm, but especially from 0-50 cm; burrows and krotovina's are common from 57-80 cm; few occur between 80-130 cm.
Compare with profile L4 from the Calhoen Report (1971).

Table 40. Laboratory data of CO.11 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH 1:1	pH NaF	% moisture
		0.5-0.02 sand	0.02-0.002 silt	<0.002 clay	gravel			
Ah1	0- 30	66	30	4		5.2	11.2	6.4
Ah2	30- 57	72	26	2		5.7	11.3	7.5
AC	57- 80	72	26	2		5.8	11.0	7.5
C1	80-130	76	22	2		5.8	10.8	8.7
C2	130+	84	14	2		5.8	10.4	13.6

Depth cm	Exchangeable cations (me/100g)					Exch.	CEC	Base
	Ca	Mg	K	Na	sum	Al	soil	Sat.%
0- 30	3.4	2.1	0.3	0.1	5.9	1.1	54.9	10.7
30- 57	3.0	2.6	0.1	0.1	5.8		53.3	11.6
57- 80	1.3	2.6	0.3	0.3	4.5		46.9	9.6
80-130	2.2	2.2	0.9	0.1	5.4		55.2	9.8
130+	0.4	2.7	0.2	0.1	3.4		48.2	7.1

Depth cm	Organic matter			P	Cation saturation%			
	%C	%N	C/N	ppm	Ca	Mg	K	Na
0- 30	10.35			2	6.2	3.8	0.5	0.1
30- 57	7.31			1	5.6	4.9	0.2	0.1
57- 80	4.65			1	2.8	5.5	0.6	0.6
80-130	5.50			1	4.0	4.0	1.6	0.1
130+	2.95			1	0.8	5.6	0.4	0.2

In a similar soil to CO.11 sampled by Calhoen (1971) at a nearby site approximately 20 m higher the following data are obtained (profile L4 or no. 5 from the said report).

Table 41. Selected laboratory data of profile no. 5 (Source: Calhoen, 1971)

Depth cm	H_2O 15-bar	Bulk dens. g/cc	Δ pH pH H_2O-pH kcl	Exch. Al	Fe_2O_3
0- 55	30.9	0.49	0.6	1.46	1.58
55- 69	22.5	0.49	0.5	0.82	2.61
69- 94	11.9	-	0.5	0.49	2.81
94-139	22.3	0.45	1.0	0.50	4.25
139+	-	-	0.7	0.34	4.86

The light mineral fraction of the sand fraction is characterized by 1) feldspar, 2) volcanic grass, 3) some quartz, and 4) some biotite in surface soil. The number of lithorelicts increases with depth. The heavy fraction is dominated by 1) hornblende, 2) augite, and 3) hypersthene. Traces of oxy-

Soil Profile Description CO.12

Date : 29 July 1981.

Location : 2,5 km North of Narino; at 1°20'N-77°20'E.

Physiography : dissected footslopes of the Galeras volcano, slope 5%.

Altitude : 2350 m.

Geology : Tertiary-Quaternary andesitic lava, TQ vp.

Parent material : andesite ash and tuff.

Vegetation : Bosque humido montano (secco) bayo but cleared for cultivation.

Land use : at the site sisal, in the immediate surroundings also maize, potatoes, onions and Eucaliptus and Pinus.

Soil climate : SMR is udic, STR is isomesic.

Ecological Zone : bh-MB; bosque húmido montano bajo.

Drainage : well-drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth in cm	Description
Ah1	0-30	Dark brown (7.5 YR3/2) moist, loam, weak fine to medium granular; slightly hard dry, friable moist, non sticky and non plastic wet; few volcanic glass; reaction to NaF = 10; pH is 5,5; many fine, medium and coarse tubular pores; many fine medium and coarse roots; gradual smooth boundary to
Ah2	30-65	black (7.5YR2.5/0) moist, with few fine faint diffuse dark reddish brown (5YR3/4) mottles along rootchannels; sandy loam; weak fine to medium subangular blocky; slightly hard dry, very friable moist, slightly sticky and non plastic wet; many volcanic glass; roots and pores as Ah1; reaction to NaF = 10; pH is 7,0; gradual; in places clear ,smooth boundary to
AC	65-88	very dark grey (10YR3/1) moist, sandy loam; weak medium to fine subangular blocky; slightly hard dry, very friable moist, slightly sticky and non plastic wet; common volcanic glass; many fine, medium and coarse pores; few fine and medium roots; reaction to NaF = 10; pH is 5,5; gradual smooth boundary to

Horizon	Depth in cm	Description
C1	88-108	yellowish brown (10YR5/6) moist, clay loam; porous massive; slightly hard dry, very friable moist, slightly sticky and non plastic wet; few volcanic glass; reaction to NaF = 9,8; pH = 5,5; common pores; very few roots; gradual smooth boundary to
C2	108-150	yellowish brown (10YR5/8) moist, sandy loam; porous massive; soft dry, very friable moist, non sticky and non plastic wet; few volcanic glass, some rock fragments; pores and roots as C1; pH 5,5.

Remarks: depth of the C2 may attain 15 m, little evidence of fauna activity in the soil, some tubules; pH relatively high because of lower elevation, less rain, higher temperature.

(x)
volcanic glass determination is preliminary and needs mineralogical confirmation, the term is used to describe the quantaty of visible minerals in the soil material in general

Table 42. Laboratory data of CO. 12 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	pH	%
		sand	silt	clay	gravel	1:1	NaF	moisture
Ah1	0- 30	64	34	2		5.2	11.5	5.3
Ah2	30- 65	74	24	2		5.6	11.4	5.3
AC	65- 88	78	20	2		5.6	11.4	11.1
C1	88-108	no dispersion*				5.7	11.1	12.3
C2	108-150	no dispersion*				5.9	10.9	3.1

Depth cm	Exchangeable cations (me/100g)					Exch.	CEC	Base
	Ca	Mg	K	Na	sum	Al	soil	sat.%
0- 30	0.4	2.5	0.2	0.1	3.2	1.5	54.3	5.9
30- 65	1.2	2.9	0.1	0.1	4.3		41.7	10.3
65- 88	0.2	0.2	0.1	0.1	0.6		62.7	6.9
88-108	0.2	0.2	0.1	0.1	0.6		51.2	1.5
108-150	0.2	0.2	0.1	0.1	0.6		45.8	1.3

Depth cm	Organic matter			P	Cation saturation%			
	%C	%N	C/N	ppm	Ca	Mg	K	Na
0- 30	11.93			1	0.7	4.6	0.4	0.2
30- 65	7.02			1	2.9	7.0	0.2	0.2
65- 88	8.29			1	0.3	0.3	0.2	0.2
88-108	1.80			1	0.5	0.5	0.2	0.2
108-150	1.10			1	0.4	0.4	0.2	0.2

* indicates presence of amorphous materials as no dispersion in Na hexametaphosphate occurs

Soil Profile Description CO.13

Date : 30 July 1981.

Location : 14 km E. of Pasto; 1°10'N-77°11'E, (Narino).

Physiography : strongly dissected volcanic upland; slope 9%.

Altitude : 3240 m.

Geology : Quaternary andesitic lava, ash and tuff, TQ vl.

Parent material : non consolidated volcanic ash.

Vegetation : Bosque Humido muy Humido

Land use : -

Soil climate : SMR is udic, STR is isomesic; the site is influenced by wet cold winds blowing from the "Laguna la Cocha".

Ecological zone : bpM; bosque pluvial montano.

Drainage : moderately well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth in cm	Description
Ah1	0-12	Dark reddish brown (5YR2.5/2) moist, loam; very weak fine subangular blocky to massive; very friable moist, non sticky, non plastic wet; smeary; many fine and medium tubular pores; common fine and medium roots; gradual wavy boundary to
Ah2	12-30	black (5YR2.5/1) moist, loam; very weak fine subangular blocky to massive; consistence, pores and roots as Ah1; gradual wavy boundary to
AB	30-51	dark brown (7.5YR3/2) moist, loam; very weak fine subangular blocky to massive; very friable moist, non sticky non plastic wet; smeary; common fine and medium pores; common fine and medium roots; gradual wavy boundary to
Bh	51-78	very dark grey (10YR3/1) moist, loam; very weak fine subangular blocky to massive; very friable moist, non sticky and non plastic wet; smeary; common fine and medium pores; many fine and medium roots; abrupt wavy boundary to

Horizon	Depth in cm	Description
Bir	78-82	reddish brown (5YR4/3) moist, loam; strong medium platy; firm moist, non sticky non plastic wet; no roots; no pores; abrupt wavy boundary to
BC	82-98	very dark grey (10YR3/1) moist, with few medium, faint, diffuse yellowish brown (10YR5/6) mottles along root channels; loam; massive; very friable moist, non sticky and non plastic wet; smeary; few fine pores; few fine and medium roots; abrupt broken boundary to
C1	98-120	brownish yellow (10YR6/6) moist with common medium distinct yellowish red (5YR5/8) mottles; loam; massive; very friable moist, non sticky and non plastic wet; smeary; few fine and medium roots; abrupt wavy boundary to
C2	120-150	yellowish brown (10YR5/4) moist, with few medium distinct yellowish red (5YR5/8) mottles; loam; massive; consistence as C1.

Remarks: apart from the Ah1 horizon, a major occurrence of roots from 51-78 cm (the 13th h) just above the placic horizon. The latter acts as a pan and upholds water, resulting in seepage just above the Bir.

Table 43. Laboratory data of CO.13 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	pH	%
		sand	silt	clay	gravel	1:1	NaF	moisture
Ah1	0- 12	organic soil			33	3.8	6.5	13.6
Ah2	12- 30	organic soil			33	4.1	7.5	8.7
AB	30- 51	58	40	2		5.1	11.6	9.9
Bh	51- 78	54	42	4		5.3	11.5	8.7
Bir	78- 82	46	48	6	17	4.8	11.6	5.3
BC	82- 98	68	30	2		5.1	11.2	12.3
C1	98-120	76	22	2		5.3	11.0	9.9
C2	120-150	48	44	8		5.3	11.4	4.2

Depth cm	Exchangeable cations (me/100g)					Exch.	CEC	Base
	Ca	Mg	K	Na	sum	Al	soil	Sat.%
0- 12	14.1	2.3	0.9	0.3	17.6	7.3	125.0	14.1
12- 30	0.4	0.2	0.2	0.1	0.9	9.3	81.3	1.1
30- 51	0.2	0.2	0.2	0.1	0.6	3.1	75.6	0.8
51- 78	0.2	0.2	0.1	0.1	0.6	0.4	55.7	1.1
78- 82	0.2	0.2	0.1	0.1	0.6	4.4	54.8	1.1
81- 98	0.2	0.2	0.1	0.1	0.6	0.4	74.6	0.8
98-120	0.2	0.2	0.2	0.1	0.7	0.2	43.5	1.6
120-150	0.2	0.2	0.1	0.1	0.6	1.4	25.0	2.4

Depth cm	Organic matter			P	Cation saturation %			
	%C	%N	C/N	ppm	Ca	Mg	K	Na
0- 12	34.08			8	11.3	1.8	0.7	0.1
12- 30	25.38			4	0.5	0.2	0.2	0.1
30- 51	11.07			1	0.3	0.3	0.1	0.1
51- 78	6.01			1	0.4	0.4	0.2	0.2
78- 82	10.25			3	0.4	0.4	0.2	0.2
82- 98	8.01			1	0.3	0.3	0.1	0.1
98-120	3.00			1	0.5	0.5	0.5	0.2
120-150	1.53			52	0.8	0.8	0.4	0.4

Soil Profile Description CO.14

Date : 30 July 1981.

Location : 18 km West of Pasto by road to the summit of the Galeras volcano; slope 38%; 1°10'N-77°22'E (Narino).

Physiography : North slope of the Galeras volcano.

Altitude : 3810 m.

Geology : Quaternary volcanic lava, ash and tuff, TQ vl.

Parent material : partly consolidated volcanic ash, tuff and cinders.

Vegetation : Bosque muy humido montana; (montane grassland with herbs and some shrubs).

Land use : none.

Soil climate : SMR is udic, STR is cryic.

Ecological zone : bmh-M; bosque muy húmido montano.

Drainage : well drained.

Moisture conditions: moist throughout.

Soil Field Description

Horizon	Depth in cm	Description
Ah1	0-30	Very dark grey (7.5YR3/1) moist, slightly gravelly sandy loam; weak fine granular; slightly hard dry, friable moist, non sticky and non plastic wet; few fine rocky fragments; many fine medium and coarse pores; many fine and medium roots; gradual wavy boundary to
Ah2	30-50	dark brown (7.5YR3/2) moist; slightly gravelly sandy clay loam; weak fine granular; slightly hard dry, friable moist, slightly sticky and slightly plastic wet; pores and roots as Ah1; gradual wavy boundary to
Ahb	50-68	very dark grey (10YR3/1) moist with common medium, distinct dark yellowish brown (10YR4/4) "mottles"; loam; porous massive; slightly hard dry, friable moist, slightly sticky and slightly plastic wet; slightly smeary; common fine and medium pores; many fine and medium roots; clear wavy boundary to

Horizon	Depth in cm	Description
C	68-98	yellowish brown (10YR5/6) moist; sandy clay loam; porous massive; slightly hard dry, friable moist, slightly plastic wet; common fine and medium pores; common fine and medium roots; clear wavy boundary to
IIAB	98-150	black (10YR2.5/1) moist; loam; porous massive; soft dry, very friable moist, slightly sticky and plastic wet; smeary; common fine and medium pores; common fine and medium roots.

Table 44. Laboratory data of CO.14 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	pH	%
		sand	silt	clay	gravel	1:1	NaF	moisture
Ah1	0- 30	60	38	2		5.5	11.0	3.1
Ah2	30- 50	78	20	2	37	5.6	10.8	3.1
Ah6	50- 68	64	34	2	33	5.4	11.3	3.1
C	68- 98	74	24	2	37	5.3	11.1	2.0
IIAB	98-150	74	24	2		5.2	10.6	3.1

Depth cm	Exchangeable cations (me/100g)						CEC	Base
	Ca	Mg	K	Na	sum	Al exch.	soil	Sat.%
0- 30	3.2	1.6	0.1	0.3	5.2	0.2	35.9	14.5
30- 50	0.4	1.2	0.1	0.2	1.9		22.3	8.5
50- 68	0.4	1.2	0.1	0.1	1.8	0.2	35.9	5.0
68- 98	0.4	1.2	0.2	0.2	2.0	0.2	33.5	6.0
98-150	0.4	1.2	0.4	0.1	2.1	2.7	33.4	6.3

Depth cm	Organic matter			P	Cation saturation %			
	%C	%N	C/N	ppm	Ca	Mg	K	Na
0- 30	6.19			1	8.9	4.5	0.3	0.8
30- 50	2.68			1	1.8	5.4	0.4	0.8
50- 68	6.46			1	1.1	3.3	0.3	0.3
68- 98	6.94			1	1.2	3.6	0.6	0.6
98-150	8.04			2	1.2	3.6	1.2	0.3

Profile L5 (No. 6 in the Calhoen report) represents a soil somewhat similar to CO.14. Some data are presented in the following Table.

Table 45. Selected laboratory data of profile No. 6 (source: Calhoen, 1971)

Depth cm	H_2O 15-bar	Bulk dens. g/cc	Δ pH pH H_2O-pH kcl	Exch. Al	Fe_2O_3
0- 38	35.9	0.49	0.8	4.51	1.32
38- 51	-	-	0.9	-	-
51- 98	10.4	0.66	0.7	0.88	1.64
98-135	-	-	-	-	-
135-190	-	-	-	-	-

The light mineral fraction of the sand fraction is characterized by feldspars and volcanic glass. In the subsoil some biote is present. The heavy minerals are mainly composed of hornblende, augite and hyperthene.
There are traces of oxy-hornblende, zircon and biotite. The mineral composition is tied to the various horizons.

APPENDIX 2

Soil classification and correlation

The criteria for soil classification as outlined by Soil Survey Staff (1975) are strictly adhered to. The presented data indicate for a number of soils in the Amazonia of Colombia a departure from the zonal classification into the Oxisol order. The recognition of an argillic or cambic horizon under humid tropical conditions and subsequent classification in the Ultisol or Inceptisol order implies that the total acreage of the Oxisols or Ferralsols on the FAO World Soil Map is exagerated in the Amazonia region of Colombia. The findings are in agreement with observations made by Mejia (1975) and Benavides (1973).
The diversity of the soils may partly be due to the composition of the parent material, which is in nearly all cases of sedimentary origin.
Especially in the eastern parts of the Llanos and the Amazonia a rejuvination of the soil material by volcanic ash admixture as a water or wind deposit is not to be excluded.

The soils are classified according to the FAO/Unesco Soil Map of the World Legend (1974) and the USDA Soil Taxonomy (1975).
This classification is an approximation as not all physical and chemical data on the soil properties are available.
For all soils an attempt is made to recognize the epipedon, the diagnostic subsoil horizon and other diagnostic properties and subsequently place the soil in the two systems mentioned above.
In Colombia the USDA Soil Taxonomy is adhered to for national soil surveys.

Profile CO.1

Epipedon

The surface horizon meets the criteria for a mollic A horizon but for the very low base saturation percentage. Therefore an *Umbric* epipedon is recognized.

Subsoil

An increase in clay is felt and seen (cutans) in the field and confirmed by laboratory data. An absolute increase of clay is reported with depth and reflected by the ration Bt1/AB>1.2. In addition the percentage clay does not decrease from its maximum amount by as much as 20% within 150 cm from the surface (deep stretched clay "bulge").

The soil profile

According to the FAO/Unesco (further referred to as "FAO") the soils classifie as a *Nitosol* and because of the presence of an Umbric A horizon as a *humic Nitosol*.
In the Soil Taxonomy the soil belongs to the order Ultisols, suborder Humults (the upper 15 cm of the Bt contains 0.88 (=0.9%)C).
The great group is Palehumults and at subgroup level Orthoxic is designated, e.g. *Orthoxic Palehumult*.
Because of the *Ustic* soil moisture regime the full classification at subgroup level may be: Orthoxic-Ustic Palehumult.
If the criterion for the %C content in the Bt is not met the soil classifies as a Paleustult.
On *family* level the soil classifies as: fine clayey, kaolinitic, acid, isohyperthermic.

Profile CO.2

Epipedon

As data on organic matter are not yet available no definite statement can be made on the type of epipedon present.
However, the percentage organic carbon is expected to be >1%, while also a very low base saturation is anticipated. However an *Umbric* A horizon is not recognized as the depth and colour requirements are not fully met, thus an *ochric* epipedon is classified.

Subsoil

There is no report on a substantial clay increase, while the CEC of the clay fraction is just more than 16 me/100g clay. The data support the presence of a *Cambic* horizon.

The soil profile

In the FAO system the soil is classified as a Cambisol and because of the low CEC clay in the B horizon, less 24 me/100g, *ferralic Cambisol*.
According to the Soil Taxonomy the soil belongs to the order Inceptisols, suborder Tropepts and because of very low base saturation as Dystropept at the great group level. The CEC clay is <24 me/100 g clay while the soil moisture regime is ustic. At subgroup level an *oxic-ustic Dystropept* is recognized.
On the *family level* the following parameters apply: clayey, kaolinitc, (acid), isohyperthermic.

Profile CO.3

Epipedon

On the basis of colour, thickness and % C an *ochric* A horizon is recognized.

Subsoil

Although there is no clear evidence of clay translocation in the field, laboratory data as well as micromorphological observations support the recognition of a Bt horizon with low base saturation and low CEC.

The soil profile

According to the FAO Legend the soil belongs to the unit Acrisols. In addition the occurrence of plinthite is seen (from 60-90cm) therefore the soil classifies as a *plinthic Acrisol*.
In the Soil Taxonomy the soil belongs to the order Ultisols, suborder Ustults,

great group Plinthustults. Because of low CEC clay (16-24 me/100g clay) in the major part of the Bt, the subgroup is designated as oxic, e.g. *oxic Plinthustult.*
On the *family level* the following criteria are met: coarse loamy, kaolinitic, acid, isohyperthermic.

Profile CO.4

Epipedon

Although the criterion for percentage organic matter is met for mollic/umbric epipedon, the A horizon fails the other ones. Therefore an *Ochric* A horizon is recognized.

Subsoil

There is no evidence of clay translocation in the field which is confirmed by laboratory analyses and micromorphological evidence. Therefore a *Cambic* B horizon (Bw) is recognized, with low base saturation.

The soil profile

In the FAO system the soil belongs to the unit Cambisols and subunit dystric; viz. *dystric Cambisols.*
According to the Soil Taxonomy the soil belongs to the order Inceptisols, suborder Tropepts, great group Dystropepts, subgroup Typic; e.g. *Typic Dystropepts.*
On the *family level* apply: fine loamy, kaolinitic, acid, isohyperthermic.

Profile CO.5

Epipedon

The bulk of the organic matter is confined to the top 10 cm and is well above 1%. However the other criteria are not met for the classification of an umbric/mollic A horizon, therefore an ochric epipedon is classified.

Subsoil

There is some field evidence for clay translocation which is supported by laboratory data. In thin section (sample at 40 cm depth) clay cutans and papules are observed in sufficient quantity to suggest that the process of clay translocation is active. Therefore an argillic B horizon (Bt) is recognized. In addition the presence of plinthite is observed within 125 cm depth.

The soil profile

According to the FAO the soil belongs to the unit Acrisol subunit *plinthic Acrisol*.
In the USDA Soil Taxonomy the soil classifies as order Ultisols, suborder Udults, great group plinthudults, subgroup typic; viz. *Typic Plinthudults*.
On the *family level* the following parameters apply: fine loamy, kaolinitic, acid, isohyperthermic.

Profile CO.6

Epipedon

Despite the high amount of organic matter in the very topsoil, the other criteria for a mollic/umbric horizon are not met, therefore an *Ochric* A horizon is classified.

Subsoil

There is some increase of clay with depth, which is partly evident in the field (few clay cutans) but not strongly supported by laboratory data nor micromorphological evidence. Also the CEC clay is too high to be diagnostic for an oxic horizon (both corrected and not corrected values for CEC clay are > 24 me/100g). Therefore a *Cambic* B horizon (Bw) is recognized.

The soil profile

In the FAO system the soil classifies as a Cambisol. There is considerable difference in the % clay obtained by ISM and IGAC analyses. This influences the calculation of the CEC clay. Therefore at subunit level the soil may be either ferralic or dystric. Thus *ferralic* or *dystric Cambisol*.
The USDA Soil Taxonomy places the soil as follows: order Inceptisols, suborder Tropepts; great group Dystropepts, subgroup oxic or typic; viz. *oxic* or *typic* Dystropept.
- Oxic if "have in all horizons above a depth of 1 m a CEC (by NH_4 OAc) of 24 or more me/100 g clay".

Profile CO.7

Epipedon

The A horizon meets the criteria for an *ochric* epipedon, as the depth requirement for umbric is not met. The soil has however a high organic matter content in the B horizon, thus qualifies for *humic*.
Subsoil

There is ample evidence in the field as well as in the laboratory for the presence of an argillic horizon (Bt). Cutans are easily observed in the

profile macroscopically and also in thin section. In addition the clay percentage increases with depth, to decrease beyond 125 cm from the surface. The base saturation percentage is very low and the CEC-clay in the Bt is less than 24 me/100 g clay.

The soil profile

According to the FAO Legend the soils belongs to the unit Acrisols with an ochric A horizon, but with a high organic matter content in the B. Therefore the soil classifies as a *humic Acrisol*.
According to the USDA Soil Taxonomy the soil belongs to the order Ultisols, suborder Humults, great group Palehumults, subgroup orthoxic, viz. *orthoxic Palehumults*.
At *family level* the following criteria apply: fine clayey, acid, isohyperthermic.

Profile CO.8

Epipedon

Although the organic matter content is high in the topsoil, the A horizon fails the thickness requirement for an Umbric A, therefore an *ochric* epipedon is recognized.

Subsoil

The subsoil exhibits features usually associated with an argillic horizon, viz. moderate angular blocky structure, presence of cutans (also confirmed in thin section) and a bulge-like clay increase with depth.
Therefore a Bt is classified. The base saturation percentage is very low while the CEC clay is between 16-24 me/100 g clay, in the major part of the argillic B horizon.

The soil profile

The soil classifies as an Acrisol according to the FAO Legend and as "ferric" on subunit level, e.g. *ferric Acrisol*.
In the Soil Taxonomy the soil is placed in the Ultisol order, suborder Udults, great group Tropudults, subgroup orthoxic, e.g. *orthoxic Tropudults*.
On the *family level* the following criteria apply: fine clayey, acid, isothermic.

Profile CO.9

Epipedon

The topsoil is not developed sufficiently to be classified as umbric but meets the ochric requirements, viz. *ochric*. There is much animal activity while also micaceous minerals are abundant macro- and microscopically seen.

Subsoil

An increase in clay is observed in the field and confirmed by laboratory data. In thin section fragments of clay cutans (papules) are observed. There is evidence that clay translocation is destroyed (obscured) by the soil fauna. However an *argillic* B horizon is classified (Bt) with very low base saturation and low CEC, but with high organic matter in the B horizon.

The soil profile

The clay distribution is such that a nitosol could be considered in the FAO system, but for the depth requirement ($\geq$ 150 cm), which is not met. The soil is placed in the unit Acrisol and because of high organic matter content in the B,as a *humic Acrisol*.
According to the USDA Soil Taxonomy the soil is placed in the order Ultisols, suborder Humults, great group Tropohumults, subgroup humoxic; e.g. *humoxic Tropohumult*.
At *family level* as: fine clayey, acid, isohyperthermic.

Profile CO.10

Epipedon

The organic matter content is very high but restricted to the very topsoil, viz. colour and thickness requirements fail an umbric epipedon, therefore an *Ochric* A horizon is recognized.

Subsoil

The amount of organic matter decreases regularly with depth, the texture remains the same throughout while the CEC soil is low and the base saturation is just above 35%.
The texture is a loamy sand throughout and the presence of albic material is recognized if, upon more detailed particle size determinations, the texture is not loamy very fine sand. If so, a cambic horizon is observed.

The soil profile

If the texture requirements for a cambic horizon are met the soil classifies as a *dystric Cambisol*, if not, as an *albic Arenosol* (FAO).
For the same reason the soil classifies as a *typic Dystropept* or *typic/lithic Quartzipsamments* (USDA).
On *family level:* sandy, acid, isothermic.

Profile CO.11[*]

Epipedon

All criteria for an *umbric* epipedon are met.

Subsoil

An A-C profile is recognized, although the subsoil shows some cambic properties. The laboratory texture is a sandy loam however dispersion is not complete and field texture is more reliable. In addition the soil material is considered smeary (thixotropic) in the upper part.

The soil profile

According to the FAO legend the soil is a *humic Andosol* if the texture is finer than silt loam, if not a *vitric Andosol*. Field evidence supports the former classification.
In the USDA Soil Taxonomy the soil belongs to the order Inceptisols, sub-order Andepts, great group Dystrandepts, subgroup hydric (because of the presence of thixotropic soil material between 25-100 cm depth), e.g. *hydric Dystrandepts*.
At *family level:* (loamy)-(ashy), thixotropic, amorphous, non calcareous,

[*] the soil materials of profiles CO. 11, 12, 13 and 14 are considered to meet low bulk densities (<0.85 g/cc) or 60% vitric ash requirements.

Profile CO.12

Epipedon

The soil material of the surface horizon meets the requirements of an *umbric* A horizon.

Subsoil

Because of difficult dispersion of some soil materials the data obtained by texture analysis must be viewed with care.
In the field a high percentage of clay and silts was assessed, which seems more appropriate than the sandy loam texture as obtained in the laboratory.
Base saturation is very low, while the soil material is considered non smeary.

The soil profile

According to the FAO the soil belongs to the unit *vitric Andosol.*
In the USDA Soil Taxonomy the soil is classified as follows: order Inceptisol, suborder Andept, great group Vitrandept, subgroup umbric; e.g. *umbric Vitrandept.*
At family level the following parameters apply: "sandy-ashy", amorphous, non calcareous, isomesic.

Profile CO.13

Epipedon

The organic matter content in the topsoil satisfies the demand for a histic horizon. However assuming that the bulk density is <1.0 g/cc the depth requirement (60 cm) is not met for a Histosol. Because of very low base saturation an *umbric* A horizon is classified.

Subsoil

The soil material is smeary in the larger part of the B horizon and thus considered thixotropic. Diagnostic is also the presence of a placic horizon from 78-82 cm depth.

The soil profile

According to the FAO the soil classifies as a humic Andosol, however because of the presence of the placic horizon, the subunit *placic Andosol* is proposed.
In the Soil Taxonomy the following classification applies: order Inceptisols, suborder Andepts, great group Placandepts; subgroup typic; viz. *typic Placandepts.*
At family level are considered: "sandy-ashy", thixotropic, amorphous, non calcareous, isomesic.

Profile CO.14

Epipedon

Criteria are met for the classification of an *umbric* A horizon.

Subsoil

In the subsoil a buried A horizon is observed from 50-68 cm depth, in addition the soil material is slightly smeary for the greater part, and the soil temperature class is considered cryic.

The soil profile

The soil belongs to the unit *humic Andosols* (FAO), however because of the cryic soil temperature regime the classification *cryic Andosol* is suggested. According to the Soil Taxonomy the soil belongs to the order Inceptisol, suborder Andepts, great group *Cryandepts*.
On family level apply: "sandy-ashy", thixotropic, amorphous, cryic.

A comparison between the various approaches to soil classification concerning these "volcanic ash" soils is given in Tables 46 and 47.

Table 46. Preliminary soil classification Pasto profiles

Profile	FAO	USDA
CO.11	humic Andosol	typic Dystrandept; sandy(ashy), thixotropic, amorphous, non calcareous
CO.12	vitric Andosol	typic Vitrandepth; sandy(ashy), amorphous, non calcareous
CO.13	placic Andosol	typic Placandepth; sandy(ashy), thioxotropic, amorphous, non calcareous
CO.14	cryic Andosol	typic Cryandepth; sandy(ashy), thiotropic, amorphous, non calcareous

The occurence of Vintrandepts and Placandepts was not reported on earlier. However, they were recently identified by a survey team of IGAC - Soils Laboratory in the area. The soils are closely associated with the other Andepts. In the area South of Pasto the Dystrandepts are associated with Alfisols at lower elevation.

The classification of the soils according to the Andisol proposal is given below. Because of limited data no classification beyond the Great Group is attempted.

Table 47. Preliminary classification with the proposed Andisol order

Profile no.	Order	Suborder	Great Group	Subgroup
CO.11	Andisols	Tropands	Haplotropands	(typic-eutic)
CO.12	Andisols	Tropands	Vitritropands	(typic-eutic)
CO.13	Andisols	Tropands	Placotropands	(typic)
CO.14	Andisols	Borands	Cryoborands	(typic)

Profiles CO. 15, 16, 17 and 18

No laboratory data are available as yet of these profiles and the preliminary remarks on their classification is based on field observations supplemented by report data on similar soils.

Profile CO.15

The A horizon is considered too thin and too light in colour to be umbric or mollic. Therefore the presence of an *ochric* epipedon is considered.
In the subsoil mottling is present similar to plinthic horizons, no textural increase is observed and CEC and base saturation values are considered low.
In the FAO system the soil is considered a *plinthic Ferralsol.*
According to the Soil Taxonomy the soil belongs to the order Oxisols, suborder Ustox, great group Haplustox, subgroup plinthic (proposed) e.g. *plinthic Haplustox.*
At family level: fine loamy to clayey, kaolinitic, acid, isohyperthermic.

Profile CO.16

The surface horizon is considered ochric, e.g. *ochric* epipedon.
In the subsoil there is not much evidence for clay translocation, while the soil material is not completely weathered. The presence of a cambic B (Bw) is considered, however with low base saturation and low CEC.
According to the FAO the soil may be classified as a *ferralic Cambisol.*
The soil belongs to the order Inceptisol, suborder Tropepts, great group Dystropepts, subgroup *ustoxic* (if CEC <16 me/100g clay); otherwise typic; e.g. *ustoxic Dystropepts.*
At family level apply: coarse to fine loamy, kaolinitic, acid, isohyperthermic.

Profile CO.17

The soil is formed on very recent alluvium and exhibits little soil profile development. An ochric A horizon is considered, underlain by "eutric"soil material.
In the FAO legend they may be classified as *eutric Fluvisols.*
According to the Soil Taxonomy the soil belongs to the order Entisols, suborder Aquents, great group Fluvaquents, subgroup tropic; thus, *tropic Fluvaquents.*
At the family level apply: coarse loamy, mixed, non calcareous, isohyperthermic.

Profile CO.18

The A horizon is classifed as *ochric.*
A buried A horizon is considered from 15-35 cm (sombric horizon).
The subsoil may further be characterized by low base saturation and low CEC clay.
The occurrence of plinthite may be considered within 125 cm from the surface.
In the FAO system the soil may be classified as a *plinthic Ferralsol.*
In the Soil Taxonomy the soil belongs to the order Oxisols, suborder Ustox, great group *Sombriustox.*
At family level apply: coarse to fine loamy, kaolinitic, acid, isohyperthermic.

Table 48. Soil classification

Profile No.	FAO/Unesco	Soil Taxonomy
CO.1	humic Nitosol	orthoxic Palehumult; fine clayey, kaolinitic, acid, isohyperthermic
CO.2	ferralic Cambisol	oxic-ustic Dystropept; clayey, kaolinitic, acid, isohyperthermic
CO.3	plinthic Acrisol	oxic Plinthustult; coarse loamy, kaolinitic, acid, isohyperthermic
CO.4	dystric Cambisol	typic Dystropept; fine loamy, kaolinitic, acid, isohyperthermic
CO.5	plinthic Acrisol	typic Plinthudult; fine loamy, kaolinitic, acid, isohyperthermic
CO.6	ferralic/dystric Cambisol	oxic or typic Dystropept; clayey, acid, iso-hyperthermic
CO.7	humic Acrisol	orthoxic Palehumult;fine clayey, acid, iso-hyperthermic
CO.8	ferric Acrisol	orthoxic Tropudult; fine clayey, acid, iso-hyperthermic
CO.9	humic Acrisol	homoxic Tropohumult; fine clayey, acid, iso-hyperthermic
CO.10	dystric Cambisol	typic Dystropept; sandy, acid, isohyperthermic
CO.11	humic Andosol	hydric Dystrandept ; loamy-ashy, thixotropic, amorphous, non calcareous, isomesic
CO.12	vitric Andosol	umbric Vitrandept; sandy-ashy, amorphous, non calcareous, isomesic
CO.13	"placic" Andosol	typic Placandept; sandy-ashy, thixotropic, amorphous, non calcareous, isomesic
CO.14	"cryic" Andosol	Cryandept; sandy-ashy, thixotropic, amorphous, cryic
CO.15	plinthic Ferralsol	plinthic Haplustox; clayey, kaolinitic, acid, isohyperthermic
CO.16	ferralic Cambisol	ustoxic Dystropepts; coarse to fine loamy, kaolinitic, acid, isohyperthermic
CO.17	eutric Fluvisol	tropic Fluvaquent; coarse loamy, mixed, non calcareous, isohyperthermic
CO.18	plinthic Ferralsol	Sombriustox; coarse to fine loamy, kaolinitic, acid, isohypertermic

APPENDIX 3

List of soil samples

Soils samples were taken according to the occurrence of the soil horizons (see Table 49).

Table 49. List of soil samples

Profile	Horizon	Depth in cm
CO.1**	Ap	0- 27
	AB	24- 47
	Bt1	47- 74
	Bt2	74-100
	BC	100-150
CO.2**	Ap	0- 12
	AB	12- 32
	BW1	32- 61
	BW2	61-100
	BWS	100-170
	BC	170-250
CO.3**	Ap	0- 16
	Bt1	16- 40
	Bt2	40- 60
	BCs	60- 90
	C	90-150
CO.4**	Ap	0- 10
	AB	10- 35
	BW1	35- 70
	BW2	70-100
	BC	100-150
CO.5**	Ap	0- 10
	AB	10- 30
	Bt1	30- 50
	Bt2	50- 75
	BC1	75-100
	BC2	100-150
	BC3	150-200
CO.6**	Ah	0- 11
	AB	11- 29
	BA	29- 50
	BW1	50- 70
	BW2	70-100
	BC1	100-125
	BC2	125-150
CO.7*	Ah	0- 20
	AB	20- 43
	Bt1	43- 60
	Bt2	60- 85
	Bt3	85-125
	BC	125-185
CO.8*	Ah	0- 8
	AB	8- 21
	Bt1	21- 50
	Bt2	50- 75
	Bts1	75-100
	BS	100-150
CO.9*	Ah	0- 10
	ABh	10- 20
	AB	20- 35
	Bt1	35- 55
	Bt2	55- 95
	BC	95-130
CO.10*	Ah	0- 5
	AB	5- 13
	B1	13- 21
	BC	21- 50
	C	50-130
CO.11*	Ah1	0- 30
	Ah2	30- 57
	AC	57- 80
	C1	80-130
	C2	130-150
CO.12*	Ah1	0- 30
	Ah2	30- 65
	AC	65- 88
	C1	88-108
	C2	108-150

(to be continued)

Profile	Horizon	Depth in cm
CO.13*	Ah1	0- 12
	Ah2	12- 30
	AB	30- 51
	Bh	51- 78
	Bir	78- 82
	BC	82- 98
	C1	98-120
	C2	120-150
CO.14*	Ah1	0- 30
	Ah2	30- 50
	ABh	50- 68
	C	68- 98
	IIAb	98-150
CO.15	Ah	0- 10
	B1	10- 40
	BS	40- 77
	BCs	77-108
	C	108-144
CO.16	Ah	0- 5
	AB	5- 25
	BW1	25- 37
	BW2	37- 65
	BW3	65- 87
	BC	87-108
	C	108-120
	R	120-170
CO.17	Ah	0- 12
	A12	12- 19
	A12	19- 43
	A13	43- 54
	A14	54- 79
	AC11	78- 86
	AC12	86-100
	AC13	100-103
	AC14	103-117
	AC15	117-121
	AC16	121-134

Profile	Horizon	Depth in cm
CO.18	Ah	0- 5
	A1	5- 15
	Ahb	15- 35
	AB	35- 59
	BS1	59- 86
	BS2	86-112
	BC	112-145
	C1	145-180
	C2	180-210

* routine laboratory analysis results available from IGAC
** routine laboratory analysis results available from IGAC/ISM as per 6 november 1981

Table 52. Laboratory data of CO.16 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	%
		sand	silt	clay	gravel	1:1	moisture
Ah	0- 5	42	48	10	83	5.1	2.0
AB	5- 25	34	48	18	90	4.8	1.5
BW1	25- 37	34	46	20	18	4.8	1.0
BW2	37- 65	36	40	24	45	5.1	1.0
BW3	65- 87	20	46	34		5.1	0.5
BC	87-108	26	40	34		5.2	1.0
C	108-120	16	46	38		5.1	1.5
(R)	120-170	40	22	38		5.1	1.5

Depth cm	Exchangeable cations (me/100 g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 5	4.5	0.8	0.3	0.2	5.8	10.6	54.7	106.0
5- 25	0.4	0.4	0.1	0.2	1.0	7.3	13.7	40.6
25- 37	0.2	0.2	0.1	0.2	0.7	6.5	10.8	32.5
37- 65	0.2	0.2	0.1	0.1	0.6	5.6	10.7	23.3
65- 87	0.2	0.2	0.1	0.2	0.7	6.4	10.9	18.8
87-108	0.2	0.2	0.1	0.2	0.7	7.3	9.6	21.5
108-120	0.2	0.2	0.1	0.2	0.7	7.7	9.1	20.3
120-170	0.2	0.2	0.1	0.2	0.7	10.1	6.9	26.6

Depth cm	%C	P ppm	Al	Cation saturation			
			me/100 g	Ca	Mg	K	Na
0- 5	2.31	3	0.1	42.4	7.5	2.8	1.9
5- 25	1.01	1	2.0	5.5	5.5	0.4	2.7
25- 37	0.67	1	2.0	3.1	3.1	1.5	3.1
37- 65	0.40	1	1.6	3.6	3.6	1.8	1.8
65- 87	0.27	1	3.1	3.1	3.1	1.6	3.1
87-108	0.20	1	3.4	2.7	2.7	1.4	2.7
108-120	0.20	1	4.3	2.6	2.6	1.3	2.6
120-170	0.13	1	4.3	2.0	2.0	1.0	2.0

Additional remarks on the soil classification

On the basis of the colour and the thickness of the A horizon an ochric epipedon is classified.

The laboratory data indicate possible clay illuviation, which however is not confirmed by the field observations. No data on thin sections are available as yet.
The CEC soil is low and the calculated CEC clay is between 16-24 me/100 g clay in some part of the B horizon.
If no Bt is observed the soil belongs to the FAO Soil Map of the World unit ferralic Cambisols, if a Bt is considered as a ferric Acrisol.
According to the Soil Taxonomy the soil classifies as an ustoxic Dystropept (without Bt) or as an oxic Haplustalf (with Bt).

Supplementary data of profiles CO. 15, 16, 17 and 18.

Table 51. Laboratory data of CO.15 (by Soils laboratory IGAC)

Horizon	Depth cm	Texture				pH	%
		sand	silt	clay	gravel	1:1	moisture
Ah	0- 10	44	46	10	-	5.1	2.0
B1	10- 40	28	42	30	36	5.0	0.5
Bs	40- 77	20	44	36	47	5.0	1.0
BCs	77-108	14	56	30	-	4.8	3.1
C	108-144	28	40	32	-	5.0	3.1

Depth cm	Exchangeable cations (me/100g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 10	4.1	3.3	0.5	0.2	8.1	14.3	56.6	143.0
10- 40	1.2	0.8	1.1	0.3	3.4	11.5	29.6	38.3
40- 77	0.8	0.4	1.0	0.3	2.5	11.0	22.7	30.6
77-108	0.2	0.2	0.2	0.2	0.8	9.9	8.1	33.0
108-144	0.2	0.2	0.2	0.2	0.8	15.7	5.1	49.1

Depth cm	%C	P ppm	Al me/100g	Cation saturation			
				Ca	Mg	K	Na
0- 10	3.33	7	6.1	28.7	23.1	3.5	1.4
10- 40	0.87	1	4.4	10.3	6.9	9.5	2.6
40- 77	0.33	2	6.0	7.3	3.6	9.1	2.7
77-108	0.28	4	6.1	2.0	2.0	2.0	2.0
108-144	0.34	4	9.2	1.3	1.3	1.3	1.3

Additional remarks on the soil classification.

Although the surface horizon contains a relatively high amount of organic matter, it is too light and too thin to be classified as umbric, therefore an ochric epipedon is recognized.

The laboratory data indicate an increase of clay with depth, sufficiently for the classification of an argillic B horizon, e.g. ratio B/eluvial horizon is 1.2.
There is however little supporting field evidence, while no information from thin sections is available.
The CEC clay as calculated from the CEC soil is more then 24 me/100 g clay throughout the profile, and therefore too high to be oxic.
If no Bt is recognized to soil is considered to have a cambic horizon, and according to the FAObelongs to the unit "ferric" Cambisols. If a Bt is seen the soil belongs to the plinthic Acrisols.
In the Soil Taxonomy the classification could be respectively ustoxic Dystropepts or Plinthustults.

APPENDIX 5

Methods of Soil Analysis

IGAC Soils Laboratory

texture	: pretreatment with H_2O_2, dispersion with sodium-hexametaphosphate; sand and clay with the hydrometer method, silt by subtraction
pH	: in soil:water ration 1:1, readings with pH meter with glass electrodes in the suspension
% moisture	: % water on basis of dried sample at 105°C
exchangeable cations	: by NH_4OAc at pH7 (see below)
CEC-soil	: determined at pH7 (see below)
CEC-clay	: calculated as CEC-soil x 100 / % clay, if corrected for organic matter then 1%C = 4.5 me
base saturation	: calculated as sum of bases x 100 / CEC-soil
%C	: Walkley-Black method
%N	: Kjeldahl method
organic matter	: calculated as %C x 1.72
exchange acidity	: by KCl and titration with NaOH
cation saturation	: calculated as cation x 100 / sum of bases
Pppm	: Bray II

ISM Soils Laboratory

texture	: pretreatment with H_2O_2, dispersion by short (1 min.) treatment in milkshaker; silt and clay with pipette method, sand fractions washed, dried and sieved
exchangeable cations	: percolation of a 5 g sample with NH_4OAc (pH7), determination of Ca, Mg, K and Na by AAS
CEC-soil	: above NH_4OAc saturated sample is leached with 1N sodium acetate (pH7) and washed free of salts; the sample is then leached with 1N ammoniumacetate (pH7) and Na is measured in the leachate by AAS
CEC-clay	: as above
base saturation	: as above
X-ray diffraction	: 10 mg of separated clay from the texture analysis is brought onto a porous plate by suction and specimens are analysed on a Philips diffractometer.

Remark

In addition to the determinations carried out at the IGAC Soils Laboratory, values on texture and CEC were also obtained from the ISM soil laboratory (profiles CO1 to CO 6).
The results compare satisfactorily, differences are mainly due to variances in laboratory procedures.
Differences in clay percentages and CEC may cause difficulties with regard to the recognition of argillic and/or oxic horizons.

APPENDIX 4

Equipment for NSRC at IGAC, Bogota

Table 50. Summarized list of items purchased for NSRC Colombia

- 7 wooden boxes à 150 cm + lids
- 12 wooden boxes à 120 cm + lids
- 31 monolith mounds
- pF rings, 7 boxes à 24 rings
- pF press for rings
- Sigma CL33, profile varnish, 9 tins à 10 l
- Sigma CL105 thinner, 20 tins à 5 l
- Lacquer S9, 17 tins à 1 l
- Thinner S9, 42 tins à 1 l
- Wood clamps, 8 large size
- Copper spray can with 2 mottles
- Plastic measuring cans 1x2l, 2x1l
- Masks (air filters), 2
- Crowbars, 2
- Spade 1
- Leather fieldbag containing:
  bandages (2 boxes a 20 rolls each), elastic bands, screws, plastic tape, tags, paper bags, plastic bags, filtpens, geological hammers (2), army knives (2x), scissors, saws (one large, one small), various knives and chisels, small sledge hammer, roll of string
- 81 tins for mammoth thin sections

Table 53. Laboratory data of CO.17 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture			PH	%
		sand	silt	clay	1:1	moisture
Ah	0- 12	78	20	2	5.8	0.5
A11	12- 19	28	58	14	5.7	1.0
A12	19- 43	36	56	8	6.0	1.0
A13	43- 54	24	64	12	6.1	1.0
A14	54- 79	48	48	4	6.1	1.0
AC11	79- 86	16	68	16	6.2	0.5
AC12	86-100	54	42	4	6.1	0.5
AC13	100-103	34	56	10	6.4	0.5
AC14	103-117	48	46	6	6.4	1.0
AC15	117-121	26	62	12	6.5	1.0
AC16	121-131	54	42	4	6.6	1.0

Depth cm	Exchangeable cations (me/100 g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 12	2.0	0.8	0.2	0.2	3.2	3.2	100.0	160.0
12- 19	4.8	0.8	0.1	0.2	5.9	7.3	80.1	52.1
19- 43	2.8	1.2	0.1	0.2	4.3	4.8	89.5	60.0
43- 54	2.8	0.8	0.1	0.2	3.9	5.2	75.0	43.3
54- 79	2.4	0.8	0.1	0.1	3.4	4.4	100.0	110.0
79- 86	4.4	2.0	0.1	0.3	6.8	6.8	100.0	42.5
86-100	2.4	1.2	0.1	0.2	3.9	4.8	81.2	120.0
100-103	3.6	0.8	0.1	0.2	4.7	5.2	90.4	52.0
103-117	2.8	0.8	0.1	0.2	3.9	4.4	88.6	73.3
117-121	4.0	0.8	0.04	0.2	5.0	6.5	76.9	54.2
121-131	2.4	0.4	0.04	0.2	3.0	3.6	83.3	90.0

Depth cm	%C	P ppm	Al	cation saturation			
			me/100 g	Ca	Mg	N	Na
0- 12	0.27	28	-	62.5	25.0	6.2	6.2
12- 19	1.01	28	-	65.7	11.0	1.4	2.7
19- 43	0.40	27	-	58.3	25.0	2.1	4.2
43- 54	0.40	23	-	53.8	15.4	1.9	3.9
54- 79	0.33	28	-	54.5	18.2	2.3	2.3
79- 86	0.47	29	-	64.7	29.4	1.4	4.4
86-100	0.33	26	-	50.0	25.0	2.1	4.2
100-103	0.40	20	-	69.2	15.4	1.9	3.9
103-117	0.33	31	-	63.9	18.2	2.2	4.6
117-121	0.27	18	-	61.5	12.3	0.6	3.1
121-131	0.13	26	-	66.7	11.1	1.1	5.6

Additional remarks on the soil classification

The laboratory data confirm the high base saturation percentage and the sedimentary origin of the various soil layers.
The proposed classification as eutric Fluvisol (FAO) or typic Fluvaquent (Soil Taxonomy) is maintained.

Table 54.Laboratory data of CO.18 (by Soils Laboratory IGAC)

Horizon	Depth cm	Texture				pH	%
		sand	silt	clay	gravel	1:1	moisture
Ah	0- 5	78	12	10		4.4	3.1
A1	5- 15	74	12	14		4.2	0.5
Ahb	15- 35	64	16	20		4.5	1.5
AB	35- 59	60	14	26		4.5	1.0
BS1	59- 86	58	16	26		4.5	1.0
BS2	86-112	56	18	26		4.6	0.5
BC	112-145	54	18	28		4.6	1.0
C1	145-180	58	18	24	17	4.6	1.5
C2	180-210	36	24	40		4.9	2.0

Depth cm	Exchangeable cations (me/100 g)					CEC	Base	CEC
	Ca	Mg	K	Na	sum	soil	sat.%	clay
0- 5	1.6	0.8	0.2	0.2	2.8	7.0	40.0	70.0
5- 15	0.2	0.2	0.1	0.1	0.6	6.8	8.8	48.6
15- 35	0.2	0.2	0.1	0.1	0.6	6.1	10.1	30.5
35- 59	0.2	0.2	0.1	0.2	0.7	6.5	10.8	25.0
59- 86	0.2	0.2	0.02	0.2	0.6	5.6	10.7	21.5
86-112	0.2	0.2	0.03	0.2	0.6	6.0	10.0	23.1
112-145	0.4	0.4	0.04	0.1	0.9	5.6	16.0	20.0
145-180	0.2	0.2	0.03	0.2	0.6	5.3	11.3	22.1
180-210	0.2	0.2	0.1	0.1	0.6	11.4	5.2	28.5

Depth cm	%C	P ppm	Al	Cation saturation			
			me/100 g	Ca	Mg	K	Na
0- 5	1.37	2	1.2	22.8	11.4	2.8	2.8
5- 15	0.67	1	1.8	2.9	2.9	1.5	1.5
15- 35	0.61	1	2.4	3.2	3.2	1.6	1.6
35- 59	0.47	1	2.8	3.1	3.1	1.5	3.1
59- 86	0.27	1	2.8	3.6	3.6	0.3	3.6
86-112	0.27	1	2.6	3.3	3.3	0.5	3.3
112-145	0.27	1	2.8	7.1	7.1	0.7	1.8
145-180	0.20	1	2.4	3.8	3.8	0.6	3.8
180-210	0.20	1	6.6	1.7	1.7	0.9	0.9

Additional remarks on the soil classification

The clay increase in the B horizon is thought to have been caused by sedimentary processes.
Micromorphological data are needed to elaborate on the macroscopic analysis.
The base saturation percentage is very low, while the calculated CEC clay values are between 16-24 me/100 g clay.
If a cambic B horizon is considered the soil belongs to the FAO Soil Map of the World unit ferralic Cambisol. Because of the assumed presence of a sombric horizon the soil classifies as a Sombritropept according to the Soil Taxonomy.