REV.

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WASHINGTON, D. C. 20523
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Agriculture — AF23-0000-G339

B. SECONDARY
Soil classification and genesis--Puerto Rico

2. TITLE AND SUBTITLE
Field guide to the soils of Puerto Rico

3. AUTHOR(S)
(100) Beinroth,F.H.
(101) Puerto Rico. Univ. College of Agr.and Mechanic Arts

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Hibiscus (Hibiscus tiliaceus) Photo: F. H. Beinroth

TROPICAL SOILS INSTITUTE

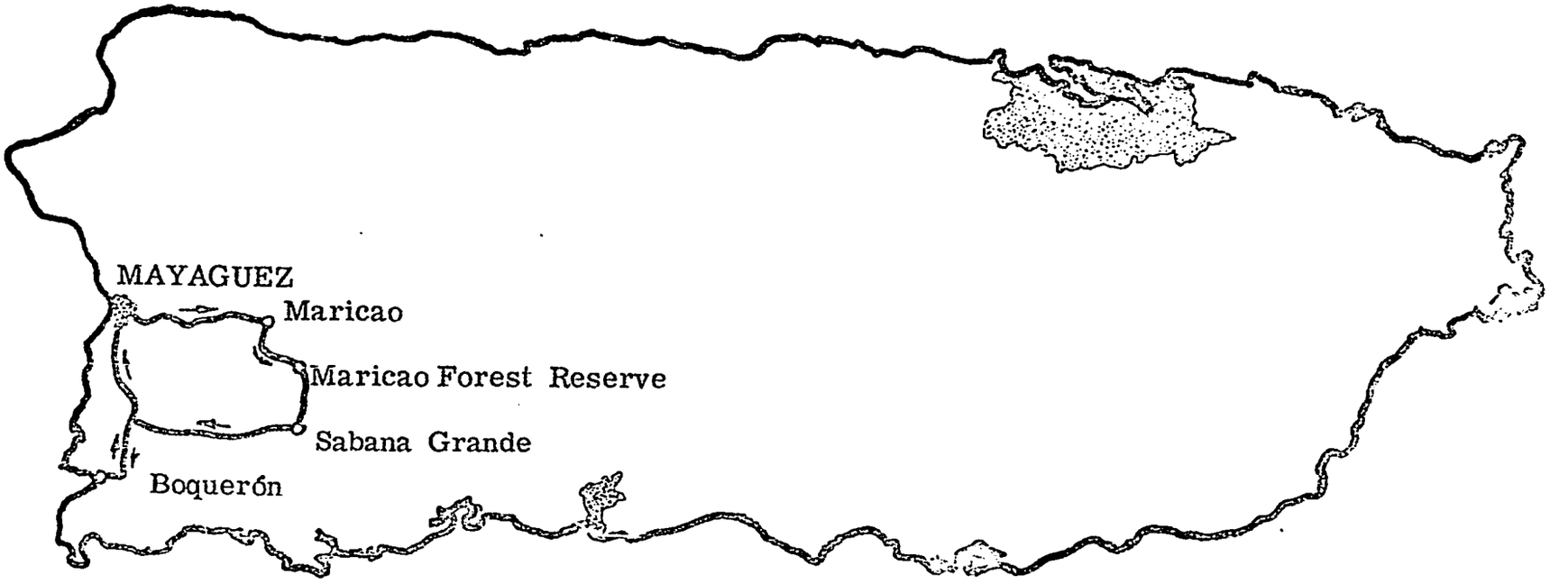
Puerto Rico, July 10 - August 4, 1972

FIELD TRIP 1 - "MARICAO"

Date	:	Wednesday, 7/12/72
Objective	:	To familiarize with a tropical environment in general, and with Puerto Rico in particular
Route	:	Mayaguez - Maricao - Maricao Forest Reserve - Sabana Grande - San Germán - Cabo Rojo - Boquerón - Cabo Rojo - Mayaguez
Soil pits	:	None
Main Topics	:	Geology, geomorphology, climate and vegetation of Puerto Rico; general soil pattern of SW Puerto Rico. Land use patterns (subsistence and coffee farming, sugarcane production)
Extracurricular	:	Playa de Boquerón, a public beach

FHB/5-72

TROPICAL SOILS INSTITUTE Puerto Rico, July 10 - August 4, 1972



Field Trip 1 - "MARICAO"

lantains (Musa paradisiaca) Photo: F. H. [illegible]th

: Acrorthox Profile (Nipe Series)

Photo: F. H. Deinrc.n

TROPICAL SOIL INSTITUTE

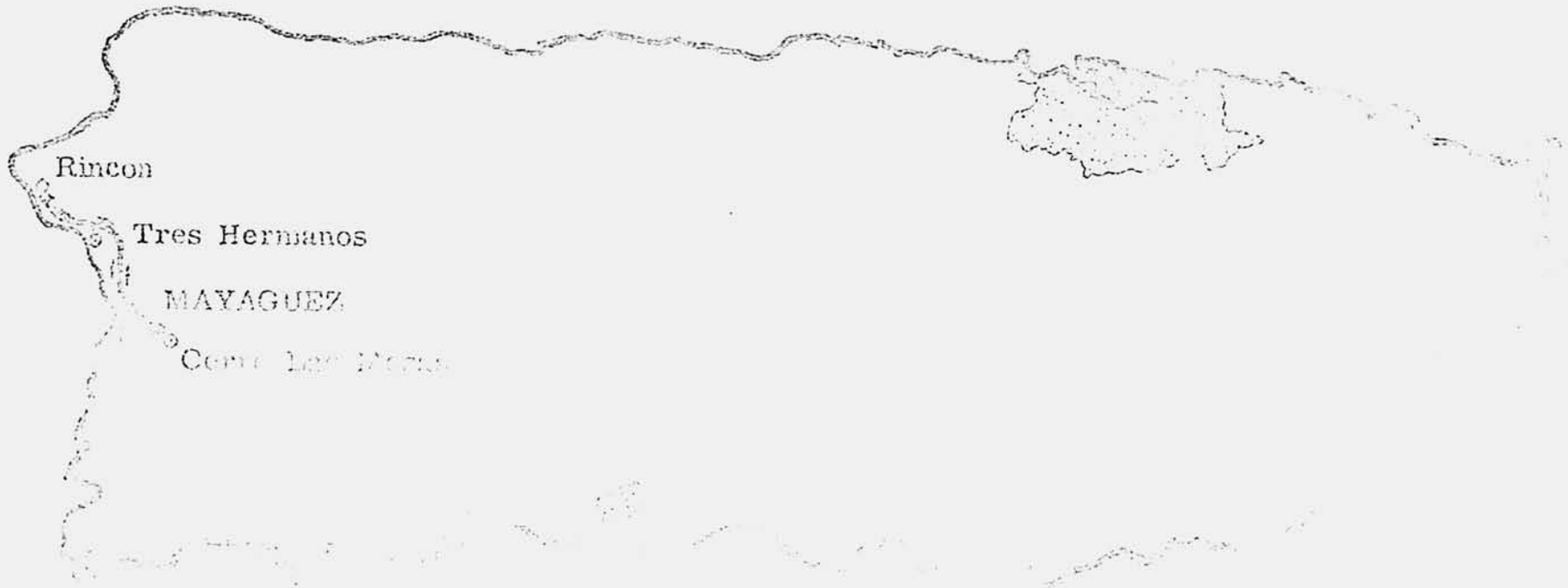
Puerto Rico, July [illegible] - August 4, 1972

FIELD TRIP 2 - "LAS MESAS"

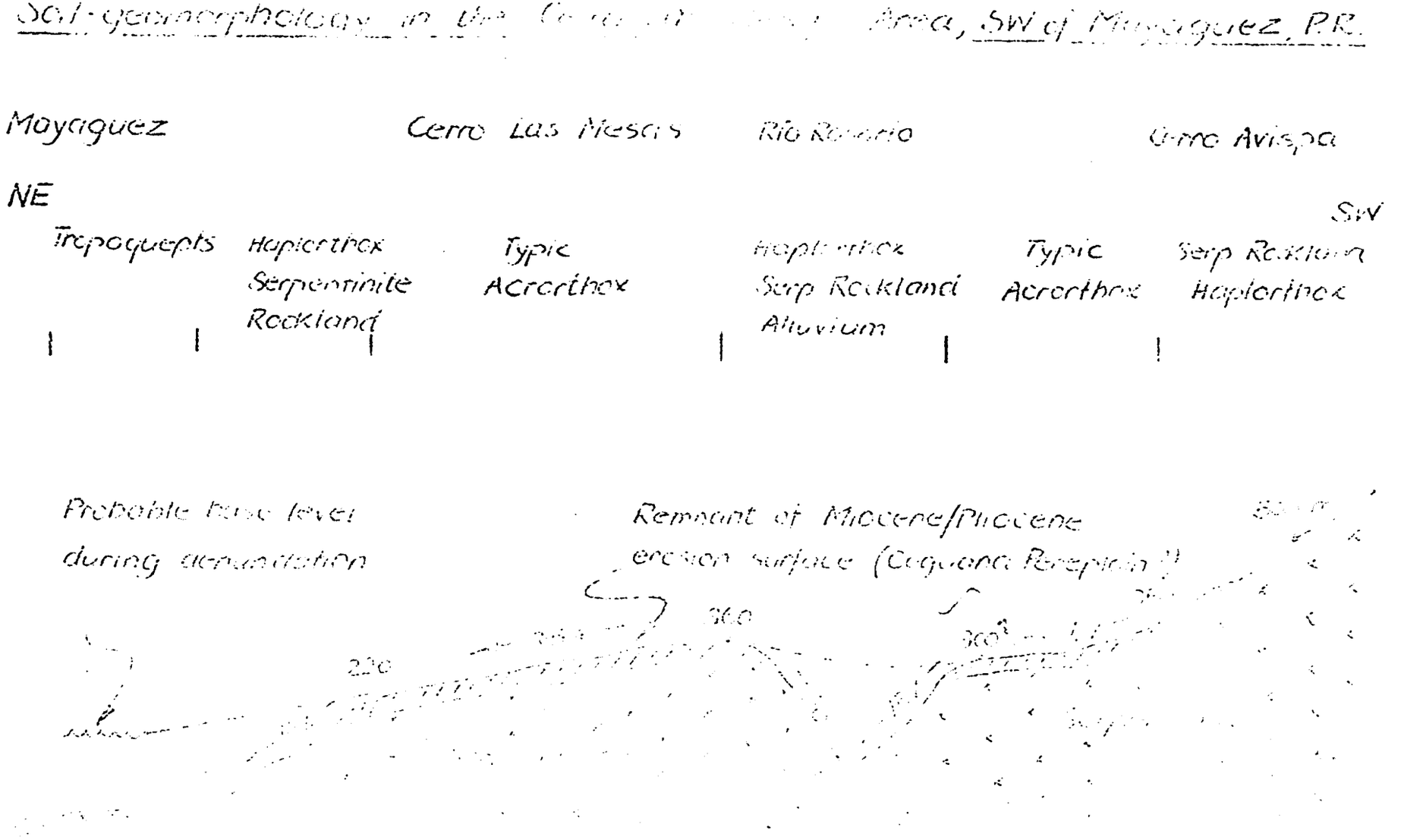
[illegible]	:	Saturday, 7/15/72
Objective	:	To study intensive tropical weathering
[illegible]	:	Aguadilla - Cerro Las Mesas - [illegible] Mayagüez
[illegible]	:	Typic [illegible] (Coto Series)
Main topics	:	Environmental classification; parent [illegible] ultrabasic rocks and their weathering; [illegible] morphology of Oxisols; fertility and agricultural [illegible]
Extracurricular	:	Rincón and Tres Hermanos beach

FHB/5-72

TROPICAL SOILS INSTITUTE Puerto Rico, July 10 - August , 1972



Soil-geomorphology in the [illegible] Area, SW of Mayaguez, P.R.



Occurrence of OXISOLS in Puerto Rico

MIL-63

SERIES: Nipe

General Characterization

Classification

Soil Taxonomy:	Subgroup:	Typic Acroxi[illegible]
	Family:	clayey, oxidic, isohyperthermic [illegible]
	Status:	final
FAO/UNESCO Legend:		Humic Ferrasols
1938 Great Group:		Laterite

Location of Sample Site

Latitude: 18°11' 2" N Longitude: 67°6' 16" W [illegible]
General Description: Cerro Las Mesas SE of Mayaguez; [illegible] on highway 349
Rosario Quadrangle

Climate

Mean annual rainfall:	200 cm (~80")
Mean annual temperature:	~25°C (~77°F)
Rainfall distribution:	Rainfall max. in August, low [illegible]
Thornthwaite type:	BA'w - Humid tropical, dry [illegible]

Vegetation and Land Use

Natural vegetation type:	Tropical moist forest
Land use and crop:	Cleared but idle - brush and grass

Parent Material and Geology

Parent material:	Saprolite
Parent rock:	Serpentinized peridotite
Geologic formation:	Early Cretaceous

Geomorphology

Slope: 2%
Aspect: W
Landform: Planar; wide interfluve
Geomorphic surface: Remnant of erosional [illegible]
Helvatian and probably Pliocene age, [illegible]

Additional Notes:

About 100 m (330') from SCS type location, see SSIR [illegible]
Auger samples

Compiled by: F. H. Beinroth Date: 2/12/72

Soil Classification: Typic Acrorthox; clayey, oxidic, isohyperthermic
Soil Name: [illegible] clay
Soil Num.: [illegible]-6-1
Location: [illegible] half mile west of kilometer marker 5.5 on Highway No. 3[illegible]. [illegible]
Photo [illegible]-11-32.
Area: Puerto Rico, State SCD, Ine Mesas ridge.
Climate: Hot - humid. Precipitation 80 to 90 inches a year.
Slope: 2 to 3 percent.
Relief: The land surface at this site is planar.
Drainage: Well drained.
Vegetation: Native grasses and trees.
Erosion: Slight to moderate.
Soil Temperature: 25 degrees C. at 48 inches.

Collected by: L. T. Alexander, C. J. Koch, Juan Jurez, Jr., and J. E. Trigo, September 1[illegible]
Described by: C. J. Koch.

Horizon and Lincoln Lab. No.	
[illegible]	0 to 11 inches. Dark reddish brown (2.5YR [illegible]/4) [illegible] shiny appearance, but do not have clay skins; very strongly acid; [illegible]
A1 7443	11 to 18 inches. Dark reddish brown (2.5YR [illegible]) clay [illegible] structure; very friable, nonsticky, nonplastic [illegible] clay skins; extremely acid; [illegible]
B21 7444	18 to 28 inches. Dark red (7.5R 3/8) clay; [illegible] nonplastic; no clay skins; extremely acid; [illegible] boundary.
B22 7445	28 to 38 inches. Dusky red to dark red (7.5R [illegible]) clay; [illegible] when wet; no clay skins; few small iron-rock [illegible] (probably [illegible]); [illegible] boundary.
B23 7446	38 to 48 inches. Dusky red to dark red (7.5R 3/4 to 3/6) [illegible] friable, nonsticky, nonplastic; no clay skins; few iron-[illegible] boundary.
B24 7447	48 to 62 inches. Dark red (7.5R 3/6) with [illegible] of [illegible] brown (7.5[illegible]) [illegible] sticky, nonplastic; no clay skins; very strongly acid; [illegible] boundary.
C1 7448	62 to 70 inches plus. Dusky red (7.5R 3/4) clay [illegible] very firm, [illegible] skins; medium acid.

Remarks: Site resampled in 1961 for bulk density and [illegible] [illegible] occupies and occupies mesa-like hilltops in western Puerto Rico. [illegible] characteristics of an old soil. This soil is limited in extent, but is [illegible] represents. The B2 horizon, when exposed, has a tendency to harden. [illegible] stated.

Mineralogy (Method 7A). Analyses on < 2-mm. material.

Horizon	Depth Inches	Kaolinite 1/ %	Gibbsite 1/ %	Goethite 2/	Quartz 2/
A1	0-11	5	25	[illegible]	[illegible]
B1	11-18	10	25	[illegible]	[illegible]
B21	18-28	20	30	[illegible]	[illegible]
B22	28-38	20	30	[illegible]	[illegible]
B23	38-48	12	30	[illegible]	[illegible]
C1	48-62	10	40	[illegible]	[illegible]
C2	62-70+	3	60	[illegible]	[illegible]

1/ Differential thermal analysis.
2/ X-ray powder patterns.
Amounts estimated are: - = none detected; x = small; xx = [illegible], xxx = [illegible].

SOIL CLASSIFICATION: Typic Acrorthox; clayey, oxidic, isomesomanganic

SOIL Nipe clay SOIL Nos. [illegible]
977(51)93-8-12

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB No. [illegible]

General Methods: 1A, 1B1a, 2A1, 2B

Depth (in)	[illegible]	Total Sand (2-0.05 mm)	Total Silt (0.05-0.002 mm)	Total Clay (<0.002 mm)	Very fine sand (0.1-0.05 mm)	Coarse sand (1-0.5 mm)	Medium sand (0.5-0.25 mm)	Fine sand (0.25-0.1 mm)	[illegible]	[illegible]	[illegible]	[illegible]
		Percent of fine earth										
0-11	[illegible]	[illegible]	36.3	54.9	1.5	2.0	0.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11-18	[illegible]	7.4	34.9	57.7	2.9	1.5	0.6	1.1	[illegible]	[illegible]	0.0	[illegible]
18-28	[illegible]	9.8	30.6	59.6	2.3	0.9	0.4	1.4	[illegible]	33.4	17.[illegible]	[illegible]
28-38	[illegible]	13.3	21.0	[illegible]	2.5	1.3	[illegible]	0.8	1.6	[illegible]	13.6	[illegible]
38-48	[illegible]	17.0	23.3	59.7	1.7	1.8	1.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
48-62	[illegible]	19.2	27.2	53.6	4.0	3.3	1.4	3.9	[illegible]	[illegible]	[illegible]	[illegible]
62-70+	[illegible]	17.1	65.3	37.6	3.8	1.6	1.0	1.4	[illegible]	0.1	[illegible]	[illegible]

Depth (in)	6A1a Silt + Clay Fraction	6B1a Moisture	6A Pyrophosphate	6C2a Ext. Iron as Fe Pyr.	Carbonate as CaCO3		1/3 Atm. Moisture Equivalent	15 Atm. Moisture	[illegible]	[illegible]	[illegible]	[illegible]
	g/cm³	%		%								
0-11	[illegible]	0.340	25	13.0			1.03	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11-18	[illegible]	[illegible]	22	12.0			1.18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18-28	[illegible]	[illegible]		10.[illegible]			1.[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28-38	[illegible]			10.2			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
38-48	0.72	0.343	19	23.1			1.36	1.33	[illegible]	[illegible]	[illegible]	[illegible]
48-62	[illegible]			29.7			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	37.
62-70+	0.19			27.3			1.72	1.70	1.72	0.008	[illegible]	[illegible]

Depth (in)	6E2b Ca	6E2b Mg	6E2b Na	6E2b K	Sum	6H1a H.S. Acidity	9A5a Sum Cations	[illegible]	[illegible]	[illegible]	[illegible]
	meq/100 g										
0-11	1.3	1.4	0.1	0.1	2.9	31.9	34.8	29.4	1.4		[illegible]
11-18	0.1	-	-	-	0.1	21.4	21.5	12.1	0.9		[illegible]
18-28	-	-	-	-	-	15.7	15.7	[illegible]			
28-38	-	-	-	-	-	12.0	12.0	[illegible]			
38-48	-	0.1	-	-	0.1	12.0	12.1	5.[illegible]	tr		0.[illegible]
48-62	-	-	-	-	-	12.8	12.8	[illegible]	[illegible]		[illegible]
62-70+		-	-	-	-	9.4	9.4	1.4	tr		tr

Depth (in)	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]	[illegible] Extract	1:1 Water	
0-11	[illegible]	[illegible]	0.49	
11-18	[illegible]	0.22	0.40	
18-28	[illegible]	0.22	[illegible]	
28-38	0.11	0.36	0.40	
38-48	[illegible]	0.29	0.44	
48-62	[illegible]	0.43	0.46	
62-70+	0.04	0.73	0.48	

a. Size [illegible]
b. [illegible]
c. [illegible] sulfate [illegible] free of [illegible]
d. A [illegible] treatment.
e. 38 kg/[illegible]
f. Based on field-[illegible]
g. Field-determined [illegible]
h. Field-determined value: 37.[illegible]

See introductory part of this [illegible] determinations.

Corals off North Coast of Puerto Rico

APPROVED BY PRINCIPAL SOIL CORRELATOR
SOUTH REGION TSC, 6/14/67

Established Series
Rev. REG 2/67

Linda J. Pastelli

CATAÑO SERIES

Tropopsamments

The Cataño series is a member of the carbonatic, isohyperthermic family of Typic [illegible]. These soils consists of deep, calcareous, brown sands having more than 4% silt plus clay in the control section.

Typifying Pedon: Cataño sand-coconut grove
(Colors are for moist soil)

A1 -- 0-4" --Light gray (10YR 7/2) sand since shell fragments, and very dark brown [illegible] subrounded grains of quartz and miscellaneous volcanic rock fragments with [illegible] coatings; overall color is very dark grayish brown (10YR 3/2); single grain; loose, nonsticky and nonplastic; many fine roots; strong effervescence; clear smooth boundary. 3 to 6 inches thick.

AC -- 4-10" --Dark brown (overall color) (10YR 3/3) sand and more than 4 percent silt plus clay consisting of light gray (10YR 7/2) shell fragments and very dark brown (10YR 2/2) miscellaneous volcanics; single grain; loose, nonsticky and nonplastic; [illegible] fine roots; strong effervescence; clear smooth boundary. 4 to 8 inches thick.

C1 -- 10-50" --Brown (overall color) (10YR 4/3) sand and more than 4 percent silt plus clay consisting of light gray (10YR 7/2) shell fragments and very dark brown (10YR 2/2) [illegible] subrounded volcanic; single grain; loose, nonsticky and nonplastic; few fine roots; strong effervescence; clear smooth boundary. 30 to 60 inches thick.

C2 -- 50-60"+ --Grayish brown (10YR 5/2) (overall color) sand; single grain; loose, nonsticky and nonplastic; very few fine roots; strong effervescence.

Type Location: Oasis SCD, Puerto Rico; 2 miles north of the city of Mayaguez; 1/2 mile on dirt road north of Boquilla bridge. 300 feet west of dirt road.

Range in Characteristics: The sandy materials extend to depth of more than 5 feet. Texture [illegible] profile is sand. The sand consists of shell fragments, quartz grains, and volcanic subrounded fragments. Percent of silt plus clay in the control section varies from 4 to 10. Overall colors of the [illegible] horizons have hues of 10YR and values and chromas of 2 to 3. The C horizons have hues of 10[illegible] 6 and 5 and chromas of 2 and 3. These soils are single grain and nonsticky and nonplastic [illegible]. Effervescence with dilute HCL varies from slight to violent.

Competing Series and their Differentiae: These are the St. Lucia (P.R.), Aguadilla, Espinal, [illegible] Moroa and Jauca series. The St. Lucia (P.R.) soils have sands with more than [illegible] percent [illegible] to [illegible]. Aguadilla soils are acid. The Espinal soils have noncalcareous [illegible] horizons and lighter colored [illegible]. The Arenales, Moroa, and Jauca soils are dry for more than 90 cumulative days in [illegible] and Moroa soils are noncalcareous. The Jauca soils have lighter colored profile.

Setting: The Cataño soils occur along the coast on elevations close to sea level with [illegible] from 0 to 5 percent. The regolith consists of sand size shell fragments, quartz grains, [illegible] volcanic subrounded fragments. The climate is humid tropical. The average annual precipitation [illegible] inches and the mean annual temperature 78°F. The mean annual soil temperature at 20 inches [illegible] 71.6°F with less than 9°F difference between mean summer and winter temperatures.

Principal Associated Soils: These are the competing Aguadilla, St. Lucia (P.R.), and Espinal [illegible] in addition to the Coroaga, and Coloso series and the land type coastal Beach. The Coroaga [illegible] soils are finer textured, have low chroma mottles, and occur farther inland. The land type coastal beach consists of unstabilized wave reworked narrow strips of sand along the coast.

CATAÑO SERIES

Drainage and Permeability: Excessively drained; runoff is very slow, and permeability is rapid.

Use and Vegetation: Mostly on coconuts and undergrouth of pasture. Small acreage is in subsistence crops.

Distribution and Extent: Humid coastal plains of Puerto Rico. The series is of moderate extent.

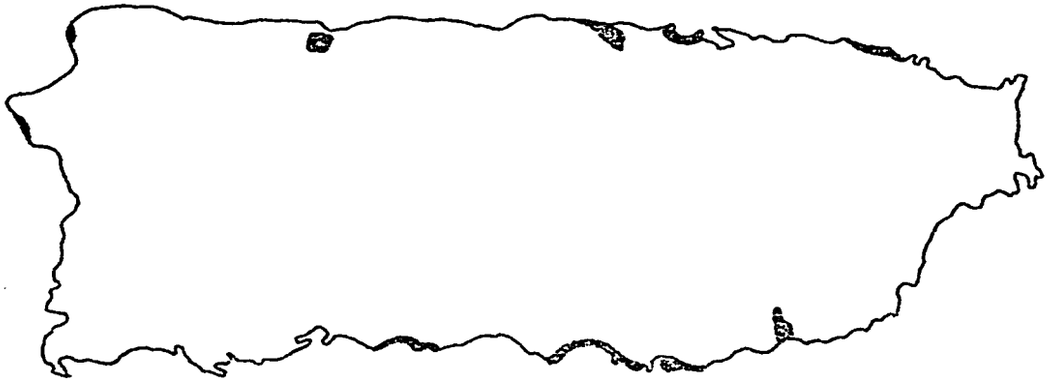
Series Established: Puerto Rico, 1942; Soil Survey of Puerto Rico.

Remarks: The Cataño series was formerly classified in the Sandy Regosols Great Soil Group.

National Cooperative Soil Survey
U.S.A.

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, FORT WORTH, TEXAS
USDA-SCS-FORT WORTH, TEX. 1967

Occurrence of ENTISOLS in Puerto Rico



FHB/68

Pineapple Fields in Karst Topography, North Puerto Rico

Photo: F. H. Beinr

TROPICAL SOILS INSTITUTE

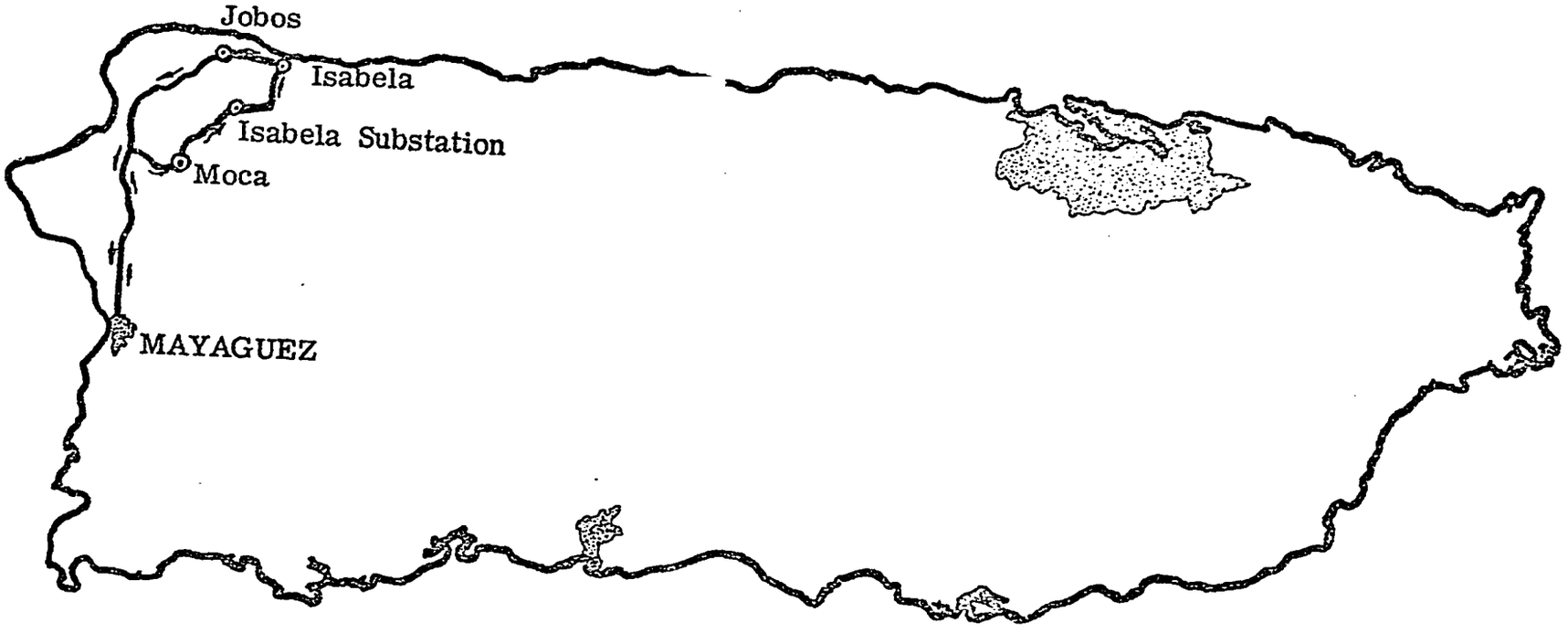
Puerto Rico, July 10 - August 4, 1972

FIELD TRIP 3 - "ISABELA"

Date	:	Wednesday, 7/19/72
Objectives	:	1. To study the genesis of an Oxisol and to see related fertility experiments 2. To view subsistence farming (share-cropping) along the NW coast of Puerto Rico
Route	:	Mayaguez - Moca - Isabela Agr. Experiment Substation - Isabela - Jobos - Mayaguez
Soil pit	:	Tropeptic Haplorthox (Coto Series)
Main Topics	:	En route: Tropical karst topography
		Isabela : Geomorphology of NW Puerto Rico; environmental characterization; soil genesis and morphology; soil water relations; soil management; fertility experiments
		Jobos : Tropical root crops; share - cropping

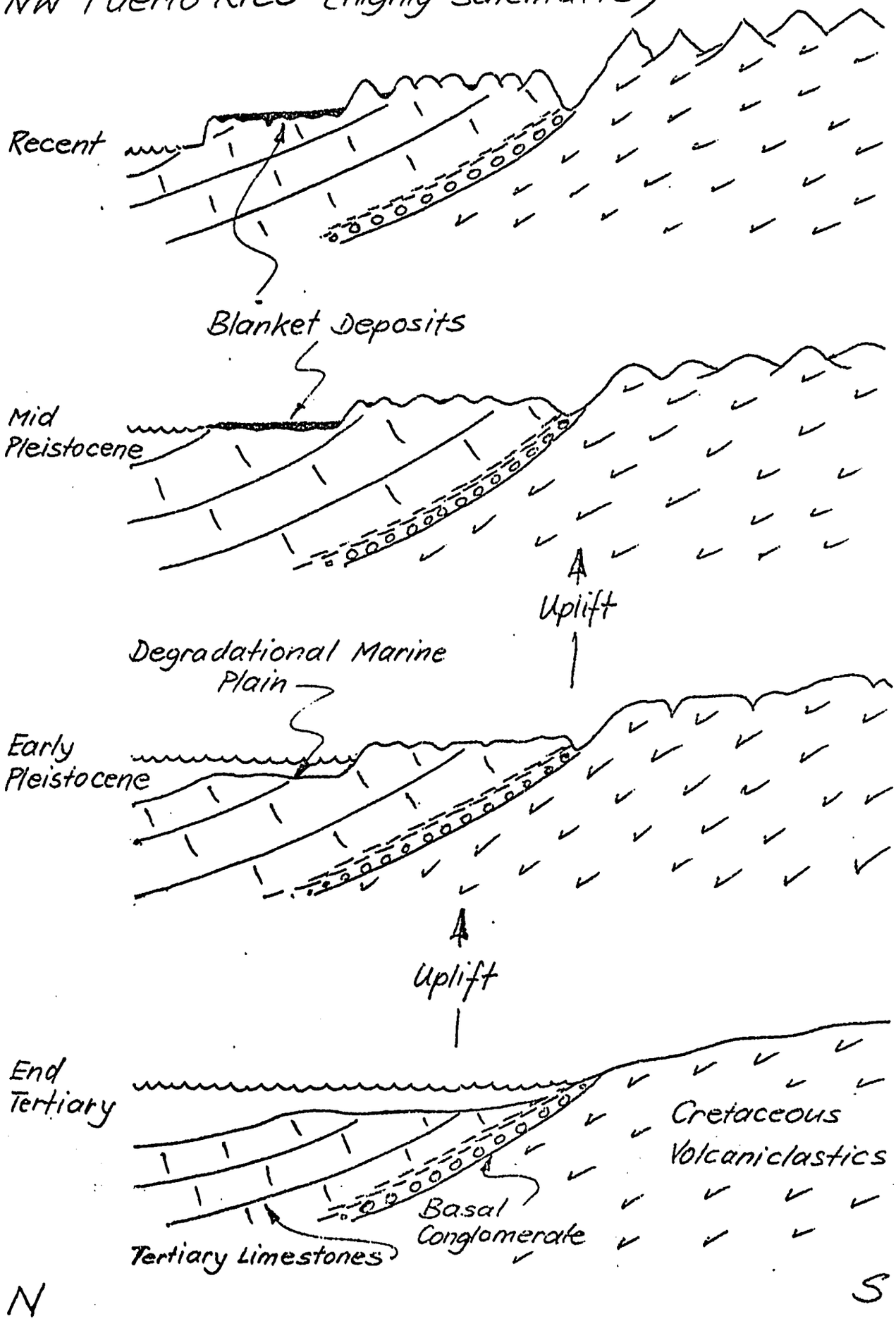
FHB/5-72

TROPICAL SOILS INSTITUTE Puerto Rico, July 10 - August 4, 1972



Field Trip 3 - "ISABELA"

Geomorphic Evolution of the Isabela Area, NW Puerto Rico (highly schematic)



SERIES: Coto

General Characterization

Classification

Soil Taxonomy:	Subgroup:	Tropeptic Haplorthox
	Family:	clayey, kaolinitic, isohyperthermic
	Status:	final
FAO/UNESCO Legend:		Humic Ferralsols
1938 Great Group:		Reddish Brown Lateritic

Location of sample Site

Latitude: 18°28' 2" N Longitude: 67°3' 25" W Elevation: 131m (430')

General Description: Isabela Agricultural Experiment Substation, 400m (1,300')N of Km 115.4 on highway 2, next to citrus orchard; Moca Quadrangle

Climate

Mean annual rainfall:	170 cm (66")
Mean annual temperature:	~25°C (77°F)
Rainfall distribution:	maxima in May and November
Thornthwaite type:	B/CA'r - Subhumid to humid tropical

Vegetation and Land Use

Natural vegetation type:	Tropical moist forest
Land use and crop:	Experiment site - citrus

Parent Material and Geology

Parent material:	Fine - textured sediments ("Blanket Deposits")
Parent rock:	largely derived from andesitic volcaniclastics, had
Geologic formation:	undergone previous weathering cycle; Pleistocene in age, overlying Miocene limestones.

Geomorphology

Slope: 0

Aspect: -

Landform: Slighty undulating plain

Geomorphic surface: Marine (?) degradation terrace of early Pleistocene age.

Additional Notes:

Sampled from a pit 400 m (1,300') NW of SCS pit S63 PR-6-1; see SSIR #12 pp. 174 and 175.

Compiled by: F. H. Beinroth Date: 2/17/72

Soil Classification: Tropeptic Haplorthox; clayey, kaolinitic, isohyperthermic
Soil type: Coto clay
Soil No.: S63PR-6-1
Location: Noroeste SCD, Puerto Rico, ten miles west of Quebradillas, 200 feet south of kilometer marker 115.0 on highway No. 2.
Vegetation and use: Sorra grass (Trichachnee insularis). Used as pasture.
Slope and land form: 3 percent. North aspect. Alluvial fan north of limestone hills.

Drainage and permeability: Well drained, with medium runoff. Permeability is moderate.
Parent materials: Transported sediments probably derived from weathered limestone and quartzitic sand deposits.
Rainfall: About 50 inches a year.
Collected by: R. B. Grossman, W. E. McKinzie, R. E. Gierbolini, J. Torres-Más on September 26, 1963.
Described by: R. E. Gierbolini.

Horizon and Lincoln Lab. Number	
Ap 18971	0 to 5 inches, dark brown (7.5YR 4/4) silty clay; weak fine granular structure; slightly hard, friable, slightly sticky, slightly plastic; common fine roots; strongly acid; clear smooth boundary.
A12 18973	5 to 10 inches, dark brown (7.5YR 4/4) silty clay; weak medium subangular blocky structure; hard, firm, slightly sticky, slightly plastic, common fine roots; common fine quartz grains; common fine black nodules; medium acid; clear smooth boundary. Field moisture, 31.4 percent.
B21 18974	10 to 17 inches, yellowish red (5YR 5/8) moist with reddish brown (5YR 5/4) coatings, yellowish red (5YR 5/8) dry; clay; moderate fine and medium subangular blocky structure; friable, slightly sticky, slightly plastic; thin discontinuous clay films; few fine roots; few fine quartz grains; few fine black nodules; strongly acid; gradual smooth boundary. Field moisture, 30.8 percent.
B22 18975	17 to 25 inches, yellowish red (5YR 4/3) moist, yellowish red (5YR 5/8) dry; clay, weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; thin patchy clay films on ped surfaces and root channels; small pieces fail abruptly upon slight pressure between fingers 1/; few fine roots; common fine pores; few fine quartz grains; few fine black nodules; black coatings along root channels; strongly acid; gradual smooth boundary. Field moisture 34.6 percent.
B23 18976	25 to 36 inches, yellowish red (5YR 4/8) moist, yellowish red (5YR 5/6) dry;clay; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; thin patchy clay films on ped surfaces and root channels; small pieces fail abruptly upon slight pressure between fingers 1/; common fine pores; common fine quartz grains; few fine black nodules; black coatings along root channels; clear smooth boundary. Field moisture 34.0 percent.
B24 18977	36 to 50 inches, yellowish red (5YR 4/8) with few fine red (2.5YR 4/8) and few fine yellowish brown (10YR 5/4) mottles; clay loam; weak fine blocky structure; friable, slightly sticky, slightly plastic; shiny ped faces; small pieces fail abruptly upon slight pressure between fingers 1/; few fine roots, few fine quartz grains; common fine pores; slightly acid; gradual smooth boundary.
B25 18978	50 to 64 inches. Same as above; split for sampling.
B26 18979	7 to 10 feet auger sample; strong brown (7.5YR 5/8) crushed color; clay loam.
B27 18980	10 to 12 feet, auger sample; strong brown (7.5YR 5/8) crushed color; clay loam.

1/ - See introductory part of the Soil Survey Investigations Report for an explanation of this and similar terms that are designed to describe the failure of the material in its natural state of organization.

Remarks: Colors given are for moist soil unless otherwise noted. Upper part of solum was at field capacity and lower part of solum was below field capacity when sampled. Reaction was determined by Soiltex. Soil temperatures: 26 degrees Centigrade at 10 feet; 26 degrees Centigrade at 11 feet; 25.5 degrees Centigrade at 12.5 feet.

Mineralogy (Method 7A): B22 horizon. The crystalline clay is kaolinite and/or halloysite almost exclusively according to X-ray evidence. There is a hint of a 14Å mineral or an interstratified mineral. A considerable proportion of the clay must be X-ray amorphous. Kaolinite percentages of the clay by differential thermal analysis are: 56 percent - Beltsville Laboratory
50 percent - Lincoln Laboratory.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL CLASSIFICATION: Tropeptic Haplorthox; clayey, kaolinitic, isohyperthermic

SOIL Coto clay **SOIL Nos.** 863PR-6-1 **LOCATION** Noroeste SCD, Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebraska **LAB. Nos.** 18972-18980 January 1967

General Methods: 1A, 1B1b, 2A1, 2B

Depth (in.)	Horizon	Total Sand (2-0.05)	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)	<0.005	<0.074	Coarse fragments: 2/2 > 2 (<19) Pct	2-19	19-76
		Pct of < 2 mm															Pct of < 76mm	
0-5	Ap	22.3	7.0	70.7	tr	2.5	5.1	7.9	6.8	2.9	4.1	13.8	15.5		81.5	-		
5-10	A12	21.8	7.1	71.1	tr	2.5	5.2	7.7	6.4	3.2	3.9	13.7	15.4		80.9	-		
10-17	B21	19.8	5.3	75.9	0.1	2.3	4.4	6.5	5.5	2.6	2.7	11.5	13.3		83.5	-		
17-25	B22	14.5	5.9	79.6	0.2	1.7	3.1	5.1	4.4	1.7	4.2	8.8	10.1	36.5	87.4	-		
25-36	B23	11.4	6.7	81.9	0.1	1.2	2.2	4.0	3.9	1.4	5.3	7.4	7.5		90.2	-		
36-50	B24	13.3	10.5	76.2	0.1	0.9	2.1	4.7	5.5	2.9	7.6	11.1	7.8		88.8	-		
50-64	B25	16.4	16.2	67.4	0.1	1.2	2.2	5.3	7.6	6.0	10.2	16.9	8.8		88.4	-		
84-120	B26	14.8	15.1	70.1	0.1	1.4	2.6	4.2	6.5	4.6	10.5	13.3	8.3		87.4	-		
120-144	B27	13.8	15.7	70.5	tr	1.0	1.8	3.9	7.1	5.1	10.6	14.6	6.7		88.6	-		

Depth (in.)	6A1a Organic carbon b Pct	6B1a Nitrogen Pct	C/N	6C2a Ext. Iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.		Bulk density: 4A1a Field-State g/cc	4A1d 1/3-Bar g/cc	4A1b Air-Dry g/cc	4D1 COLE	Water content: 4B4 Field-State Pct	4B1c 1/3-Bar Pct	4B2 15-Bar Pct	4C1 1/3-to 15-Bar in/in		pH: 8C1c (1:1) N KCl	8C1a (1:1) H_2O
0-5	2.44	0.252	10	9.6			1.25	1.30	1.39	0.020	28.5	25.0	22.5	0.03		4.1	4.8
5-10	1.69	0.197	9	9.8			1.30	1.34	1.44	0.024	28.2	28.0	22.8	0.07		3.9	4.5
10-17	0.99	0.143	7	10.1			1.30	1.32	1.41	0.020	28.6	31.5	23.7	0.10		3.9	4.5
17-25	0.62	0.127	5	10.6			1.28	1.30	1.38	0.020	29.3	30.6	26.4	0.05		4.1	4.6
25-36	0.46	0.113	4	11.5			1.24	1.25	1.32	0.017	31.5	33.3	26.8	0.08		5.5	5.9
36-50	0.25			11.2			1.46c	1.45	1.48	0.007	26.1	27.3	25.0	0.03		5.9	6.3
50-64	0.19			11.2				1.4d					23.5			5.8	6.0
84-120	0.15			12.9									23.0			5.4	5.5
120-144	0.11			13.3									23.1			4.9	4.6

Depth (in.)	Extractable bases: 6H2a Ca	6G2a Mg	6P2a Na	5R1a 6Q2a K	Sum	6H1a Ext. Acidity	Cat. Exch. Cap.: 5A3a Sum Cations	5A1a NH_4OAc	6G1d KCl-Ext. Al	6L2a NH_4OAc Ext. SO_4		5A3b Bases Plus Al m/100g Clay					Base saturation: 5C3 Sum Cations Pct	5C1 NH_4OAc Pct.
	meq/100 g																	
0-5	3.6	0.9	0.1	0.4	5.0	20.4	25.4	13.3	0.6	0.5		7.9					20	38
5-10	2.1	0.5	0.1	0.1	2.8	20.0	22.8	10.6	1.4	1.7		5.9					12	26
10-17	1.2	0.4	0.1	0.1	1.8	16.4	18.2	7.3	1.6	3.3		4.5					10	25
17-25	3.7	0.6	0.1	0.1	4.5	15.6	20.1	5.8	0.9	3.8		6.8					22	78
25-36	3.6	0.7	0.1	0.1	4.5	9.7	14.2	5.8		1.8		5.5					32	78
36-50	4.1	0.6	0.1	0.1	4.9	8.5	13.4	5.7		1.6		6.4					37	86
50-64	3.7	0.9	0.1	tr	4.7	8.9	13.6	5.5		2.3		7.0					35	85
84-120	1.8	2.0	0.1	tr	3.9	11.4	15.3	4.9		3.3		5.6					25	80
120-144	1.4	1.2	0.1	tr	2.7	11.2	13.9	4.8	0.1	2.6		3.8					19	56

Depth (in.)	Ratios to Clay 8D1: NH_4OAc CEC	Ext. Iron	15-Bar Water		
0-5	0.19	0.14	0.32		
5-10	0.19	0.14	0.32		
10-17	0.09	0.13	0.31		
17-25	0.07	0.13	0.33		
25-36	0.07	0.14	0.33		
36-50	0.07	0.15	0.33		
50-64	0.08	0.17	0.35		
84-120	0.07	0.18	0.33		
120-144	0.07	0.19	0.33		

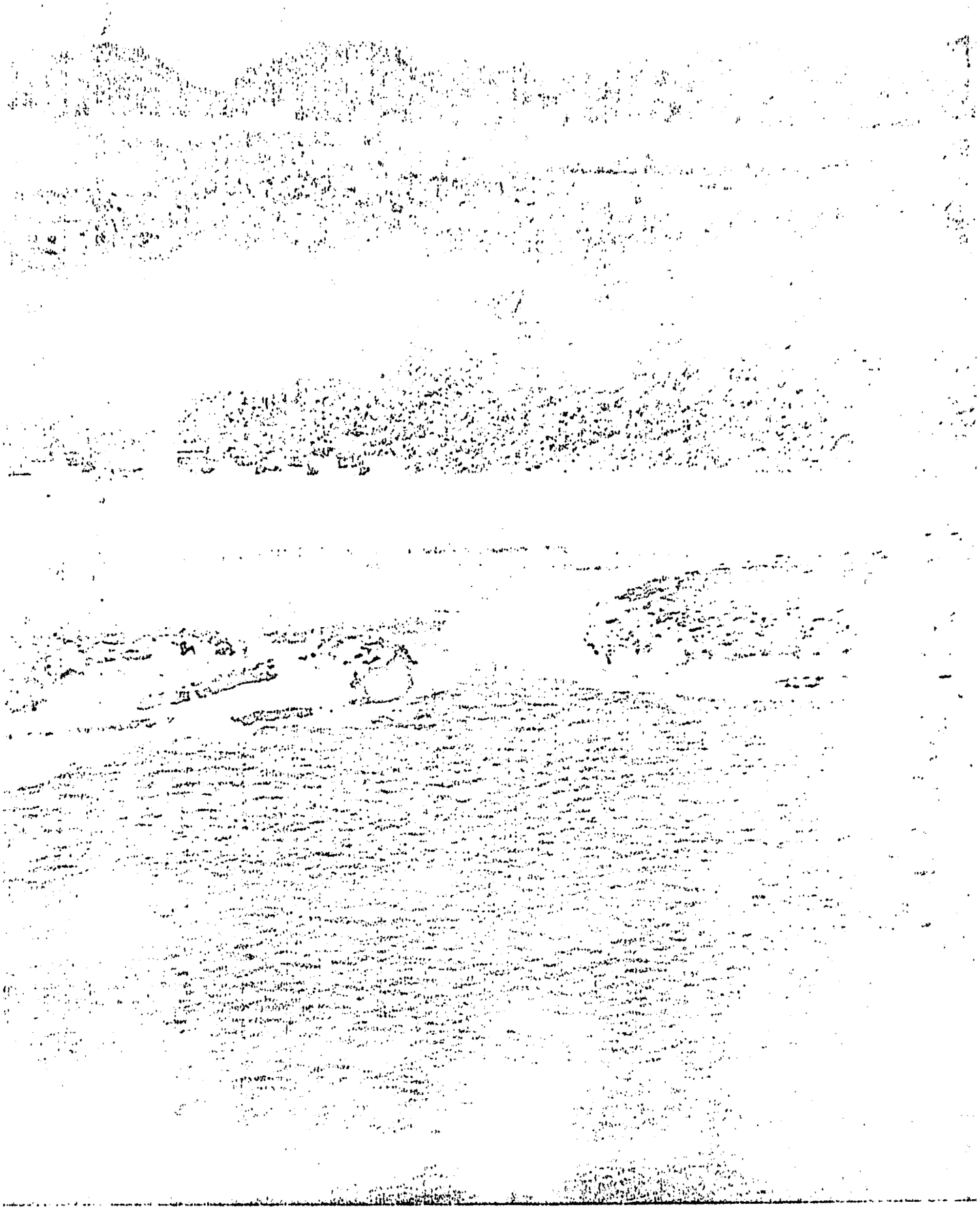
a. Earthy nodules: 15-25 percent (0.5-0.05 mm.).
b. 14 kg/m² to 60 inches (Method 6A).
c. Estimated.
d. Range in duplicate clods is 0.11 g/cc.

COTO SERIES - Tropeptic Haplorthox

Horizon	Depth cm	Extractable SO_4S * $\mu g/g$ soil	Silicon		
			Saturation Extract	1:10 Water	1:10 Phospate
			Si, ppm, solution		Si, $\mu g/g$ soil
Ap	0-13	0	1.86	1.14	103.8
A 12	13-25	293	1.18	.58	111.2
B 21	25-45	265.	.82	.51	117.9
- -					
B 24	90-125	553	.42	.30	139.9

Unpublished data of R. L. Fox, Dept. of Agronomy and Soil Science, University of Hawaii

*) Repeated extraction (4 times) with 500 ppm P (CaH_2PO_4)
Soil: Extracting solution ratio was 1:5 for each extraction



North Coast of Puerto Rico (Mar Chicita) Photo: F. H. Beinroth

APPROVED BY PRINCIPAL SOIL CORRELATOR
SOUTH REGION TSC, 6/8/67

Linda J. Rastelli

Tentative Series
REG-LHR, 4/67

GUERRERO SERIES

The Guerrero series is a member of the clayey, oxidic, isohyperthermic family of Arenic Plinthic Paleudults. These soils have thick dark brown sandy surface horizons over thick, fine textured B2t horizons.

Typifying Pedon: Guerrero sand-pasture and coconuts (Colors are for moist soil)

Ap	--	0-10"	--Grayish brown (10YR 5/2) dry, dark brown (7.5YR 4/2) moist, sand; single grain; loose, nonsticky, nonplastic; many fine roots; medium acid; clear smooth boundary. 8 to 12 inches thick.
A12	--	10-22"	--Dark brown (7.5YR 4/4) sand; single grain; loose, nonsticky, nonplastic; many fine roots; few fine soft black concretions; medium acid; clear smooth boundary. 8 to 18 inches thick.
A13	--	22-28"	--Yellowish red (5YR 4/6) loamy sand; single grain; loose, nonsticky, nonplastic; few fine roots; few black concretions; medium acid; clear smooth boundary. 4 to 10 inches thick.
B21t	--	28-36"	--Yellowish red (5YR 4/6) sandy clay; weak coarse subangular blocky structure; firm, slightly sticky, plastic; very few roots; common fine soft black concretions; strongly acid; sand grains are coated and bridged by red colored clays; clear wavy boundary. 6 to 10 inches thick.
B22t	--	36-44"	--Strong brown (7.5YR 5/6) clay with common fine prominent red (2.5YR 4/6), and common fine faint dark brown (7.5YR 4/4) mottles; weak coarse subangular blocky structure; firm, slightly sticky, plastic; few fine black concretions; many fine quartz grains; strongly acid; 10 to 20 percent soft plinthite; clear wavy boundary. 6 to 10 inches thick.
B23t	--	44-50"	--Strong brown (7.5YR 5/8) clay with common medium distinct yellowish brown (10YR 5/6), common fine and medium prominent dark red (2.5YR 3/6), and common medium prominent light gray (10YR 6/1) mottles; weak coarse subangular blocky structure; firm, slightly sticky, plastic; many fine quartz grains; very strongly acid; 10 to 20 percent soft plinthite; clear wavy boundary. 6 to 8 inches thick.
B24t	--	50-70"+	--Yellowish brown (10YR 5/6) clay with common medium prominent light gray (10YR 7/1) and few fine prominent dark red (2.5YR 3/6) mottles; weak coarse subangular blocky structure; firm, slightly sticky, plastic, many fine quartz grains; very strongly acid; 5 to 10 percent soft plinthite.

Type Location: Moroeste SCD, Puerto Rico, 1.0 mile west of the town of Isabela; 80 feet north and 30 feet west of kilometer marker 1.7 of highway 459.

Range in Characteristics: These soils have medium acid A horizons and strongly or very strongly acid B2t horizons. Thickness of the sandy A horizons varies from 20 to 40 inches. Thickness of the argillic horizon is over 50 inches. Colors of surface horizons range in hues of 7.5YR and 10YR, values of 4 or more and chromas of 2 to 4. Colors of the B2t horizons range in hues of 7.5YR and 5YR, values of 4 and 5 and chromas higher than 6. The B2t horizons have more than 5% nonindurated plinthite nodules. Texture of the A horizons is sand and that of the B2t horizons varies from sandy clay to clay. Structure of the B2t horizons ranges from weak moderate to weak coarse subangular blocky. Base saturation (by sum of cations) is less than 35% at 50 inches below the top of the argillic horizon. The organic matter content is less than 1.5% in the upper 6 inches of the argillic horizon.

Competing Series and their Differences: These are the Cabo Rojo, Cidral, Maleza, Bejucos, Rio Lejas, Jobos and Guanajibo series in the same Great Group. The Cabo Rojo soils have surface horizons with moist color values of less than 4. The Cidral soils have finer textured and thinner A horizons and lack the nonindurated

plinthite nodules. The Maleza and Bejucos soils have thinner sandy A horizons, lack the plinthite nodules and, in addition, the Maleza soils are redder, with hues redder than 5YR. The Rio Lajas soils have darker surface horizons and less than 35 percent clay in the B horizons. The Jobos and Guanajibo soils lack the thick sandy A horizon.

Setting: The Guerrero soils occur on gently sloping coastal plains with slope gradients of 2 to 5%. The regolith consists of coarse over fine textured sediments. The climate is humid tropical. The average annual precipitation is 60 inches and mean annual temperature 75°F. The mean annual soil temperature at depth of 20 inches is more than 72°F and the difference between mean summer and winter temperatures is less than 9°F.

Principal Associated Soils: These are the competing Jobos, Rio Lajas and Maleza series.

Drainage and Permeability: Excessively drained and slow runoff, permeability is rapid in the surface and moderately slow in the subsoil.

Use and Vegetation: Native pasture and subsistence crops.

Distribution and Extent: Humid coastal plains of Puerto Rico. The series is of minor extent.

Series Proposed: Noroeste SCD, Puerto Rico; Guerrero is the name of a "barrio" where the series was first recognized.

Remarks: These soils were formerly mapped in the Guayabo series but differ from it being usually moist and not having a subhorizon from 7 to 20 inches dry for as much as 60 consecutive days in most years.

National Cooperative Soil Survey

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, FORT WORTH, TEXAS
USDA-SCS-FORT WORTH TEX. 1967

APPROVED BY PRINCIPAL SOIL CORRELATOR
SOUTH REGION TSC, 6/13/67

Established Series
Rev-REG-LHR
3/67

Linda J Bartell

MALEZA SERIES

The Maleza series is a member of the clayey, oxidic, isohyperthermic family of Typic Paleudults. These soils have moderately coarse textured, very friable A horizons over thick, red, plastic, fine textured B2t horizons.

Typifying Pedon: Maleza fine sandy loam-native pasture
(Colors are for moist soil)

Ap	--	0-[illegible]	--Reddish brown (5YR 4/3) sandy loam; single grain; loose, very friable, slightly sticky, nonplastic; common fine roots; slightly acid; clear smooth boundary. 6 to 12 inches thick.
B1	--	10-17"	--Dark reddish brown (2.5YR 3/4) sandy clay loam; weak medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; few black sandy concretions; slightly acid; clear smooth boundary. 5 to 9 inches thick.
B21t	--	17-34"	--Red (10R 4/6) clay; weak medium subangular blocky structure; slightly hard, firm, slightly sticky, slightly plastic; few fine roots; few patchy clay films on ped faces and root channels; common very fine concretions; slightly acid; abrupt wavy boundary. 10 to 20 inches thick.
B22t	--	34-60"+	--Red (2.5YR 4/6) clay with common fine distinct weak red (10R 4/4) and common fine distinct strong brown (7.5YR 5/6) mottles; weak medium subangular blocky structure; hard, firm, slightly sticky, slightly plastic; few patchy clay films; strongly acid.

Type Location: Noroeste SCD, Puerto Rico; 0.4 miles west of the town of Isabela. 0.5 mile on dirt road from kilometer marker 1.4 of highway 459. 20 feet west of dirt road.

Range in Characteristics: Thickness of the solum is over 60 inches and that of the argillic horizon over 50 inches. Colors of the A horizons have hues of 5YR, values of 4 and chromas of 3 and higher. The B2t horizons have colors in hues of 10R and 2.5YR, values of 4 and chromas of 4 and higher. Sandy loam is the dominant type. Texture of the B2t horizons ranges from sandy clay to clay. Structure of the B2t horizons ranges from weak medium to coarse subangular blocky. These soils have slightly sticky and nonplastic A horizons and slightly sticky and slightly plastic B2t horizons. Reaction ranges from slightly to medium acid throughout. Base saturation (by sum of cations) is less than 35 percent at 50 inches below the top of the argillic horizon. The organic matter content is 1.5 percent or less in the upper 6 inches of the argillic horizon.

Competing Series and their Differentiae: These are the Bejucos and Cidral series in the same subgroup and the Cabo Rojo, Rio Lajas, Jobos and Guanajibo series in the same Great Group. The Bejucos soils are more acid and have yellower profiles. The Cidral soils have less than 20 percent oxides of iron and aluminum in the clay fraction. The Cabo Rojo soils have Ap horizons with moist color values of less than 4. The Río Lajas soils have thick, sandy surface horizons and coarser textured profiles. The Jobos and Guanajibo soils have more than 5 percent nonindurated plinthite in their profiles.

Setting: The Maleza soils occur on gently sloping coastal plains of slope gradients of 2 to 5 percent. The regolith consists of coarse textured over fine textured sediments. The climate is humid tropical. The average annual precipitation is 68 inches and the mean annual temperature 77°F. Soil temperature at 20 inches is over 22°C (71.6°F) and the difference between mean summer and winter temperature is less than

MALEZA SERIES

5°C (9°F).

Principal Associated Soils: These are the competing Bajucos, Rio Lajas, Jobos, and Guanajibo series in addition to the Coto, Cotito, and Matanzas series. The Coto and Cotito soils have finer textured and darker A horizons, and thinner, yellower B2t horizons. The Matanzas soils are dark red, have finer textured A horizons, and have thinner B horizons.

Drainage and Permeability: Well drained, slow runoff, and moderate permeability.

Use and Vegetation: Pasture, subsistence crops and coconuts.

Distribution and Extent: North coastal plains of Puerto Rico. The series is of moderate extent.

Series Established: Soil Survey of Puerto Rico, 1942.

Remarks: The Maleza series was formerly classified in the Reddish Brown Lateritic Great Soil Group.

National Cooperative Soil Survey
U.S.A.

APPROVED BY PRINCIPAL SOIL CORRELATOR
SOUTH REGION TSC, 6/8/67

Tentative Series
REG-LHR, 3/67

JOBOS SERIES

The Jobos series is a member of the clayey, oxidic, isohyperthermic family of Plinthic Paleudults. These soils have dark grayish brown, loose, nonsticky and nonplastic sandy A horizons over thick, mottled, plastic, fine textured argillic horizons that have nonindurated plinthite.

Typifying Pedon: Jobos sandy loam-native pasture
(Colors are for moist soil)

Ap -- 0-10" --Dark grayish brown (10YR 4/2) moist and light brownish gray (10YR 6/2) dry, sandy loam; weak medium subangular blocky structure breaking to single grain; loose, nonsticky, nonplastic; few fine roots; few fine subrounded black concretions; strongly acid; abrupt smooth boundary. 6 to 18 inches thick.

B21t -- 10-16" --Red (10R 4/6) and strong brown (7.5YR 5/6) clay; strong coarse subangular blocky structure; very hard, very firm, slightly sticky, plastic; few fine roots follow cleavage planes; thick continuous dark brown clay films on ped surfaces; strongly acid; 10 to 25 percent by volume of nonindurated plinthite; gradual smooth boundary. 5 to 8 inches thick.

B22t -- 16-29" --Red (10R 4/6) and strong brown (7.5YR 5/6) clay with few fine distinct light gray (10YR 7/1) mottles; moderate medium and coarse subangular blocky structure; very hard, very firm, slightly sticky, plastic; few fine roots; continuous brown clay films on vertical cleavage planes and patchy clay films on horizontal planes; few fine black concretions; strongly acid; 10 to 25 percent by volume of nodules of nonindurated plinthite; gradual wavy boundary. 12 to 16 inches thick.

B23t -- 29-34" --Red (10R 4/6), yellowish brown (10YR 5/6) and light gray (10YR 7/2) clay; weak coarse subangular blocky structure; very hard, very firm, slightly sticky, plastic; very few roots; thin patchy clay films; strongly acid; less than 10 percent by volume of nonindurated plinthite; gradual smooth boundary. 4 to 8 inches thick.

B24t -- 34-64"+ --Red (10R 4/6), yellowish brown (10YR 5/6) and light gray (10YR 7/2) clay; weak coarse subangular blocky structure; very hard, very firm, slightly sticky, plastic; very thin patchy clay films on ped faces; strongly acid; less than 10 percent by volume of nonindurated plinthite.

Type Location: Noroeste SCD, Puerto Rico; 5 miles west of the town of Isabela; 50 feet south of kilometer marker 9.1 of highway 459.

Range in Characteristics: Thickness of the solum is over 60 inches and that of the argillic is over 60 inches. Thickness of the A horizon ranges from 6 to 18 inches. Colors of the A horizons have hues of 10YR, values of 4 and chromas of 2 and 3. The B2t horizons have colors in varying proportions of red, strong brown, yellowish brown and light gray in a reticulate pattern. The low chroma mottles are due to the parent material and not to impeded drainage. Texture of the A horizons is dominantly sandy loam. Texture of the B2t horizons is clay. Structure of the B2t horizons varies from moderate to strong subangular blocky and clay films from thick continuous to thin patchy. These soils have nonsticky and nonplastic A horizons and slightly sticky and plastic B2t horizons. Reaction ranges from strongly to very strongly acid throughout. Base saturation (by sum of cations) is less than 35 percent at 50 inches below the top of the argillic horizon. Organic matter content is less than 1.5 percent in the upper 6 inches of the argillic horizon. Nodules of nonindurated plinthite, in amounts exceeding 5 percent by volume, occur within 20 inches of the soil surface.

Competing Series and their Differences: This is the Guanajibo series in the same Subgroup and the Cabo Rojo, Cidral, Maloza, Bajucos, Rio Lajas and Guerrero series in the same Great Group. The Guanajibo soils have coarser textured B horizons and the nonindurated plinthite occurs deeper than 20 inches. The Cabo

JOBOS SERIES

Rojo and Cidral soils have mixed mineralogy in the clay fraction. The Malaza and Bajucos soils do not have nonindurated plinthite in their profiles within 60 inches of the surface. The Rio Lajas soils have coarser textured argillic horizons and sandy A horizons more than 20 inches thick. The Guerrero soils have sandy A horizons thicker than 20 inches.

Setting: The Jobos soils occur on nearly level to gently sloping coastal plains on slope gradients of 2 to 5 percent. The regolith consists of fine textured sediments overlain by coarser textured sediments. The climate is humid tropical. The average annual precipitation is 67 inches and the mean annual temperatures 77°F. The mean annual soil temperature at 20" is more than 71.6°F with less than 9°F difference between mean summer and winter temperatures.

Principal Associated Soils: These are the competing Malaza, Rio Lajas, Bajucos, and Guerrero series.

Drainage and Permeability: Moderately well drained, runoff is slow and permeability is rapid in the A horizons and slow in the B2t horizons.

Use and Vegetation: Coconuts, subsistence crops and pasture.

Distribution and Extent: Humid coastal plains of northern Puerto Rico. The series is of moderate extent.

Series Proposed: Moroeste SCD, Puerto Rico, 1962. Recommended for establishment.

Remarks: These soils were formerly included in the Sabana Seca series and classified in the Ground Water Laterite Great Soil Group.

National Cooperative Soil Survey
U.S.A.

›pical Beach, Puerto Rico

Photo: F. H. Beinroth

TROPICAL SOILS INSTITUTE

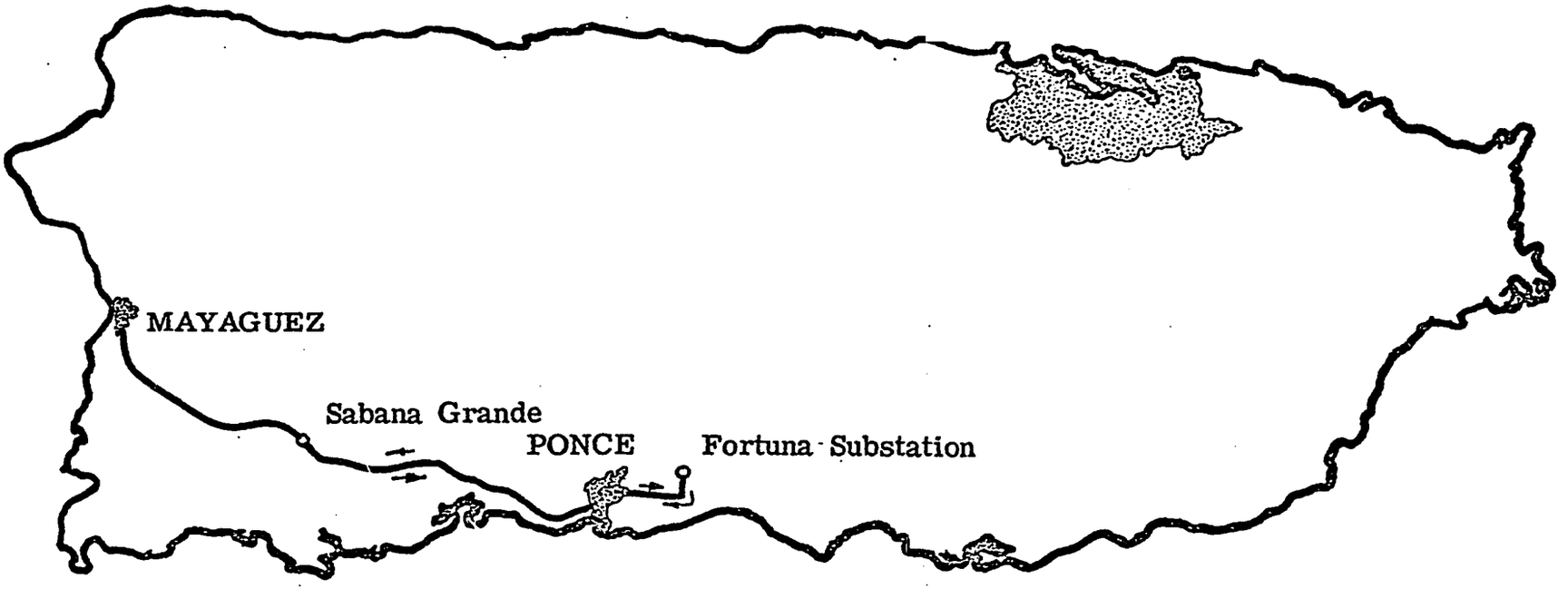
Puerto Rico, July 10 - August 4, 1972

FIELD TRIP 4 - "FORTUNA"

Date	:	Saturday, 7/22/72
Objective	:	To study soils and geomorphology of the dry south coast, and to see a collection of tropical fruit trees
Route	:	Mayaguez - Ponce - Fortuna Agr. Experiment Substation - Ponce - Mayaguez
Soil pits	:	Cumulic Haplustoll (San Anton Series)
Main Topics	:	Environment of semi-arid south coast; genesis of tropical Mollisols; irrigation; tropical fruit production
Extracurricular	:	Museum of Arts, Ponce

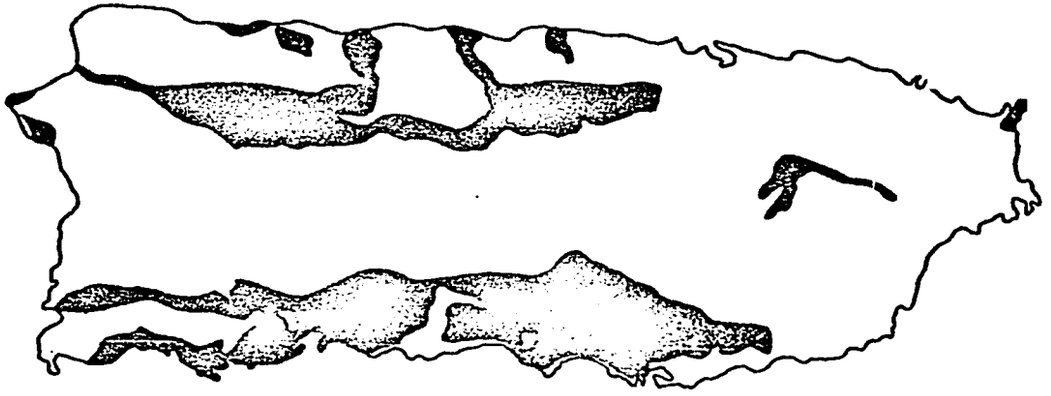
FHB/5-72

TROPICAL SOILS INSTITUTE Puerto Rico, July 10 - August 4, 1972



Field Trip 4 - "FORTUNA"

Occurrence of MOLLISOLS in Puerto Rico



FHB/68

APPROVED BY PRINCIPAL SOIL CORRELATOR
FOR THE DIRECTOR'S REVIEW
SOUTH REGION TSC, 5/65
Lindy J. Bartelli

Established Series
Rev. WEM, 5/65

SAN ANTON SERIES
Haplustolls

The San Anton series comprises Cumulic ~~Eutropepts~~, members of a fine loamy, mixed, non acid, isothermic family. These soils have very dark grayish brown to brown moderately fine textured profiles, weak cambic horizons and stratified C horizons.

Typifying Pedon: San Anton silty clay.
(Colors for moist conditions unless otherwise noted)

Ap	0-8"	Very dark brown (10YR 2/2) silty clay; weak fine granular structure; friable, slightly sticky and slightly plastic; few fine roots, few fine volcanic fragments; neutral; gradual wavy boundary. 5 to 10 inches thick.
B2	8-20"	Very dark grayish brown (10YR 3/2) silty clay loam; weak fine and medium subangular blocky; friable, slightly sticky and slightly plastic; no roots, a few fine volcanic fragments; neutral, clear wavy boundary. 8 to 15 inches thick.
C1	20-33"	Dark brown (10YR 3/3) silty clay loam; weak fine granular structure; friable moist, slightly sticky and slightly plastic; slightly alkaline; clear wavy boundary. 9 to 15 inches thick.
C2	33-40"	Very dark grayish brown (10YR 3/2) silty clay loam; massive; friable, slightly sticky and slightly plastic; no roots; slightly alkaline, clear smooth boundary. 6 to 9 inches thick.
IIC3	40-47"	Dark brown (10YR 3/3) silt loam; massive; very friable, slightly sticky and slightly plastic; no roots; neutral; clear wavy boundary. 6 to 12 inches thick.
IIIC4	47-52"	Brown to dark brown (10YR 4/3) sandy loam; massive; very friable, non sticky and non plastic; no roots; clear wavy boundary. 3 to 6 inches thick.
IVe5	52-65"+	Olive brown (2.5Y 4/4) loamy sand; massive; very friable, non sticky and non plastic neutral.

Type Location: Lajas Valley, Puerto Rico. 350 meters north Highway 116, Km. 30.7 and 150 meters southwest of Loco River.

Range in Characteristics: Clay loam, silty clay loam and silty clay are the principal types. The color of the A horizons have values of 2 to 4, chromas of 2 and 3 in hues of 10YR to 5YR. The B horizon colors have values of 2 to 4, chromas of 2 to 4 in hues of 10YR to 5YR. Texture of the B horizon varies from silt loam, silty clay loam, clay loam to gravelly clay loam. Structure of the B horizon ranges from weak fine to weak medium subangular blocky. The C horizons are stratified with materials ranging in texture from silty clay loam to loamy sand with varying amounts of gravel and with colors with values of 4, chromas of 2 to 4 in hues of 10YR to 5YR. Below 40 inches, colors are olive (5Y 4/4) to olive brown (2.5Y 4/4). Soil reaction ranges from slightly acid to alkaline.

Competing Series and Their Differentiae: These include the Cornhill, Amelia, Vives, Estacion, Tao, Caribe, and Guamani series. The Cornhill soils have similar upper profiles but are underlain by plastic clays within 40 inches of the surface, and have highly plastic C horizons. The Amelia soils have a very gravelly (skeletal) sola. The Vives soils have thicker sola and clay cambic horizons. The Estacion and Toa soils (Cumulic Eutropepts) are more acid and occur in areas lacking dry periods of 60 days. The Caribe soils, (Cumulic Haplorthents) have coarser textured profiles and lack a cambic horizon. The Guamani soils, (Typic Ustropepts) are shallow (10-20 inches) to gravel.

Setting: The San Anton soils occur on nearly level flood plains and alluvial fans with slope gradients of 0 to 2 percent being dominant but includes areas where the flood plain has been dissected and slopes range up to 12 percent; the regolith consists of stratified medium to moderately fine textured sediments derived from volcanic and limestone rocks. The climate is semiarid. Average annual rainfall ranges from 35 to 50 inches and mean annual temperature is 78 to 80°F.

Principal Associated Soils: These include the Fraternidad, Santa Isabel, Aguirre and Cartagena soils which occur on older finer textured sediments with high shrink-swell characteristics; *Arenales soils which have coarser textured profiles (sands and loamy sands) and the Vayas soils (Cumulic Normaquepts) have low chroma mottles in the upper 20 inches.

Drainage and Permeability: Well drained with medium runoff; solum moderately permeable with underlying sediments ranging from moderate to moderately rapid.

U. S. D. A., SOIL CONSERVATION SERVICE, FORT WORTH, TEXAS
0000-000-FORT WORTH, TEX. 1000

San Anton Series

Use and Vegetation: Acreage largely cultivated and used for the production of sugar cane, tomatoes and subsistence crops. Many ares are irrigated.

Distribution and Extent: In tho semiarid section of Puerto Rico and the American Virgin Islands.

Series Established: Puerto Rico, 1936.

National Cooperative Soil Survey

USA

Land capability: III c, irrigated: I-2

APPROVED BY THE PRINCIPAL SOIL CORRELATOR
FOR THE DIRECTOR'S REVIEW
SOUTH REGION TSC, 5/65
Linda J Bartelli

Established Series
Rev. WEM: 5/65

AGUILITA SERIES

Calciustolls

The Aguilita series consists of Typic ~~Rendolls~~, members of a loamy skeletal, carbonatic isothermic family. These soils have thin very dark grayish brown gravelly moderately fine textured A horizons and dark grayish brown gravelly moderately fine textured AC horizons resting on soft limestone.

Typifying Pedon: Aguilita gravelly clay loam.
(Colors for moist conditions unless otherwise noted)

A	0-6"	Mixed very dark grayish brown (10YR 3/2) and light brownish gray (10YR 6/2) gravelly heavy clay loam; moderate fine subangular blocky structure; slightly hard, firm slightly sticky and slightly plastic; approximately 50 percent limestone rock fragments; calcareous; common fine roots;clear smooth boundary. 3 to 8 inches thick.
AC	6-10"	Mixed very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) clay loam; weak fine granular structure; firm; 50 to 70 percent limestone fragments; calcareous; few fine roots; gradual smooth boundary. 3 to 6 inches thick.
C	10-60"+	White (10YR 8/1) soft limestone or marl including few to common hard limestone or sandstone concretions.

Type Location: St. Croix, Virgin Islands. One half mile north of intersection (located 3/4 mile east Insular Experiment Station on road to Christiansted) and 125 feet west.

Range in Characteristics: Depth to soft limestone or marl ranges from 4 to 14 inches and limestone fragments range from common to many. Color of the A horizon ranges from very dark grayish brown (10YR 3/2) to dark yellowish brown (10YR 3/4) and the texture ranges from gravelly clay loam to gravelly clay. The AC horizon ranges from dark grayish brown (10YR 4/2) to brown (10YR 5/3) in color and from a gravelly clay loam to gravelly clay in texture. This horizon may also have discontinuous pockets of weak blocky structure. The underlying limestone can be penetrated with a spade but commonly has hard limestone fragments mixed throughout. Color ranges from white to light gray.

Competing Series and Their Differentiae: These include the Sion soils in the same subgroup in a fine loamy family. The Fredensborg, Soller, Colinas, and Pozo Blanco soils in different subgroups of the same great group and the San German soils. The Sion soils are similar in being underlain by very soft limestone or marl but have slightly thicker sola (10-20 inches) and are free of limestone fragments. The Fredensborg and Soller soils (Ustertic Rendolls), have thicker (14 inches) clay sola. The Colinas soils have thicker sola (more than 14 inches) with a cambic horizon and in addition lack calcic horizons. The Pozo Blanco soils have cambic horizons, over a calcic horizon. The San German soils (Lithic Haplorthents) are underlain by limestone sufficiently hard to qualify as lithic.

Setting: The Aguilita soils occur on gently to steeply sloping limestone mountains and hills with slope gradients of 2 to 60 percent. The regolith consists of residuum derived from limestone. The climate is semiarid. The average annual rainfall ranges from 30-45 inches and the average annual temperature ranges from 78 to 80°F.

Principal Associated Soils: These include the Descalabrado, Hesselberg, Cramer and Guayama series in addition to the Sion, Fredensborg, Soller, Colinas, Pozo Blanco and San German series. The Descalabrado and Hesselberg soils, (Lithic Ustropepts) have thin cambic horizons and rest on hard rock at depths of 10 to 20 inches. The red Hesselberg soils are derived from residuum of hard limestone and occur on nearly level to gentle slopes. The Cramer soils, with thin argillic horizons (Lithic Argiustolls) and the Guayama soils with thin cambic horizons (Lithic Eutropepts) rest on hard volcanic rocks at 10 to 20 inches.

Drainage and Permeability: Well drained with medium to excessive runoff and moderate permeability.

Use and Vegetation: Acreage largely in grass and brush. Small acreage cleared and in Guinea grass and used as pasture.

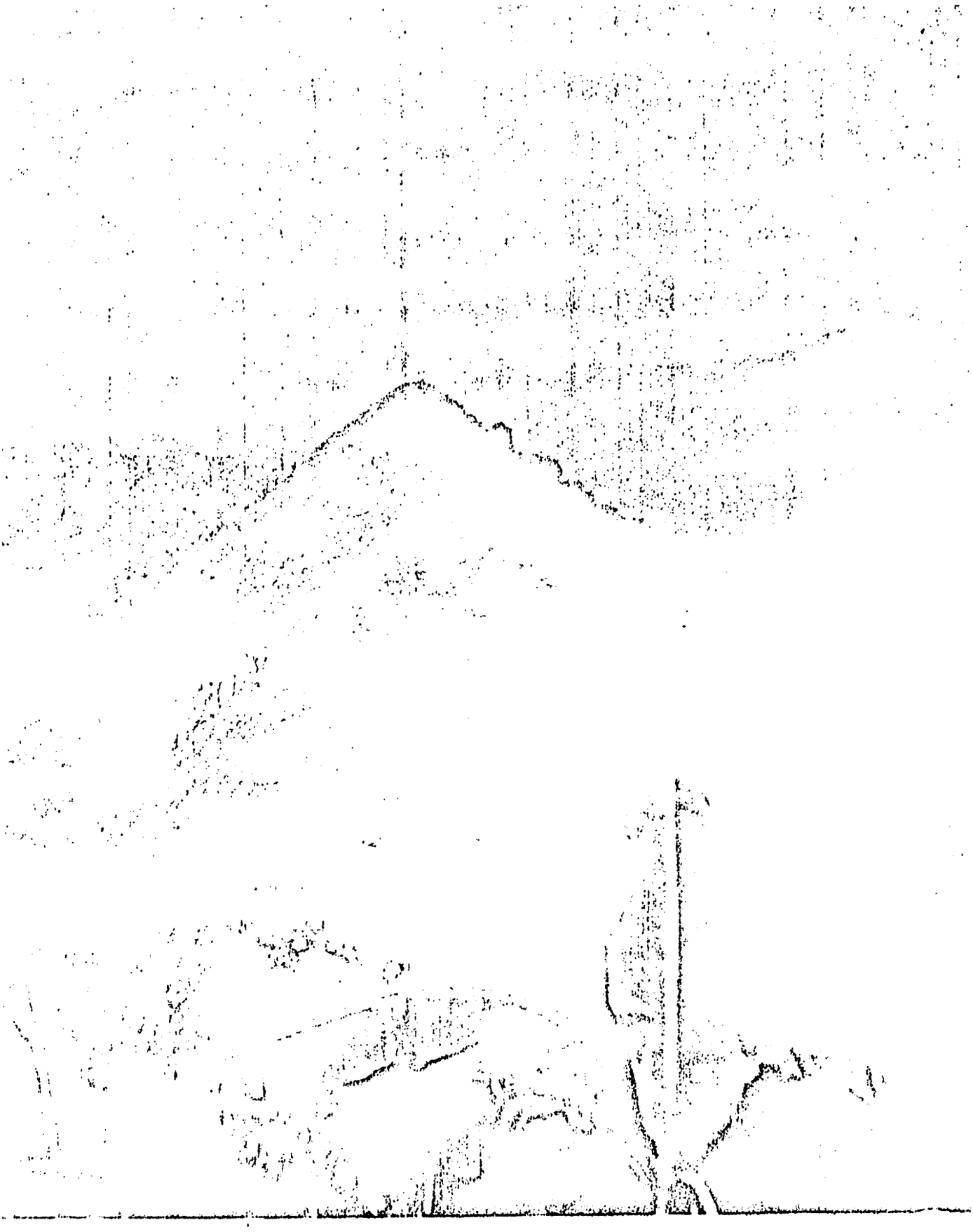
Distribution and Extent: In the semiarid sections of Puerto Rico and American Virgin Islands. Series is of moderate extent.

Series Established: Puerto Rico, 1936.

Remarks: Type location changed to St. Croix as good field notes are available and also the Aguilita soils of St. Croix are very similar to the Aguilita soils along the southern coast of Puerto Rico.

National Cooperative Soil Survey

USA



:ro la Torre, Puerto Rico

Photo: F. H. Beinroth

TROPICAL SOILS INSTITUTE

Puerto Rico, July 10 - August 4, 1972

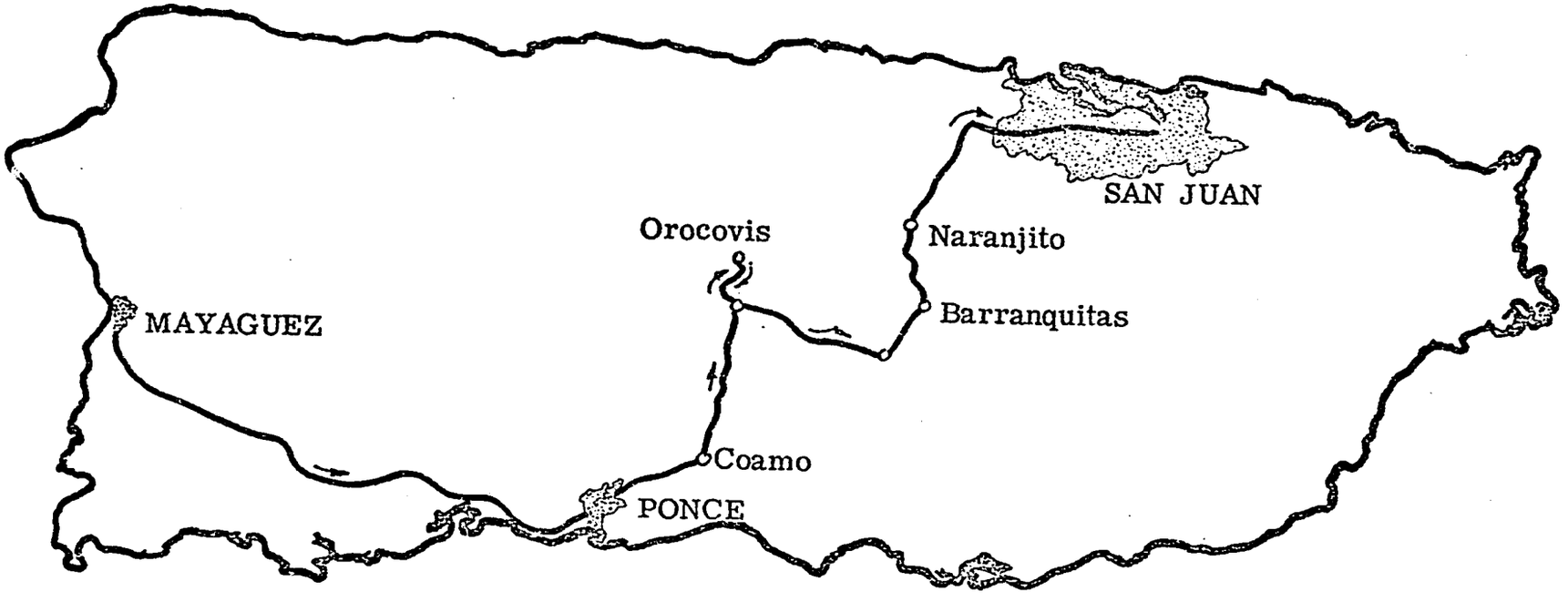
FIELD TRIP 5 - "SAN JUAN

First Day : :Orocovis - Barranquitas

Date	:	Friday, 7/28/72
Objective	:	1. To visit an experiment site with intensive pasture management 2. To discuss geomorphology and genesis of an oxisol and to see it's response to nitrogen
Route	:	Mayaguez - Ponce - Coamo - Orocovis - Barranquitas - Narangito - San Juan
Soil pit	:	Tropeptic Haplorthox (Catalina Series)
Main Topics	:	Orocovis : Intensive pasture management on [illegible] Barranquitas : Geomorphology and soil patterns of central Puerto Rico; Oxisol genesis experiments
Remarks	:	Over - night in San Juan, Hotel Borinquen

FHB/5-72

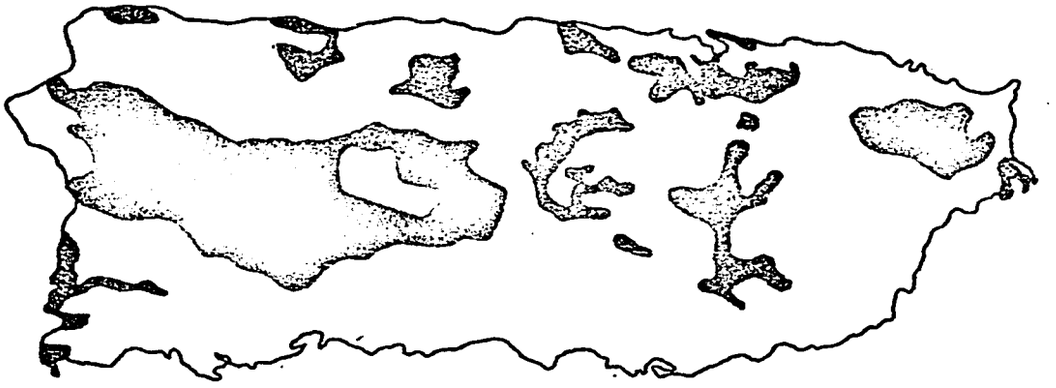
TROPICAL SOILS INSTITUTE Puerto Rico, July 10 - August 4, 1972



Field Trip 5 - "SAN JUAN"

First Day : "OROCOVIS - BARRANQUITAS"

Occurrence of ULTISOLS in Puerto Rico



FHB/68

Soil Classification: Typic Tropohumult; clayey, mixed,1/ isohyperthermic
Soil Type: *Amatas clay
Soil Nos.: 861PR-8-1
Location: Coate Soil Conservation District, Mayaguez, Puerto Rico, on Highway 406, near kilometer marker 2.45, 200 meters on dirt road and 350 feet southwest of road. Photo No. GS-LR-3 140.
Vegetation and Use: Native pasture and weeds. Few orange trees.
Slope and Land Form: 27 percent. Southwest aspect. Sideslope in uplands.
Drainage and Permeability: Well drained, medium runoff, medium internal drainage. Permeability is moderate.
Parent Material: Residuum or very local colluvium from volcanic rocks.
Collected by: R. B. Grossman, W. E. McKinzie, O. R. Carter, L. H. Rivera, December 5, 1961.
Described by: W. E. McKinzie, December 5, 1961.

Horizon and Lincoln Lab. No.

Ap 16825 — 0 to 4 inches. Brown to dark brown (7.5YR 4/4) with few fine faint reddish brown (5YR 4/4) mottles, clay loam; moderate fine granular structure; friable when moist, slightly sticky and slightly plastic when wet; many fine roots; few fine charcoal fragments; clear smooth boundary.

B21t 16826 — 4 to 9 inches. Yellowish red (5YR 5/6) clay with moderate fine subangular blocky structure; friable when moist, nonsticky and slightly plastic when wet; many fine roots; few fine pores; few fine black particles; fails semiplastically,2/ clear smooth boundary.

B22t 16827 — 9 to 15 inches. Red (2.5YR 5/8) clay with moderate medium to fine subangular blocky structure; friable when moist, slightly sticky and slightly plastic when wet; many fine roots; few fine pores; thin patchy clay films; fails semiplastically; clear smooth boundary.

B23t 16828 — 15 to 25 inches. Red (2.5YR 5/6) clay with weak fine subangular blocky structure; friable when moist, nonsticky and slightly plastic when wet; few roots; few fine pores; black stains in root channels; no clay films; fails semiplastically; clear smooth boundary.

B3 16829 — 25 to 32 inches. Red (2.5YR 5/6) with common fine faint yellow mottles, clay; weak fine and medium subangular blocky structure; very friable when moist, nonsticky and slightly plastic when wet; few roots; many fine pores; fails abruptly; clear smooth boundary.

C1 16830 — 32 to 45 inches. Variegated brownish yellow (10YR 6/6) saprolite and red (2.5YR 5/6) clay; massive to very weak structure; very friable when moist, nonsticky and slightly plastic when wet; many fine pores; fails abruptly; clear smooth boundary.

C2 16831 — 45 to 60 inches. Variegated brownish yellow (10YR 6/6) and red (2.5YR 5/6) silty clay saprolite; massive structure; very friable when moist, nonsticky and slightly plastic when wet.

C3 16832 — 72 to 96 inches. Red (2.5YR 5/6) variegated with dusky red, white, gray clay loam saprolite; massive structure; very friable when moist, nonsticky and nonplastic when wet. (Auger sample; 5- to 6-foot depth discarded.)

C4 16833 — 96 to 120 inches. Auger sample.

Remarks: The Ap, B22t and C1 horizons were sampled for the Bureau of Public Roads. Colors given are for moist soil. Soil was at field capacity when sampled.

Mineralogy, Micromorphology (Methods 7B1, 4E1, 7A). Most of the grains are reddish brown, iron-bearing earthy nodules; some whitish grains come in near the bottom of the profile. The very fine sand consists mainly of iron oxide-coated grains which have white interference colors around the periphery where the opaque coating is thin. The bottom horizon has some uncoated grains with low interference colors. Very little quartz. No grains of ferromagnesian minerals identified. No mica flakes were observed under the stereoscopic microscope in these horizons. No clay films observed in thin sections of the B2t, and the fabric has weak clay orientation. The following data were obtained by differential thermal analysis (kaolinite) and by X-ray diffraction (Beltsville laboratory data).

Horizon	< 2mm. Soil Powder				Iron-Free Clay				
	Kl	Q	Gb	G	Kl	Vm		Mt	Mi
	%				%				
Ap	34	X	T	T	35	T	—	T —	T
B21t	32	X	T	T	40	X	—	X —	T
B22t	30	X	T	T	50	X	—	X —	T
B23t	32	X	T	T	40	X	—	T —	X
B3	33	X	T	T	40	X	—	X —	X
C1	40	X	T	T	40	X	—	X	XX
C2	33	X	T	T	30	-		T	XX
C3	42	X	T	X	40	T	—	T —	T
C4	44	T	T	X	33	X	—	X —	X

T	Trace	Kl	Kaolinite	Mi	Mica
X	Small	Q	Quartz	Gb	Gibbsite
XX	Moderate	Fl	Feldspar		
XXX	Abundant	G	Goethite		
XXXX	Dominant	Vm	Vermiculite		
		Mt	Montmorillonite		

1/ Fails oxidic family class because of decrease in iron to clay ratios when clay percentage based on 2.5 times the 15-bar water content.

2/ Two terms are used in the descriptions to describe the rate of failure of natural fabric: fails abruptly and fails semiplastically. To fail abruptly means that no plasticity is observed prior to failure. Stress builds up as the piece of soil is squeezed and dissipates quickly as the piece of soil breaks apart into numerous fragments or peds due to failure along natural planes of weakness. In semiplastic failure, deformation is readily observed prior to rupture.

SOIL CLASSIFICATION: Typic Tropohumult; clayey, mixed, isohyperthermic

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL #Ramatas clay SOIL Nos. 861PR-8-1 LOCATION Costa BCD, Puerto Rico

SOIL SURVY LABORATORY Lincoln, Nebraska LAB. Nos. 16825-16833 November 1966
General Methods: 1A, 1bia, 2A1, 2B

Depth (in.)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2–0.05) a	Total: Silt (0.05–0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2–1)	Sand: Coarse (1–0.5)	Sand: Medium (0.5–0.25)	Sand: Fine (0.25–0.1)	Sand: Very fine (0.1–0.05)	Silt: 0.05–0.02	Silt: Int. III (0.02–0.002)	Silt: Int. II (0.2–0.02)	(2–0.1)			Coarse fragments 2A2: > 2 (>19) Pct.	2 – 19	19 – 76
		Pct. of < 2 mm														Pct.	Pct. of < 76mm	
0-4	Ap	6.0	29.4	64.6	1.3	1.1	0.6	1.3	1.7	4.4	25.0	6.9	4.3			tr		
4-9	B21t	2.5	28.1	69.4	-	0.1	0.2	0.7	1.5	3.8	24.3	5.8	1.0			tr		
9-15	B22t	2.7	34.4	62.9	-	tr	0.1	0.5	2.1	6.0	28.4	8.5	0.6			-		
15-25	B23t	6.1	46.3	47.6	-	0.1	0.1	0.9	5.0	9.9	36.4	15.6	1.1			-		
25-32	B3	10.7	50.7	38.6	0.1	0.2	0.2	2.1	8.1	12.6	38.1	22.2	2.6			-		
32-45	C1	15.3	51.0	33.7	0.2	0.4	0.4	3.2	11.1	13.5	37.5	27.2	4.2			-		
45-60	C2	18.1	50.3	31.6	0.2	0.9	0.6	4.3	11.9	12.9	37.4	28.1	3.2			-		
72-96	C3	21.1	51.9	27.0	3.6	2.2	1.5	4.8	9.0	13.2	38.7	25.4	12.1			6		
96-120	C4																	

Depth (in.)	6A1a Organic carbon b Pct	6B1a Nitrogen Pct.	C/N	6C2a Ext. Iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.		Bulk density 4A1a Field-State g/cc	4A1c 30-cm. g/cc	4A1b Air-Dry g/cc	4B1 COLE d	Water content 4B4 Field-State Pct	4B3 30-cm. Pct.	4B1b 1/3-Bar Pct	4B2 15-Bar Pct.		pH 8C1c (1:1) H KCl	8C1A H2O
0-4	4.90	0.430	11	8.1			0.89		1.10	0.073	63.3		47.5	32.1		3.9	4.6
4-9	2.00	0.211	9	8.4			1.06		1.42	0.10	49.6e		39.8	31.4		3.7	4.7
9-15	1.16	0.121	10	8.0			1.16		1.40	0.064	43.3		39.0	31.4		3.8	4.9
15-25	0.59	0.067	9	7.7			1.1c				f		36.7	30.1		3.8	5.0
25-32	0.36	0.049	7	7.3			1.09	1.17	1.24	0.044	47.0	41.0	40.7	28.6		3.8	4.9
32-45	0.31			7.3			1.04	1.09	1.14	0.032	48.9	43.4	39.6	28.0		3.7	4.8
45-60	0.25			6.9			1.04	1.10	1.16	0.036	48.9	46.4	40.0	23.5		3.7	4.8
72-96	0.10			8.1										24.3		3.7	4.7
96-120	0.06			8.7										24.7		3.7	4.9

Depth (in.)	Extractable bases 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	5B1a Sum	6H1a Ext. Acidity	Cat. Exch. Cap. 5A3a Sum Cations	5A1a NH_4OAc	6G1d KCl-Ext. Al		5A3b Bases Plus Al meq/100g Clay					Base saturation 5C3 Sum Cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g																
0-4	2.4	1.5	0.1	0.4	4.4	31.5	35.9	24.7	4.0		13.0					12	18
4-9	2.8	0.7	tr	0.1	3.6	23.2	26.8	17.6	5.4		13.0					13	20
9-15	2.9	0.8	0.1	0.1	3.9	19.9	23.8	16.0	4.5		13.4					16	24
15-25	1.1	0.5	0.1	0.1	1.8	19.9	21.7	14.7	7.0		12 g					8	12
25-32	0.5	0.5	tr	0.2	1.2	21.3	22.5	15.4	9.1		14 g					5	8
32-45	0.7	0.3	tr	0.2	1.2	21.2	22.4	16.2	9.2		15 g					5	7
45-60	0.5	0.3	tr	0.2	1.0	21.5	22.5	15.1	10.0		19 g					4	7
72-96	0.1	0.3	tr	0.1	0.5	20.0	20.5	14.1	10.2		18 g					2	4
96-120	tr	0.3	tr	0.1	0.4	18.8	19.2	13.6	10.0		17 g					2	3

Depth (in.)	Ratios to Clay 8B1 NH_4OAc CEC	Ext. Iron	15-Bar Water		
0-4	0.38	0.12	0.50		
4-9	0.25	0.12	0.45		
9-15	0.25	0.13	0.50		
15-25	0.31	0.16	0.63		
25-32	0.40	0.19	0.74		
32-45	0.48	0.22	0.83		
45-60	0.48	0.22	0.74		
72-96	0.52	0.30	0.90		
96-120					

Underlining indicates that the non-clay probably has strong clay-like properties.

a. Earthy nodules: > 50 percent.
b. 14 kg/m² to 60 inches (Method 6A).
c. Estimated.
d. Field state.
e. Field-determined value: 48.8 percent.
f. Field-determined value: 46.5 percent.
g. Clay percentage is estimated (15-bar water percentage x 2.5).

HUMATAS SERIES - Typic Tropohumults

Horizon	Depth cm	Extractable SO_4S * $\mu g/g$ soil	Silicon		
			Saturation Extract	1:10 Water	1:10 Phospate
			Si. ppm. solution		Si. $\mu g/g$ soil
Ap	0-14	12	7.71	1.90	66.8
B21	14-28	180	5.11	1.07	36.9
B22	28-55	356	3.84	.99	33.6
B3	55-80	353	5.04	.90	35.7
C1	80-110	307	4.80	.98	27.4
C2	110-125	290	5.28	1.10	28.2

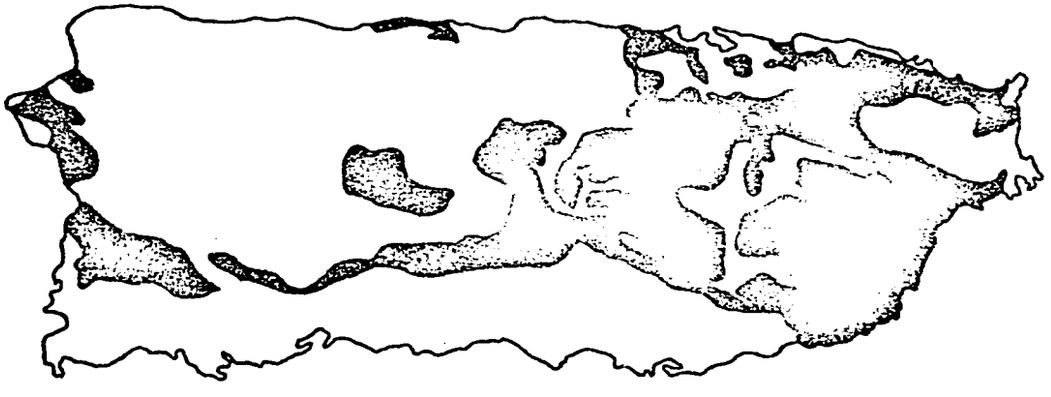
Unpublished data of R. L. Fox, Dept. of Agronomy and Soil Science, University of Hawaii

*) Repeated extraction (4 times) with 500 ppm P (CaH_2PO_4)
Soil: Extracting solution ratio was 1:5 for each extraction

Soil Study Area, Barranquitas, Puerto Rico

Photo: F. H. Beinroth

Occurrence of INCEPTISOLS in Puerto Rico



FHB/68

Soil Classification: Typic[1] Eutropept; clayey,[2] mixed,[3] isohyperthermic, shallow
Soil Type: Series not designated
Soil No.: 61PR-4-2
Location: Cibuco Soil Conservation District, Puerto Rico; 80 feet west of marker KB H9, Highway 152. Barranquitas Soil Study Area.
Elevation: 610 to 615 meters.
Slope: 20 percent to north and 10 to 15 percent to west.
Vegetation and Land Use: Brushy road bank; previously cultivated.
Parent Material: Designated by Briggs as "basaltic-andesite flow breccia". (Briggs, R. P. Laterization in East-Central Puerto Rico. Trans. Second Caribbean Geol. Cong. 103-109. 1959.)
Collected and Described by: R. B. Grossman, March 12, 1961.

Horizon and Lincoln Lab. No.

Ap1 14885 — 0 to 1 inch. Dark reddish brown (5YR 3.5/4) silty clay; moderate medium and coarse granular; friable; sticky and plastic; overlay of slope wash plus some Ap2.

Ap2 14886 — 1 to 6 inches. Brown (10YR 4/3) clay loam with portions and many macrosurfaces dark grayish brown (10YR 4/2); moderate medium subangular blocky that crushes to medium granular; firm; slightly sticky and plastic; fails abruptly;[4] many medium and coarse pores both exped and inped; possible weak broken clay films on pore walls; common saprolite of pebble and sand-size that crushes easily between fingers; roots common; clear to abrupt boundary.

B 14887 — 6 to 13 inches. Brown (10YR 5/3) fine loam with strong brown (7.5YR 5/6) macrosurfaces; soft saprolite, common; weak coarse subangular blocky; firm to friable; distinct broken clay films, mainly along pore walls and on surfaces of saprolite; reddish brown (5YR 4/4) clayey surfaces are quite general and predominate in several isolated parts; few roots; wavy clear to abrupt boundary.

C1 14888 — 13 to 22 inches. Saprolite. Largely rock structure; after saturation with water, breaks down easily between fingers; about 60 percent reddish brown (5YR 4/3), 30 percent white (10YR 8/2) and 10 percent yellowish green, the latter two colors occurring as small (less than 5 mm. across) disconnected parts; fracture surfaces have black coatings of Fe-Mn(?).

C2 14889 — 22 to 34 inches. Similar to above; differences are that it cannot be easily broken in hands after saturation, has strong brown (7.5YR 5/6) rather than reddish brown as the principal color and perhaps has more yellowish green material. Criterion for separation from the superjacent horizon is resistance to breakdown in hands after saturation.

R1 14890 — 34 to 54 inches. Saprolite; numerous clay-rich seams, more than in superjacent horizon; reddish brown (5YR 4/3) clay common on surfaces of saprolite fragments.

R2 14891 — About 15 feet. Chipped away pillow lava from outcropping ledge; quartz veins common; carbonate occurs in fractures.

R3 14892 — About 35 feet. A "cobble" of pillow lava about 10 inches across that pried away easily from exposure.

Mineralogy (Method 7A).

Horizon	Depth Inches	Montmorillonite	Vermiculite	Mica	Kaolin %
Ap1	0-1	xx	xx	x	27
Ap2	1-6	xxx	xx	tr	21
B	6-13	xx	xxx	tr	23
C1	13-22	xx	xxx	tr	20
C2	22-34	xx	xxx	tr	15
R1	34-54	xxx	xxx	tr	11

Amounts estimated by X-ray diffraction are: tr = trace, x = small, xx = moderate, xxx = abundant. Kaolin percentages estimated by differential thermal analysis. Montmorillonite and vermiculite occur in interlayer association. Vermiculite dominates, accompanied by a small montmorillonite component.

1/ It is assumed that the criteria for Vertic Lithic Eutropepts will also be applied to shallow families and that the measured clay percentage is the relevant value.

2/ Family texture based on clay percentage estimated as 2.5 times the 15-bar water content.

3/ Fails oxidic family class because of decrease in iron to clay ratios when clay percentage estimated as 2.5 times the 15-bar water content.

4/ Two terms are used to describe the rate of failure of natural fabric: fails abruptly and fails semiplastically. To fail abruptly means that no plasticity is observed prior to failure. Stress builds up as the piece of soil is squeezed and dissipates quickly as the piece of soil breaks apart into numerous fragments or peds due to failure along natural planes of weakness. In semiplastic failure, deformation is readily observed prior to rupture.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL CLASSIFICATION: Typic Eutropept; clayey, mixed, isohyperthermic, shallow

SOIL Series not designated SOIL Nos. S61PR-4-2 LOCATION Cibuco SCD, Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 14885-14892 December 1966

General Methods: 1A, 1B1b, 2A1, 2B

Depth (in.)	Horizon	Size class and particle diameter (mm) 3A1: Total: Sand (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)	3A1c Water-Disp. Clay <0.002		Coarse fragments 2A2: >2 (<19)	2-19	19-76
		Pct. of < 2 mm														Pct.	Pct. of < 76mm	
0-1	Ap1	22.6	33.4	44.0	1.1	3.9	3.4	7.7	6.5	9.8	23.6	20.5	16.1			tr		
1-6	Ap2	32.5	35.5	32.0	2.3	5.7	5.0	10.9	8.6	11.1	24.4	25.6	23.9			tr		
6-13	B	44.8	33.9	21.3	4.3	7.3	6.8	15.3	11.1	11.4	22.5	30.8	33.7	14		tr		
13-22	C1	56.9	29.9	13.2	7.2	12.4	8.5	17.0	11.8	11.2	18.7	32.3	45.1			tr		
22-34	C2																	
34-54	R1																	

Depth (in.)	6A1a Organic carbon	6B1a Nitrogen	C/N		6E2a Carbonate as $CaCO_3$	6C2a Ext. Iron as Fe	Bulk density: 4A1a Field-State		4A1b Air-Dry	4D1 COLE	Water content: 4B4 Field-State		4B2 15-Bar			pH: 8C1c (1:1) N KCl	8C1a (1:1) H_2O
	Pct.	Pct.			Pct.	Pct.	g/cc	g/cc	g/cc		Pct.	Pct.	Pct.				
0-1	2.26	0.186	12			5.5							24.4			3.9	4.9
1-6	1.77	0.158	11			4.5	1.26		1.33	0.017	24.9		22.5			3.7	5.0
6-13	0.73	0.072	10			3.9	1.17		1.26	0.024	32.1		19.8			3.6	5.0
13-22	0.15				-(a)	2.9	1.62		1.70		14.6		17.2			3.6	5.5
22-34							1.96		2.04	0.014	9.0						
34-54							1.96		2.08	0.020	9.6						

Depth (in.)	Extractable bases 5B1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. Acidity	Cat. Exch. Cap.: 5A3a Sum Cations	5A1a NH_4OAc	6G1d KCl-Ext. Al		5A3b Based Phn Al me/100g Clay			8D3 Ca/Mg		Base saturation: 5C3 Sum Cations	5C1 NH_4OAc
	meq/100 g															Pct.	Pct.
0-1	14.1	10.6	0.2	1.0	25.9	22.7	48.6	34.0	1.9		63.2			1.3		53	76
1-6	13.2	9.4	0.2	0.4	23.2	24.8	48.0	35.0	4.6		50 a			1.4		48	66
6-13	14.6	13.2	0.4	0.2	28.4	23.6	52.0	38.2	4.9		67 a			1.1		55	74
13-22	24.8	20.6	0.5	0.2	46.1	10.8	56.9	45.8	1.5		111 a			1.2		81	101
22-34																	
34-54																	

Depth (in.)	Ratios to Clay 8D1: NH_4OAc CEC	Ext. Iron	15-Bar Water		
0-1	0.77	0.13	0.55		
1-6	1.09	0.14	0.70		
6-13	1.79	0.18	0.93		
13-22	3.47	0.22	1.30		
22-34					
34-54					

Underlining indicates that the non-clay probably has strong clay-like properties.

a. Clay percentage is estimated (15-bar water percentage x 2.5).

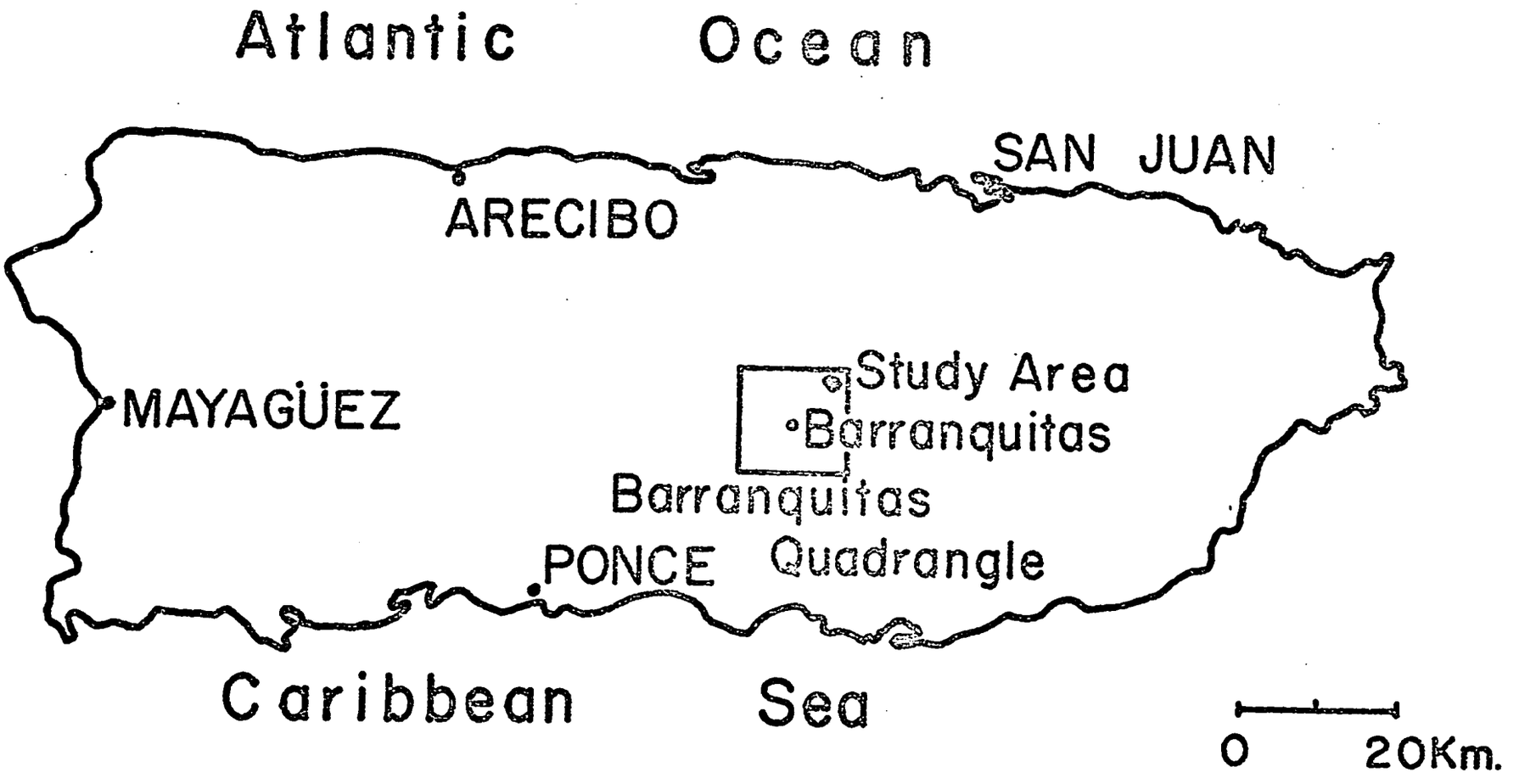


Figure 1: Location of study area near Barranquitas, Puerto Rico.

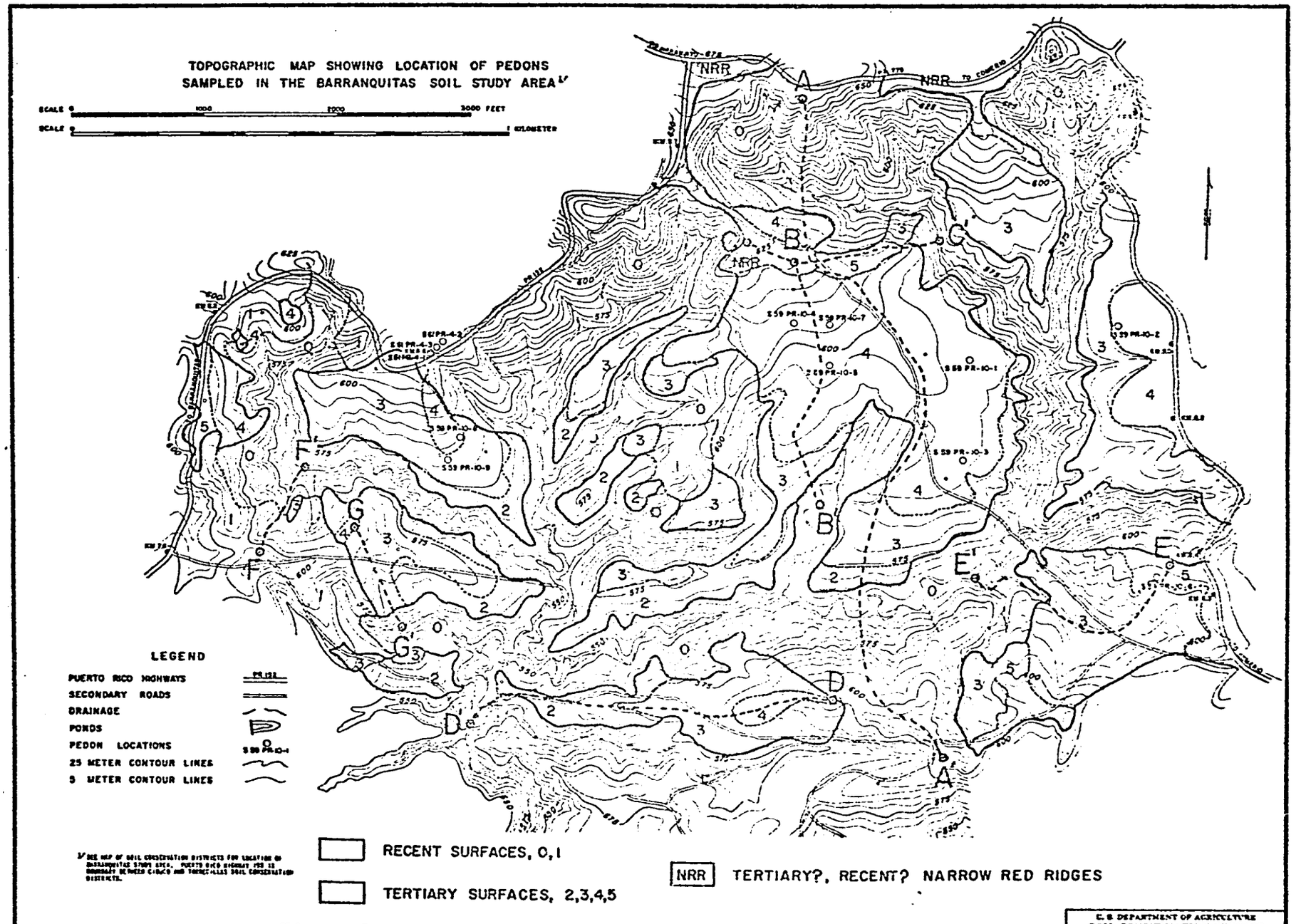


Figure 2: Geomorphic Surface map of the Barranquitas study area.

TABLE 2

Slopes of Geomorphic Surfaces In Percent

Surface	Slope (mean)		(standard deviation)
2, 3, 4, and 5			
Footslope	4.1	±	2.8
Backslope	19.1	±	8.4
0 and 1			
Backslope	37.6	±	23.8

TABLE 3

Mean altitude range of geomorphic surfaces in the Barranquitas study area

Surface	Mean altitude range in meters
0	540 - 670
1	585 - 620
2	560 - 575
3	565 - 625
4	590 - 610
5	600 - 615
NRR (narrow red ridge)	610 - 675

TABLE 4

Slopes, in Percent, by Soil Orders, Barranquitas Area

	Mean	Standard Deviation	Range Min.	Max.	Number of Observations
OXISOLS					
Footslopes	4.1	± 2.8	1	10	19
Backslopes	19.1	± 8.4	9	34	14
Valley Sides	36.0	± 10.8	16	51	13
ULTISOLS					
Valley Sides	36.3	± 16.8	3	72	26
INCEPTISOLS					
Valley Sides	39.8	± 16.4	5	70	23

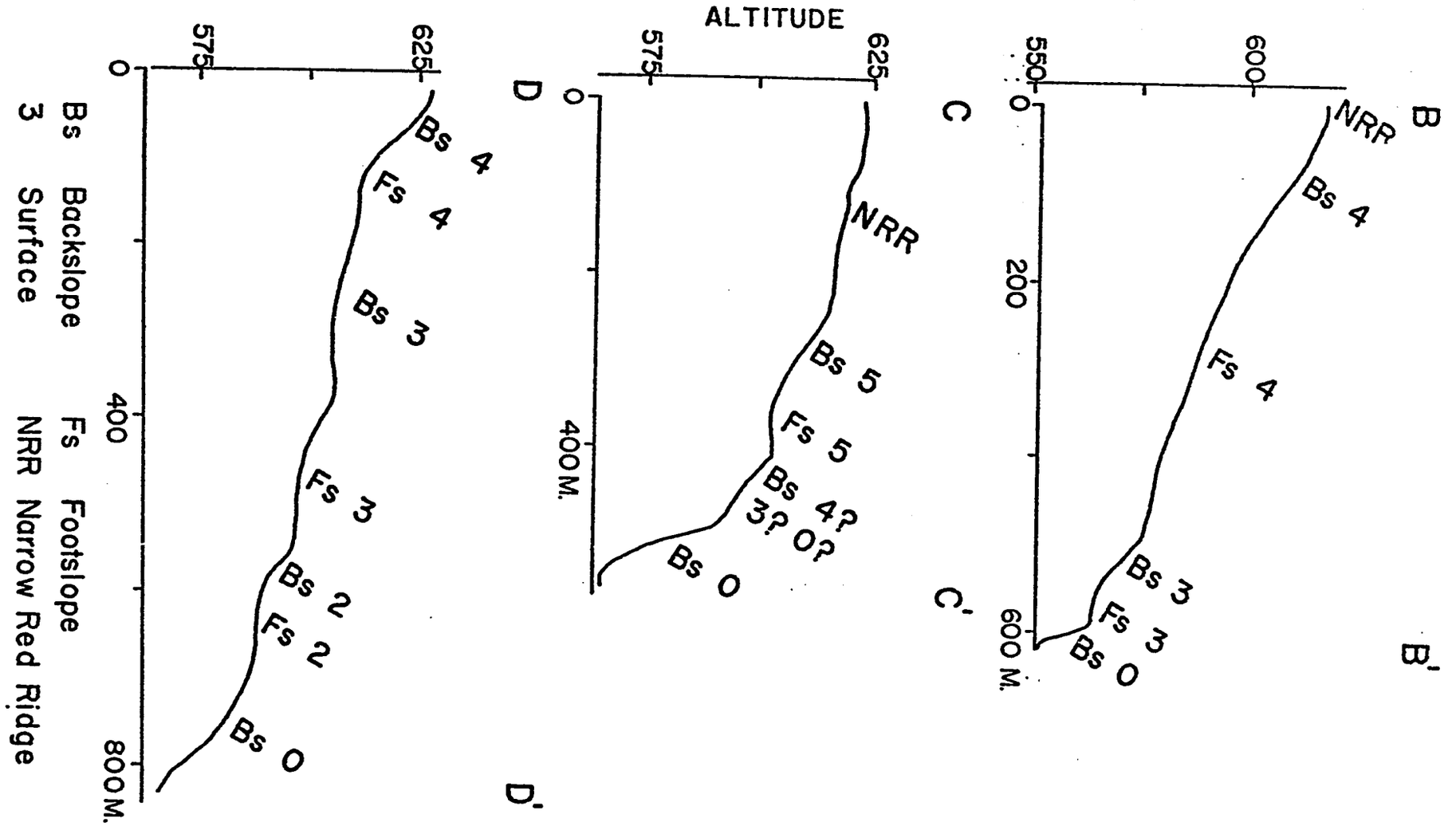


Figure 4: Profiles across the footslopes and backslopes of 2, 3, 4, and 5 surfaces.

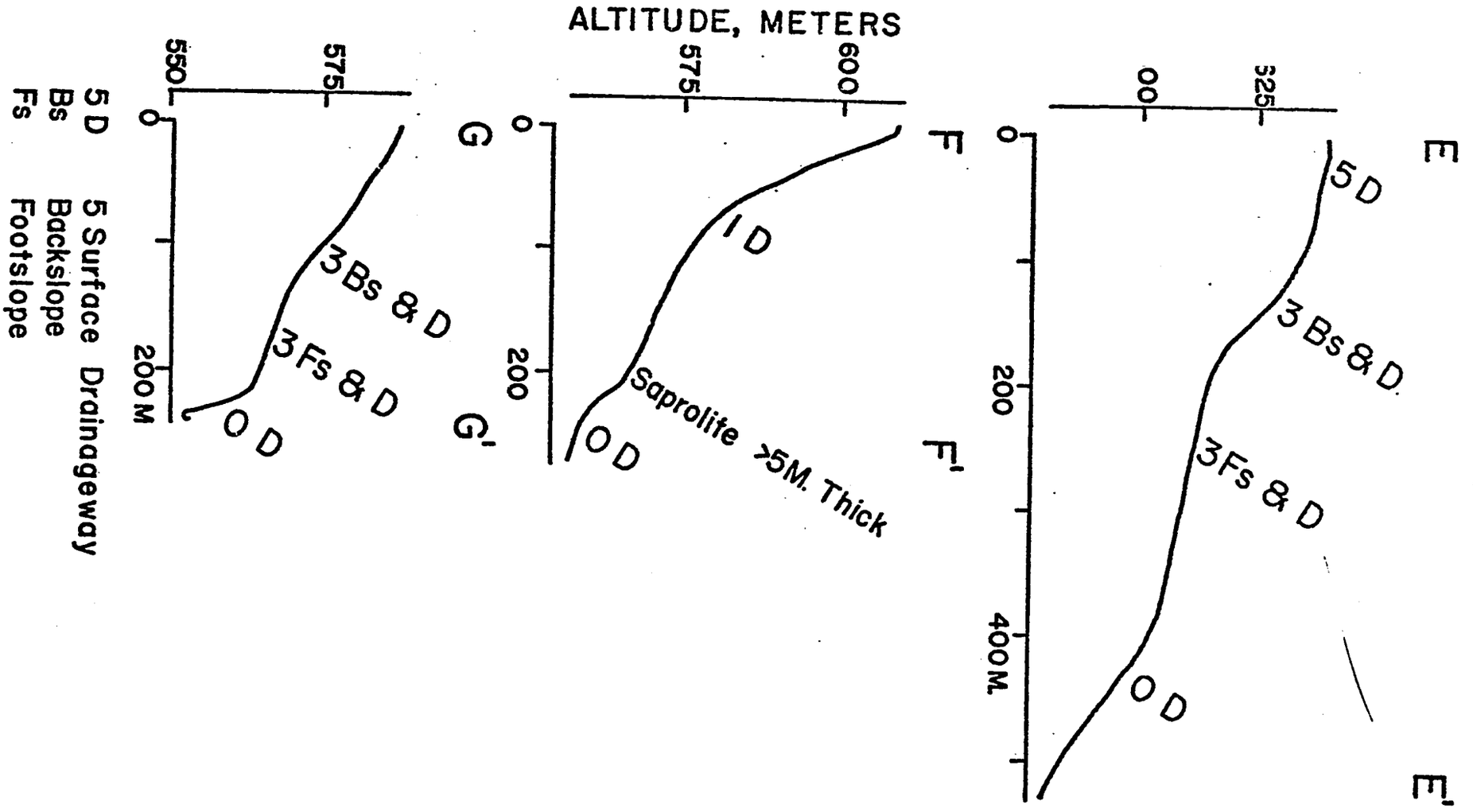


Figure 6: Drainageways with convex profiles and distance from drainage divide expressed in arithmetic function.

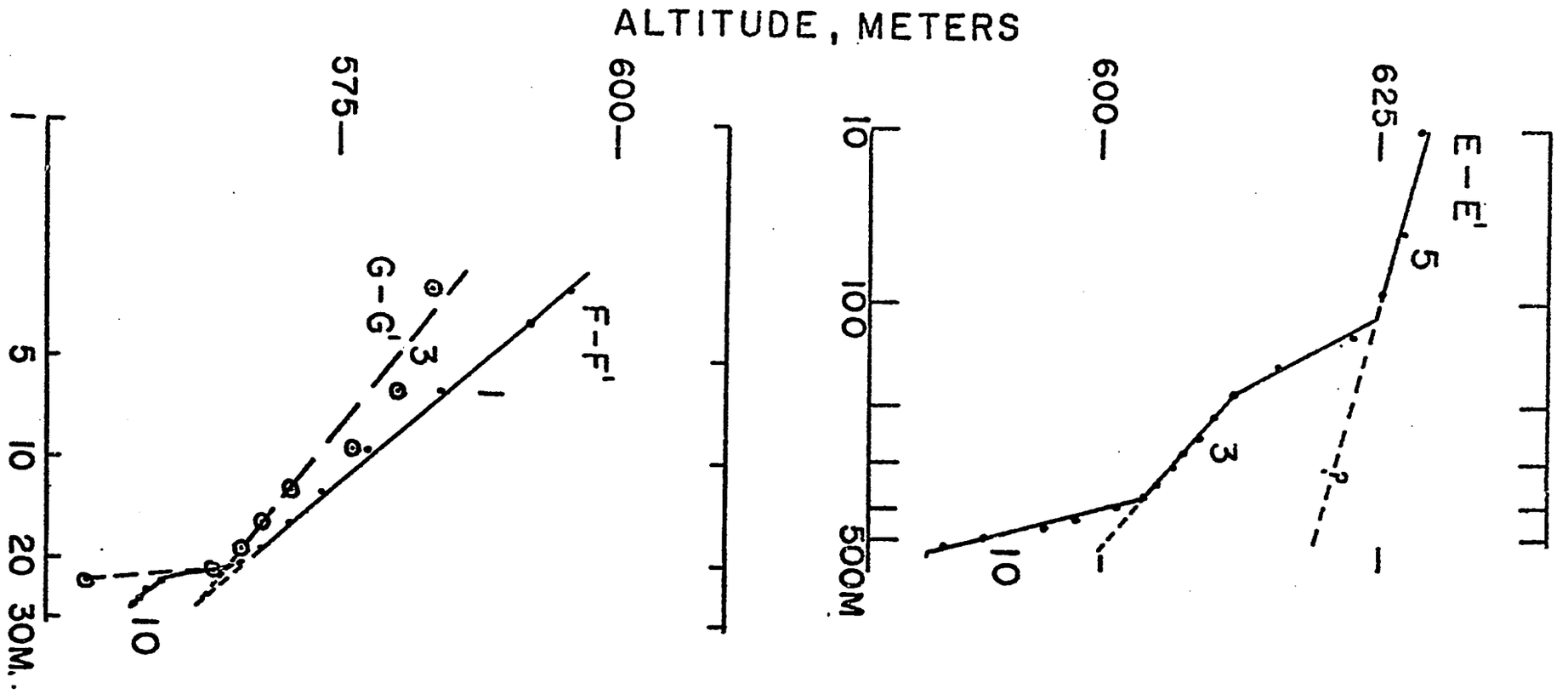


Figure 7: Drainageways with convex profiles and distance from drainage divide expressed in log function.

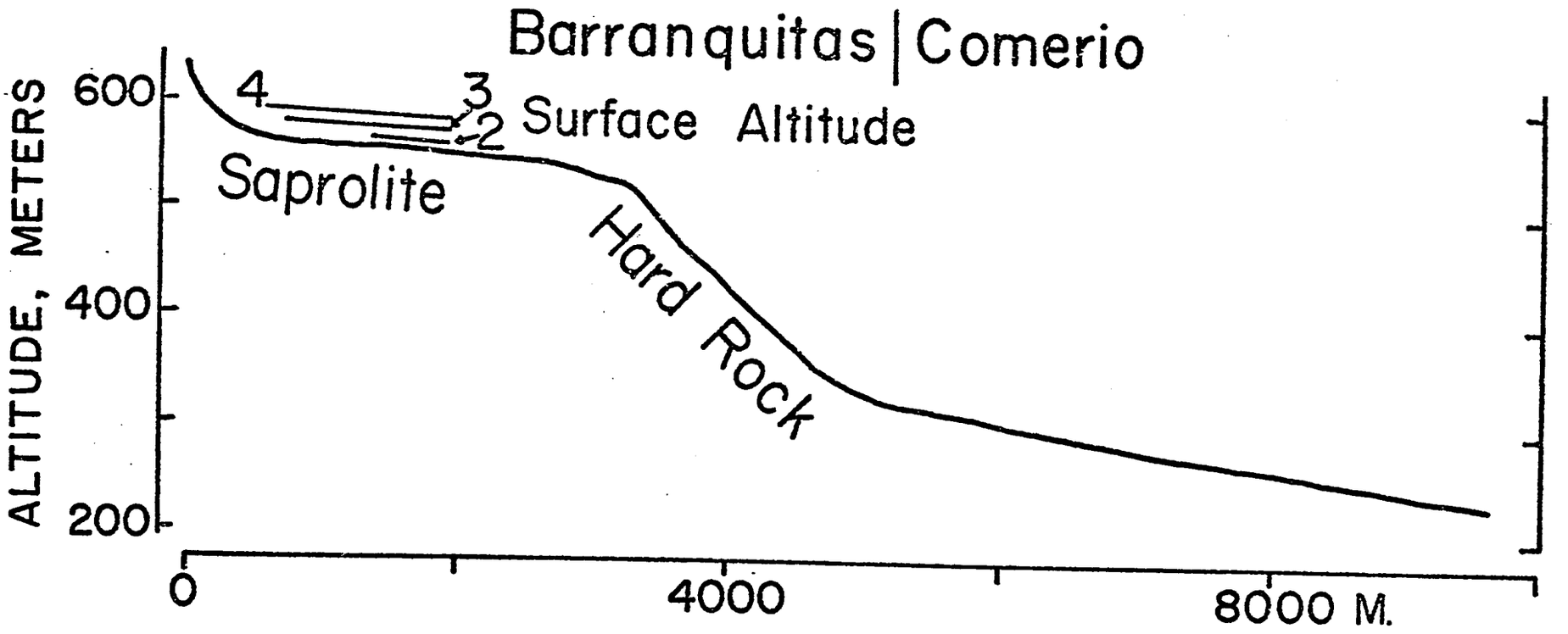


Figure 8: Profile of Rio Frio.

SERIES: CATALINA

General Characterization

Classification

Soil Taxonomy: Subgroup: Tropectic Haplorthox
Family: clayey, oxidic, isohyperthermic
Status: final
FAO/UNESCO Legend: Humic Ferralsols
1938 Great Group: Reddish Brown Lateritic

Location of Sample Site

Latitude: 18°14' 31" N Longitude: 66°16' 40" W Elevation: 607m (2,200')
General Description: Cornell Experiment Site "Barranquitas"; 550m (1,800')
SE of km 9.7 on highway 152 Barranquitas Quadrangle

Climate

Mean annual rainfall: ~160 cm (~63")
Mean annual temperature: ~ 23°C (~73.5°F)
Rainfall distribution: Rainfall maxima in May and November
Thornthwaite type: BA'r - Humid tropical

Vegetation and Land Use

Natural vegetation type: Tropical to subtropical moist forest
Land use and crop: Experimental area - corn

Parent Material and Geology

Parent material: Strongly weathered saprolite
Parent rock: Choritized basaltic - andesitic lava flow breccia
Geologic formation: Upper Cretaceous (Formation "L")

Geomorphology

Slope: 7%
Aspect: SE
Landform: Upper footslope, concave
Geomorphic surface: Erosion surface of mid - Miocene age; remnant of "St. John Peneplain"; no field evidence of discontinuity between regolith and solum

Additional Notes:

Sampled in a pit located 40m ('30') NE of SCS pit S 59 PR-10-7, see SSIR - 12 pp. 164-167

Compiled by: F.H. Beinroth Date: 2/11/72

CATALINA
Tropeptic Haplorthox; clayey, oxidic, isohyperthermic

PROFILE DESCRIPTION (SCS)

Ap — 0 to 6 inches. Dark reddish brown (5YR 3/3) clay with 10 percent colored reddish brown (2.5YR 4/4); massive in the upper part to weak fine granular in the lower part; friable, slightly sticky, plastic; many sand-size aggregates; abundant roots; abrupt smooth boundary.

B21 — 6 to 13 inches. Dark reddish brown (2.5YR 3/4) clay; moderate medium to fine angular to subangular blocky; firm, slightly sticky and plastic; fails semiplastically to abruptly, 1/ few fine and common very fine pores (less than in the B22); many soft black sand-size aggregates; roots common; clear boundary.

B22 — 13 to 20 inches. Dark reddish brown (2.5YR 3/4) clay with some ped surfaces having slightly lower chroma; moderate to weak, medium to fine subangular to angular blocky; firm, slightly sticky, plastic; fails abruptly to semiplastically; few fine and common very fine pores; few sand-size aggregates; no reflective or pressure surfaces; roots common; clear wavy boundary.

B23 — 20 to 34 inches. Reddish brown (2.5 YR 4/5) clay with a few reddish brown (2.5YR 4/4) ped surfaces; weak fine angular to subangular blocky; firm, slightly sticky, plastic; fails abruptly; few fine and common very fine pores; very few sand-size aggregates; moderate reflective or pressure surfaces common with a few surfaces striated; possibly a few thin patchy clay films; very few roots; clear smooth boundary.

B24 — 34 to 46 inches. Dark reddish brown (2.5YR 3/4 to 4/4) clay; weak fine angular blocky; firm, slightly sticky, plastic; fails abruptly; few fine and many very fine pores; very few sand-size aggregates; moderate reflective or pressure surfaces common with a few surfaces striated and possibly some thin patchy clay firms; few roots; gradual boundary.

B25 46 to 60 inches. Dark reddish brown (2.5YR 3/4) fine silty clay loam; weak fine angular blocky; firm, monsticky, plastic; fails abruptly; few fine and common very fine pores; very few sand-size aggregates; moderate reflective or pressure surfaces common with a few surfaces striated and possibly some thin patchy clay films; very few roots; clear smooth boundary.

C1 60 to 72 inches. Dark reddish brown (2.5YR 3/4) silty clay loam; weak fine angular blocky; firm, nonsticky, plastic; fails abruptly; many fine and common very fine pores; weak reflective or pressure surfaces common; possibley some thin patchy clay films; very few sand-size quartz grains; 2 percent saprolite; arbitrary boundary.

C2 72 to 84 inches (6 to 7 feet). Dark reddish brown to dark red (2.5YR 3/4 to 3/6) silty clay loam; 25 percent saprolite; firm, nonsticky, plastic; arbitrary boundary.

C3 84 to 120 inches (7 to 10 feet). 75 percent saprolite; dusky red (10R 3/4) and dark reddish brown (2.5YR 3/4) silty clay loam matrix with strong brown (7.5YR 5/8) and gray splotches; firm, nonsticky; plastic; arbitrary boundary.

C4 120 to 132 inches (10 to 11 feet). Saprolite; dusky red (10R 3/4) to dark reddish brown (2.5YR 3/4) with dark gray (10YR 4/1) common and occasional splotches of strong brown (7.5YR 5/8) and white; silty clay loam; firm, nonsticky, plastic.

1/ Two terms are used to describe the rate of failure of natural fabric: fails abruptly and fails semiplastically. To fail abruptly means that no plasticity is observed prior to failure. Stress builds up as the piece of soil is squeezed and dissipates quickly as the piece of soil breaks apart into numerous fragments or peds due to failure along natural planes of weakness. In semiplastic failure, deformation is readily observed prior to rupture.

Mineralogy
Beltsville Laboratory: Interpretations of X-ray and Differential Thermal Analyses of the Clay and Silt Fractions

		< 2μ fraction			2-50μ fraction		
Horizon	Depth Inches	Vermiculite	Kaolinite %	Gibbsite %	Kaolinite %	Gibbsite %	Quartz
Ap	0-6	x	30	15	-	5	cc
C1	60-72	—	40	—	40	—	ccc

Notes: Vermiculite: X-ray, oriented samples; (x = small amount). Quartz: X-ray, powder (unoriented); c = height unit of 3.35Å reflection. 7.2Å reflection peak (kaolinite) very diffuse in Ap, sharper in C. Kaolinite and gibbsite by DTA.

Lincoln Laboratory: B22 horizon. Field-moist (Lab. No. 66L119) and air-dry (Lab. No. 12848) samples were compared. Kaolinite percentages by Differential Thermal Analyses are:

Air-dry (12848)	Field-moist (66L119)
35	40
40	50 (iron-free)
30	
50	

Gibbsite content is considerably greater in the air-dry samples (25 to 50 percent gibbsite) than in the field-moist smaples (10 percent gibbsite). Diffraction patterns show small amounts of goethite and vermiculite in addition to the kaolinite and gibbsite. All minerals are rather poorly ordered.

SOIL CLASSIFICATION: Tropeptic Haplorthox; clayey, oxidic, isohyperthermic

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL Catalina clay SOIL Nos. S59PR-10-8 S59(66)PR-10-8 LOCATION Torrecillas SCN, Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 12846-12856 66L119-66L121 (field-moist) November 1966

General Methods: 1A, 1H1a, 2A1, 2B

Depth (in.)	Horizon	Site class and particle diameter (mm) 3A1: Total Sand (2-0.05) b	Total Silt (0.05-0.002)	Total Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: (0.05-0.02)	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)	3A1c Water-Disp. Clay (0.002)		Coarse fragments 2A2 > 2 (<19) Pct	2-19	19-76
		Pct of < 2 mm														Pct	Pct of < 76mm	
0-6	Ap	5.3	17.6	77.1	0.3	0.5	0.6	1.7	2.2	3.3	14.3	6.9	3.1	47		tr		
6-13	B21	6.0	17.2	76.8	0.1	0.6	0.7	2.0	2.6	3.6	13.6	7.4	3.4	tr		tr		
13-20	B22	3.1	13.0	83.9	0.1	0.2	0.3	1.0	1.5	1.4	11.6	3.5	1.6			-		
20-34	B23	1.9	14.9	83.2	tr	0.2	0.2	0.6	0.9	2.3	12.6	3.6	1.0			-		
34-46	B24	5.7	23.9	70.4	0.2	0.6	0.6	1.9	2.4	4.7	19.2	8.3	3.3			tr		
46-60	B25	11.6	35.7	52.7	0.3	1.2	1.3	4.3	4.5	7.4	28.3	14.4	7.1			tr		
60-72	C1	15.0	36.6	48.4	0.4	1.5	1.7	5.4	6.0	8.6	28.0	17.8	9.6			tr		
72-84	C2	17.7	36.2	46.1	0.7	2.3	2.5	6.2	6.0	8.0	28.2	17.6	11.7			-		
84-120	C3	9.6	46.2	44.2	0.1	0.6	0.8	3.3	4.8	7.8	38.4	14.7	4.8			tr		
120-132	C4	13.5	44.3	42.2	1.0	1.6	1.2	3.9	5.8	9.9	34.4	15.1	7.7			tr		
0-6	Ap a	6.3	19.9	73.8	0.3	0.7	0.8	2.1	2.4	2.3	17.6	5.9	3.9			tr		

Depth (in.)	6A1a Organic carbon c Pct	6B1a Nitrogen Pct.	C/N	6C2a Ext. Iron as Fe Pct.	Carbonate as $CaCO_3$ Pct.	Bulk density: 4A1a Field-State g/cc	4A1b g/cc	4A1h Oven-Dry g/cc	4H1 COLE	Water content: 4B4 Field-State Pct	4B1b 1/3-Bar Pieces Pct.	4B2 15-Bar Pct.	pH: 8C1c (1:1) H KCl	8C1a (1:1) H_2O
0-6	4.30	0.370	12	9.4		0.96		1.23	0.087	51.8	41.8	31.9	5.0	5.6
6-13	1.75	0.179	10	9.8		1.07		1.34	0.078	49.3	40.3	33.6	4.6	4.7
13-20	0.70	0.109	6	10.1		1.06		1.31	0.073	48.9	43.7	35.7	4.8	4.8
20-34	0.50	0.080	6	11.5		1.11		1.33	0.064	47.2	42.1	34.2	4.3	5.0
34-46	0.25	0.039	6	14.8		1.42		1.52	0.024	31.6	35.1	30.0	4.2	5.1
46-60	0.16			14.3		1.40		1.52	0.028	31.4	32.6	27.4	3.9	5.1
60-72	0.12			14.0		1.41d		1.52	0.024	32.0	34.9	26.2	3.8	4.9
72-84	0.13			13.2								26.7	3.8	4.7
84-120	0.06			12.8								27.3	3.8	4.9
120-132	0.05			14.3								27.8	3.8	4.8
0-6	4.31	0.376	11	9.7								31.8	5.4	5.9

Depth (in.)	Extractable bases 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	5H1a Sum	6H1a Ext. Acidity	Ext. Exch. Cap. 5A3a Sum Cations	5A1a NH_4OAc	6O1d KCl-Ext. Al	5A3b Bases Plus Al me/100g Clay	Base saturation 5C3 Sum Cations Pct.	5C1 NH_4OAc Pct.
	meq/100 g											
0-6	8.3	1.5	0.1	0.9	10.8	19.7	30.5	20.5				
6-13	1.8	0.2	tr	0.5	2.5	18.8	21.3	10.6	0.3	3.6	35	53
13-20	1.4	0.2	tr	0.1	1.7	15.2	16.9	7.5	0.1	2.1	12	24
20-34	0.5	0.6	tr	tr	1.1	13.4	14.5	7.7	0.6	2.0	10	23
34-46	0.1	0.1	tr	tr	0.2	13.4	13.6	7.6	1.2	2.0	8	14
46-60	tr	0.2	tr	tr	0.2	14.1	14.3	8.4	2.3	4.7	1	3
60-72	0.1	0.1	0.1	tr	0.3	14.1	14.4	8.9	3.3	7.4	1	2
72-84	0.1	0.1	0.1	tr	0.3	14.1	14.4	8.7	3.5	8.2	2	3
84-120	0.1	0.2	0.1	tr	0.4	12.8	13.2	8.8	4.2	7 e	2	3
120-132	0.1	0.1	0.1	tr	0.3	13.4	13.7	7.9	3.6	6 e	3	4
0-6	11.0	1.3	0.1	1.0	13.4	16.8	30.2	20.7			2	4
											44	65

Depth (in.)	Ratios to Clay 8H1: NH_4OAc CEC	Ext. Iron	15-Bar Water
0-6	0.26	0.12	0.41
6-13	0.14	0.13	0.44
13-20	0.09	0.12	0.43
20-34	0.09	0.14	0.41
34-46	0.11	0.21	0.43
46-60	0.15	0.27	0.52
60-72	0.18	0.29	0.54
72-84	0.19	0.29	0.58
84-120	0.20	0.29	0.62
120-132	0.19	0.34	0.66
0-6	0.28	0.13	0.43

Underlining indicates that the non-clay probably has strong clay-like properties.

a. Sampled along pit face several feet from first sample.
b. Earthy nodules: > 50 percent.
c. 15 kg/m² to 60 inches (Method 6A).
d. Range in duplicate clods is 0.12 g/cc.
e. Clay percentage is estimated (15-bar water percentage x 2.5).

Temperatures taken on September 21, 1963, when the site was revisited were:

Depth	Temperature
40 inches	24.2 degrees C.
5 feet	24.0 degrees C.
9 feet	23.7 degrees C.
13 feet	23.4 degrees C.
18 feet	23.0 degrees C.

*Field-moist samples: Site resampled, S59(66)PR-10-8, to obtain field-moist soil material for 15-bar study (Method 4B2).

Laboratory Number	Depth (in.)	15-bar Water Content: Air-Dry Pct.	Field-Moist Pct.
66L119	13-20	31.3	35.4
66L120	48	28.7	28.9
66L121	72	28.0	31.7

Catalina Ap

Sand, 1.5%; Silt, 15.5%; Clay, 83.0%

Mineral Composition (untreated soil)

Mineral	< 100 mesh	Clay (< 2 μm)
Chlorite	1-10%	1-10%
Kaolinite	25-40%	>40%
Gibbsite	25-40%	10-25%
Goethite	25-40%	10-25%
Quartz	10-25%	detected
Hematite	1-10%	1-10%
Magnetite	detected	detected
Maghemite	detected	detected

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Catalina Ap

Discussion

The principal clay mineral present in this horizon is kaolinite (K). EM's show little indication of hexagonal morphology although some 60 degree angulation is discernible.

Quartz was present mainly in the sand and silt size fractions. Gibbsite and goethite were also present in appreciable amounts in the silt fraction. These concentration differences are apparent when the clay fraction and the whole soil (< 100 mesh) are compared. As a result of the removal of 17% sand plus silt, the kaolinite concentration was greater than 40% of the X-ray crystalline material.

The dark clusters on the EM labeled (I) are iron oxides. The elongated particles with clusters are goethite (G). Quartz, hematite, magnetite and chlorite can not be identified on the EM.

At the top of the EM a hole in the supporting substrate can be seen as a light area. The particles are supported in the hole by a gel-hull which serves as an aglutenating agent. An arrow points toward a curved solid-air interface of the gel. This horizon contained 4.7 ppm silicon in the saturation extract; a source for the silicon being the gel-hull.

Unpublished data of R. C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Catalina B21

Sand, 0.1%; Silt, 11.8%; Clay, 88.1%

Mineral Composition (untreated soil)

Mineral	Silt and Clay (< 325 mesh)
Chlorite	1-10%
Kaolinite	25-40%
Gibbsite	25-40%
Goethite	25-40%
Quartz	1-10%
Hematite	1-10%
Magnetite	detected
Maghemite	detected

Unpublished data of R. C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Catalina B21

Discussion

The mineralogy of the B21 is very similar to that of the Ap horizon. A decrease in soluble silicon content to 1.1 ppm is reflected in crisper appearing particles. The micrograph showed that the horizon was highly flocculated by the large floccules present. However, individual particles of kaolinite (K) are discernible. The dark clusters are iron oxides. A slightly elongated particle is goethite (G).

This soil could not be dispersed in distilled water without the use of a dispersing agent. All dispersing agents were avoided for this study in order to obtain EM's of soils not influenced by chemical treatment. The XRD data and the EM, furthermore, were taken from the same sample. The EM's showed the silt fraction particles to be small, thus their presence posed no problem for electron microscopy.

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Catalina B22

Mineral Composition (untreated soil)

Mineral	< 100 mesh
Chlorite	1-10%
Kaolinite	25-40%
Gibbsite	25-40%
Goethite	25-40%
Quartz	15-25%
Hematite	1-10%
Magnetite	1-10%
Maghemite	detected

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Catalina B23

Mineral Composition (untreated soil)

Mineral	< 100 mesh
Chlorite	1-10%
Kaolinite	25-40%
Gibbsite	25-40%
Goethite	25-40%
Quartz	1-10%
Hematite	1-10%
Magnetite	1-10%
Maghemite	detected

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University o Hawaii

Catalina B24

Mineral Composition (untreated soil)

Mineral	< 100 mesh
Chlorite	detected
Kaolinite	25-40%
Gibbsite	15-25%
Quartz	1-10%
Hematite	1-10%
Magnetite	1-10%

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Catalina B25

Mineral Composition (untreated soil)

Mineral	<100 mesh
Kaolinite	25-40%
Gibbsite	1-10%
Goethite	25-40%
Quartz	1-10%
Hematite	15-25%
Magnetite	1-10%
Amphibole	detected

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Ciales (Picacho) A

Sand, 51.0%; Silt, 16.7%; Clay, 32.3%

Mineral Composition (untreated soil)

Mineral	< 100 mesh	Clay (< 2 μm)
Montmorillonite	detected	1-10%
Hydrated Halloysite	1-10%	1-10%
Dehydrated Halloysite	1-10%	1-10%
Kaolinite	1-10%	15-25%
Lepidocrocite	1-10%	1-10%
Gibbsite	15-25%	15-25%
Goethite	15-25%	15-25%
Quartz	25-40%	1-10%
Amphibole	detected	detected

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Ciales (Picacho) A

Discussion

According to soil taxonomy, this soil has a mixed mineralogy. The micrographs show montmorillonite (M), halloysite (H) and iron oxides. The grape-like clusters are goethite (G). Because of the tabular habit of gibbsite and kaolinite, it is difficult to differentiate the two. The kaolinite, furthermore, lacks its usual hexagonal morphology and the particles are very small. Amphibole was detected on the EM's and identified by XRD. The micrograph shows an amphibole (A) particle which consists of long needle-like crystals. It is difficult to distinguish between amphibole and halloysite when the amphibole particles are large. Only selected area electron diffraction can make the distinction. The particle labeled AH is one which can not be clearly identified. Quartz and lepidocrocite are not discernible from the EM.

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Ciales (Picacho) B21

Sand, 36.0%; Silt, 18.9%; Clay, 45.1%

Mineral Composition

Mineral	< 100 mesh	Clay (< 2 μm)
Montmorillonite	detected	1-10%
Hydrated Halloysite	1-10%	1-10%
Dehydrated Halloysite	1-10%	1-10%
Kaolinite	1-10%	15-25%
Lepidocrocite	1-10%	1-10%
Gibbsite	15-25%	15-25%
Goethite	15-25%	15-25%
Quartz	25-40%	1-10%
Amphibole	detected	detected

Unpublished data of R.C. Jones, W. Sakai, W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Ciales (Picacho) B21

Discussion

The mineralogy of this horizon is similar to that of the A horizon. Montmorillonite (M), halloysite (H) and kaolinite (K) comprise the layer silicates. Unlike the kaolinite in the A horizon, the kaolinite particles here partially exhibit the hexagonal morphology characteristic of kaolinite.

The particle labeled (A) in the EM is similar in morphology of other amphiboles seen in EM micrographs. The oxide which appears as clusters and which are distinguishable from the layer silicates is goethite. Lepidocrocite, gibbsite and quartz are not discernible from this EM.

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Ciales (Picacho) B22

Mineral Composition

Mineral	<100 mesh
Montmorillonite	detected
Hydrated Halloysite	1-10%
Dehydrated Halloysite	1-10%
Kaolinite	15-25%
Lepedocrocite	1-10%
Gibbsite	1-10%
Goethite	15-25%
Quartz	1-10%
Magnetite	1-10%
Feldspar	detected
Amphibole	detected

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Giales (Picacho) B3

Mineral Composition (untreated soil)

Mineral	< 100 mesh
Montmorillonite	detected
Hydrated Halloysite	1-10%
Dehydrated Halloysite	1-10%
Kaolinite	15-25%
Lepidocrocite	1-10%
Gibbsite	1-10%
Goethite	15-25%
Quartz	15-25%
Magnetite	1-10%
Feldspar	detected
Amphibole	detected

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Ciales (Picacho) C1

Mineral Composition (untreated soil)

Mineral	< 100 mesh
Montmorillonite	detected
Mica	1-10%
Hydrated Halloysite	detected
Dehydrated Halloysite	1-10%
Kaolinite	15-25%
Lepidocrocite	1-10%
Gibbsite	15-25%
Goethite	15-25%
Quartz	15-25%
Magnetite	1-10%
Feldspar	detected
Amphibole	detected

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department o
Agronomy and Soil Science, University of Hawaii

CATALINA SERIES - Tropeptic Haplorthox

Horizon	Depth cm	Extractable SO_4S * $\mu g/g$ soil	Silicon		
			Saturation Extract	1:10 Water	1:10 Phospate
			Si, ppm, solution		Si, $\mu g/g$ soil
Ap	0-16	414	4.70	1.78	108.7
B21	16-35	1080	1.06	.70	104.6
B22	35-60	1310	1.21	.83	126.6
B23	60-80	1267	.40	.30	139.4
B24	80-120	1225	.29	.30	129.5
B25	120-130	195	.40	.53	129.5

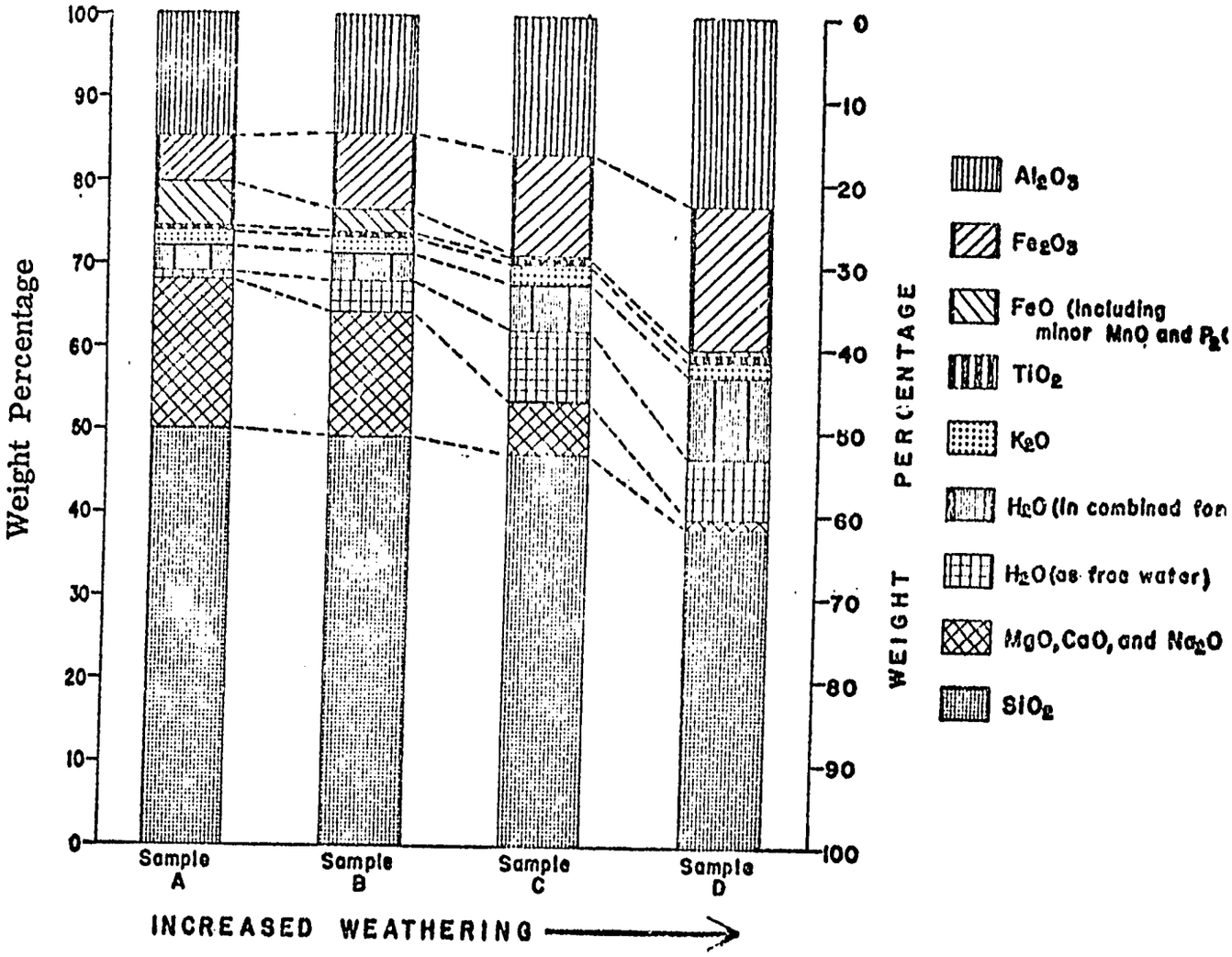
Unpublished data of R. L. Fox, Dept. of Agronomy and Soil Science, University of Hawaii

*) Repeated extraction (4 times) with 500 ppm P (CaH_2PO_4)
Soil: Extracting solution ratio was 1:5 for each extraction

TABLE 1 - Chemical analysis of a basaltic-andesitic lava flow breccia and the saprolite derived from it, as percentages of oxides by weight (after Briggs - 1960, table 2).

Oxide Determined	Lava Flow Breccia	Saprolite
SiO_2	50.08	38.27
TiO_2	.68	1.04
Al_2O_3	14.81	22.68
Fe_2O_3	5.60	17.27
FeO	4.62	.36
MgO	6.41	1.14
CaO	8.11	.00
Na_2O	3.48	.08
K_2O	1.77	1.82
H_2O (combined)	2.90	9.85
H_2O (free)	1.00	7.27
P_2O_5	.35	.16
MnO	.19	.04
Total	100.00	99.98
SiO_2:Al_2O	3.38	1.69
Al_2O_3:Total Fee Oxides	1.45	1.29

Lateritic Weathering in East-Central Puerto Rico



Sample A - Fresh basaltic andesite flow breccia

Sample B - Weathered flow breccia

Sample C - Strongly weathered flow breccia

Sample D - Flow breccia saprolite

Source: BRIGGS, R. P., 1960, Laterization in East-Central Puerto Rico. Transact. Second Carib. Geol. Conf., Mayaguez, P.R., pp. 103-119

Lateritic Weathering in East-Central Puerto Rico

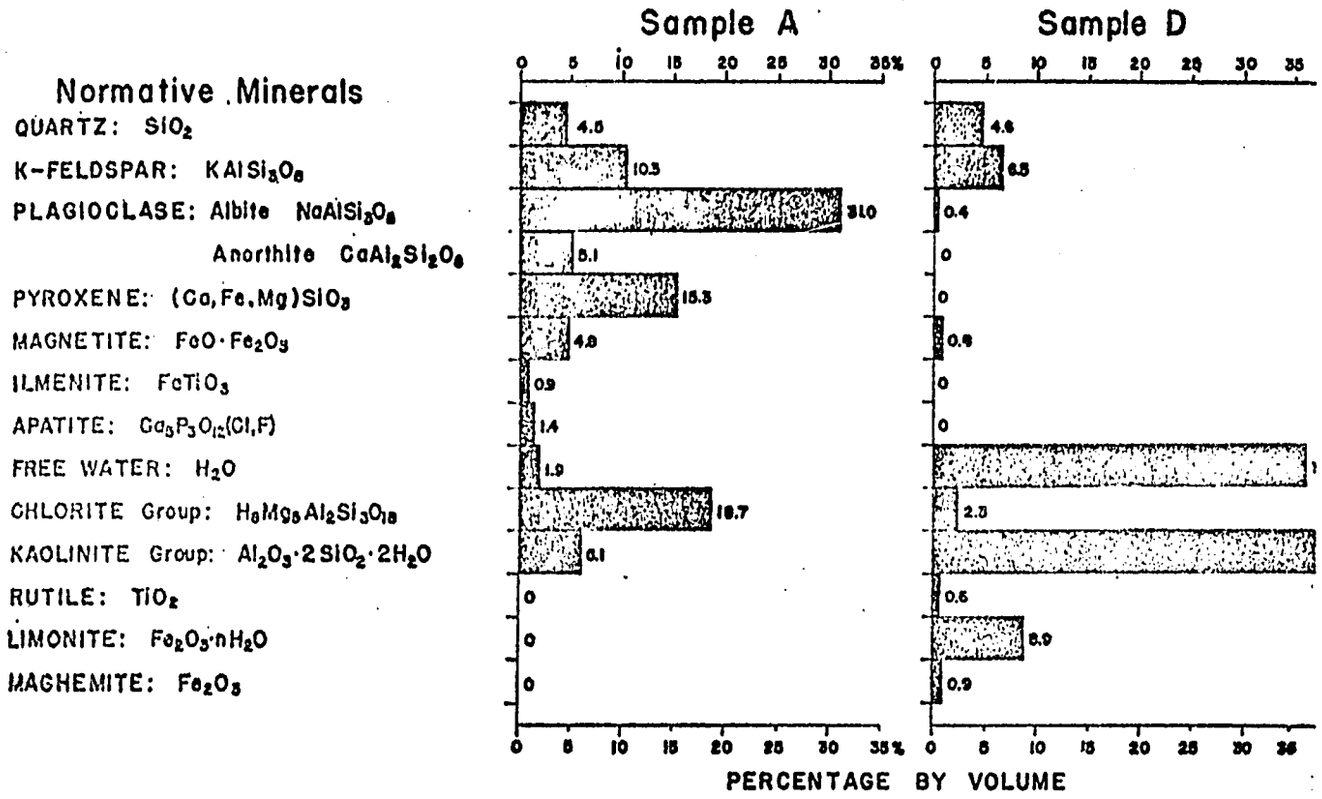
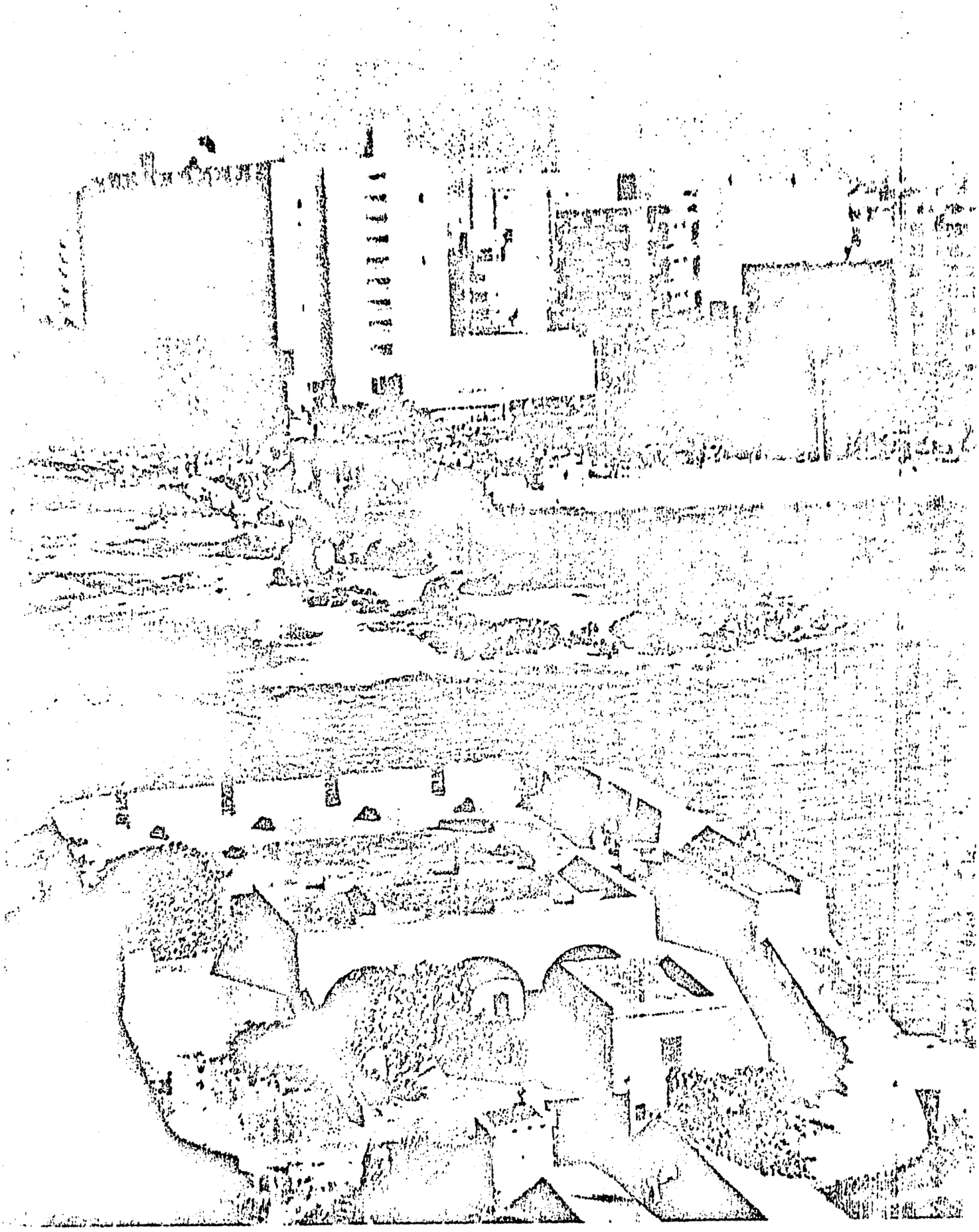


FIG. 6.—Normative mineral assemblages by percentage of volume calculated from the standard cells of samples A and D as presented in graph form.

Sample A - Fresh basaltic andesite flow breccia

Sample D - Flow breccia saprolite

Source: BRIGGS, R. P., 1960, Laterization in East-Central Puerto Rico. Transact. Second Carib. Geol. Conf., Mayaguez, P.R., pp. 103-119



Fort San Cristobal and Condado, San Juan, Puerto Rico Photo: F. H. Beinroth

TROPICAL SOILS INSTITUTE

Puerto Rico, July 10 - August 4, 1972

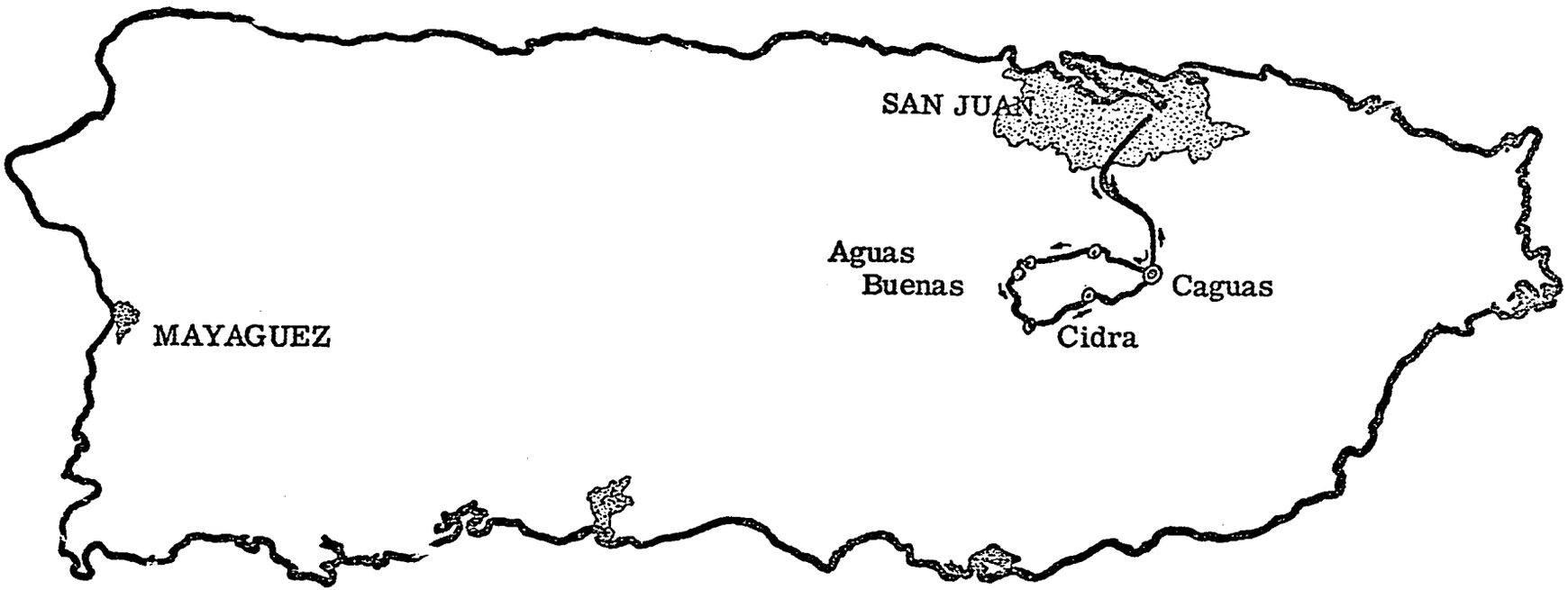
FIELD TRIP 5 - "SAN JUAN"

Second Day : "Aguas Buenas - Cidra"

Date	:	Saturday, 7/29/72
Objective	:	To visit an intensively managed coffee farm, and an experiment site with N and P trials, and to see the corresponding Ultisols
Route	:	San Juan -(Agr. Experimental Station, Rio Piedras)- Aguas Buenas - Cidra - Caguas - San Juan
Soil pits	:	Orthoxic Tropohumult (Daguey Series) - Aguas Buenas Orthoxic Palehumult (Torres Series) - Cidra
Main Topics	:	Aguas Buenas : Intensive coffee farming Cidra : N and P experiments
Remarks	:	Over-night in San Juan, Hotel Borinquen

FHB/5-72

TROPICAL SOILS INSTITUTE Puerto Rico, July 10 - August 4, 1972



Field Trip 5 - "SAN JUAN"

Second Day : "AGUAS BUENAS - CIDRA"

Daguey A1 (0-10 cm)

Sand, 6.4%; Silt, 27.5%; Clay, 66.1%

Mineral Composition (untreated soil)

Mineral	< 100 mesh	Clay (< 2 μm)
Vermiculite	detected	1-10%
Mica	detected	not detected by XRD
Dehydrated Halloysite	detected in E.M.'s; not detected by XRD	detected in E.M.'s; not detected by XRD
Kaolinite	25-40%	>40%
Goethite	1-10%	10-25%
Quartz	25-40%	1-10%
Hematite	1-10%	1-10%
Magnetite	1-10%	not detected

Unpublished data of R. C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Daguey A1 (0-10 cm)

Discussion

Electron micrographs of scattered layer silicates with moiré patterns suggest the presence of small amounts of mica in the clay fraction. The concentration is too small to be detected by XRD. A broad 10.0A peak of the whole soil also suggests the presence of hydrated halloysite.

Electron micrographs offer only a vague hint of hexagonal morphology. Considerable mechanical and/or chemical weathering has taken place. Most of the quartz is of sand and silt sizes which account for its decrease in the clay fraction. This mineral is not descernible by EM.

Although hematite is 1-10% in both the whole soil and the clay fraction, its peak for the clay fraction was broad, indicating small particle size.

The electron micrograph of the Daguey A1 shows many clusters of iron oxide (I) and a lath shaped crystal of halloystie (H).

The saturation extract of the Daguey A1 (0-10 cm) contained 5.6 ppm silicon as compared to 1.25 ppm for the B21 horizon. The electron micrograph of the A1 clay shows diffuse particle overlap indicating the presence of a gel coating containing silicon. At the arrow, the gel coating forms a curved solid-air interface.

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science. University of Hawaii

Daguey B21 (10-30 cm)

Sand, 3.00%; Silt, 20.00%; Clay, 77.00%

Mineral Composition (untreated soil)

Mineral	< 100 mesh	Clay (< 2 μm)
Vermiculite	1-10%	detected
Mica	detected	detected
Dehydrated Halloysite	detected	detected
Kaolinite	25-40%	>40%
Goethite	10-25%	25-40%
Quartz	25-40%	10-25%
Hematite	1-10%	1-10%
Magnatite	1-10%	1-10%

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Daguey B21 (10-30 cm)

Discussion

Mica and halloysite are also present in the B21 horizon. Again, the broad XRD peak suggests the small particle size of mica and the 10.0A peak indicates the presence of hydrated halloysite. Electron micrographs confirm the presence of halloysite (H).

The kaolinite in this horizon, as seen in the electron micrographs, has much better hexagonal morphology than that in the A1 horizon. However, the majority of the particles appear weathered.

Goethite is the dominant X-ray crystalline iron oxide. Quartz is not discernible on the micrograph.

There is a hint of gel material at the curved solid-air interface as indicated by the arrow.

The clusters of iron oxide (I) are almost always associated with the layer silicates. This association usually indicates a charge attraction.

Unpublished data of R. C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

DAGUEY SERIES _ Orthoxic Tropohumults

Horizon	Depth cm	Extractable SO_4S * $\mu g/g$ soil	Silicon		
			Saturation Extract	1:10 Water	1:10 Phospate
			Si, ppm, solution		Si, $\mu g/g$ soil
Ap	0-10	0	5.6	1.95	77.2
B21	10-30	170	1.25	.72	76.4
B22	30-60	250	1.26	.90	42.3
B3	60-95	373	2.06	1.31	124.5

Unpublished data of R. L. Fox, Dept. of Agronomy and Soil Science, University of Hawaii

*) Repeated extraction (4 times) with 500 ppm P (CaH_2PO_4)
Soil: Extracting solution ratio was 1:5 for each extraction

SERIES: DAGUEY

General Characterization

Classification

Soil Taxonomy: Subgroup: Orthoxic Tropohumults
Family: clayey kaolinitic, isohyperthermic
Status: tentative
FAO/UNESCO Legend: Humic Acrisols
1938 Great Group: Reddish Brown Lateric

Location of Sample Sit

Latitude: 18° 13' 50" N Longitude: 66° 10' 2" W Elevation: 500m (1,650
General Description: Vicente's coffee farm, approx. 1 km.(.6 miles) south of Bayamoncito on highway 156 and 1 km (.6 miles) east of highway 791; Comerio Quadrangle

Climate

Mean annual rainfall: ~ 200 cm (78")
Mean annual temperature: ~23.5°C (74° F)
Rainfall distribution: Less humid in February and March
Thornthwaite type: BB'r - Humid mesothermal

Vegetation and Land Use

Natural vegetation type: Tropical moist forest
Land use and crop: Pasture, coffee on adjacent farm

Parent Material and Geology

Parent material: Strongly weathered saprolite
Parent rock: Andesitic - basaltic volcaniclastics
Geology formation: Lower Cretaceous

Geomorphology

Slope: 12%
Aspect: NE
Landform: Upper backslope (concave)
Geomorphic surface: Remnant of Tertiary erosion surface, possibly correlates with the youngest erosion cycle of the "St. John Peneplain

Additional Notes:

Classification is tentative: if clay content in the B21 and B22 exceeds 75% it should be a Tropeptic Haplorthox Sampled at road cut

Compiled by: FH Beinroth Date: 2/17/72

Established Series
Rev. REG
9/71

DAGUEY SERIES

The Daguey series is a member of a clayey, oxidic, isohyperthermic family of Orthoxic Tropohumults. These soils have brown, fine textured, granular A horizons, and red, fine textured, very strongly acid, well developed B horizons.

Typifying Pedon: Daguey clay - pasture.
(Colors are for moist soil unless otherwise stated.)

Ap -- 0-10" -- Brown (7.5YR 4/4) clay; weak medium subangular blocky breaking to moderate
(0-25 cm) fine granular structure; firm, slightly sticky, slightly plastic; very strongly acid; abrupt wavy boundary. (8 to 12 inches (20-30 cm) thick)

A3 -- 10-14" -- Reddish brown (5YR 5/4) clay; weak medium subangular blocky structure; firm,
(25-36 cm) slightly sticky, slightly plastic; thin patchy clay films; very strongly acid; clear smooth boundary. (3 to 5 inches (7-12 cm) thick)

B1 -- 14-23" -- Yellowish red (5YR 4/6) clay; few medium distinct yellowish brown (10YR 5/4)
(36-58 cm) mottles; weak coarse prismatic breaking to moderate medium subangular and angular blocky structure; firm, slightly sticky, slightly plastic; thin patchy clay films; very strongly acid; clear smooth boundary. (6 to 11 inches (15-28 cm) thick)

B21t -- 23-31" -- Red (2.5YR 4/6) clay; strong medium and fine subangular blocky structure;
(58-79 cm) firm, slightly sticky, slightly plastic; thin continuous clay films on ped faces; very strongly acid; gradual smooth boundary. (6 to 10 inches (15-25 cm) thick)

B22t -- 31-43" -- Red (2.5YR 4/6) clay; strong medium and fine subangular blocky structure;
(79-110 cm) firm, slightly sticky, slightly plastic; thin patchy clay films; very strongly acid; gradual smooth boundary. (8 to 14 inches (20-36 cm) thick)

B23t -- 43-59" -- Red (2.5YR 4/6) clay; moderate fine subangular blocky structure; firm,
(110-150 cm) slightly sticky, slightly plastic; thin patchy clay films; very strongly acid; gradual smooth boundary. (10 to 20 inches (25-51 cm) thick)

B3 -- 59-72" -- Red (2.5YR 4/6) clay; few small angular fragments of rock; weak medium and
(150-185 cm) fine subangular blocky structure; firm, slightly sticky, slightly plastic; very thin patchy clay films; very strongly acid; clear smooth boundary. (10 to 16 inches (25-41 cm) thick)

C1 -- 72-86" -- Yellowish red (5YR 4/6) silty clay loam; common fine strong brown (7.5YR
(185-220 cm) 5/6) and reddish yellow (7.5YR 6/6) mottles; massive but with some evidence of original rock structure; friable, slightly sticky, slightly plastic; very strongly acid; gradual smooth boundary. (12 to 13 inches (30-46 cm) thick)

C2 -- 86-90" -- Saprolite with well defined rock structure, similar in color and texture to
(220-230 cm) C1 horizon.

Type Location: Cibuco SCD, Puerto Rico; 40 feet west of Highway 113, 80 feet south of road junction to house.

Range in Characteristics: Thickness of the B horizons ranges from 40 to 70 inches (100-180 cm) and that of the B2t horizons from 24 to 44 inches (61-110 cm). Colors of the B2 horizons are in hues of 10R or 2.5YR, in values of 4 or 5 and chromas of 6 through 8. Yellowish brown mottles are few or common and are more evident in the upper B horizons. Grade of structure in the B2 horizons ranges from strong to moderate inclusive. The soil is strongly or very strongly acid. Cation exchange capacity of these soils ranges from 18 to 22 meq./100 grams of clay in the argillic horizon. The organic carbon content in the upper 6 inches (15 cm) of the argillic horizon ranges from 1.0 to 1.6 inclusive. Mean annual soil temperature at 20 inches (50 cm) ranges from 72° to 78° F. inclusive.

Competing Series and Their Differentiae: These are Alonso series in the same family and Daguao, Humatas, Limones, and Naranjito series. The Alonso soils have darker colors with chromas of 3 or less. Daguao, Humatas, and Naranjito soils all have exchange capacities in excess of 24 meq. per 100 grams of clay. The Limones soils have wetter upper B horizons in hues of 7.5YR or yellower.

U. S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, FORT WORTH, TEXAS
GPO 862-862 (FORT WORTH, TEX. 1971)

Daguey Series

Setting: The Daguey soils occur on the more stable sloping sideslopes, ridgetops and footslopes of the volcanic uplands with slope gradients of 12 to 20 percent. The soil formed in fine textured residuum from very highly weathered basic volcanic rocks. The climate is humid tropical. The average annual precipitation is 85 inches (215 cm) and the mean annual temperature 76° F.

Principal Associated Soils: These are the competing Humatas soils and Consumo soils. The Consumo soils occur on steeper less stable surfaces and have thinner B horizons.

Drainage and Permeability: Well drained; medium or rapid runoff depending on the steepness of the slopes; moderate permeability.

Use and Vegetation: Coffee, pasture and subsistence crops. Very small acreage in sugarcane.

Distribution and Extent: Humid volcanic uplands of Puerto Rico. The series is of limited extent.

Series Established: Ponce Survey Area, Puerto Rico; 1971.

Remarks: These soils were formerly classified in the Reddish Brown Lateritic great soil group.

National Cooperative Soil Survey
U. S. A.

SERIES: Torres

General Chacterization

Classification

Soil Taxonomy: Subgroup: Orthoxic Palehumults
Family: clayey, oxidic ?, isohyperthermic
Status: tentative

FAO/UNESCO Legend: Humic Nitosols

1938 Great Group: Reddish Brown Lateritic

Location of Sample Site

Latitude: 18°12' 3" N Longitude: 66°7' 5" W Elevation: 450 m (1,470')

General Description: Cornell Experiment Site "Cidra"; Soltero's Farm, N of highway 172, 10 Km (6miles) WSW of Caguas

Caguas Quadrangle

Climate

Mean annual rainfall: 200 cm (78")

Mean annual temperature: ~23°C (73.5°F)

Rainfall distribution: less humid in February and March

Thornthwaite type: BB'r - Humid mesothermal

Vegetation and Land Use

Natural vegetation type: Tropical moist forest

Land use and crop: Experiment site - corn

Parent Material and Geology

Parent material:
Parent rock:
Geologic formation:

Highly weathered, fine textured sediments derived from predominantly volcaniclastic and plutonic rocks of Lower Cretaceous age

Geomorphology

Slope: 5%

Aspect: N

Landform: planar, adjacent to shoulder

Geomorphic surface: Probably a depositional surface of Pliocene age associated with the "Caguana Peneplain", now undergoing dissection

Additional Notes:

Sampled in a pit

Compiled by: F. H. Beinroth Date: 2/17/72

Established Series
Rev. RAB-LHR
4-68

TORRES SERIES

The Torres series is a member of the clayey, oxidic, isohyperthermic family of Orthoxi Palehumults. These soils have dark brown, moderately fine textured, friable, acid A horizons; thick, yellowish red and yellowish brown, fine textured, blocky, friable, acid B horizons.

Typifying Pedon: Torres silty clay loam-sugarcane
(Colors are for the moist soil)

Ap -- 0-11" --Dark brown (10YR 4/3) silty clay loam with few fine distinct yellowish red (5YR 4/8) mottles; weak medium subangular blocky structure; friable, slightly sticky, slightly plastic; many fine roots; common root channels; clay coatings along root channels; few fine black concretions; few fine volcanic fragments; few krotovinas; extremely acid; abrupt wavy boundary. 8 to 14 inches thick.

B21t -- 11-19" --Yellowish red (5YR 5/6) silty clay; moderate medium subangular blocky structure; friable, slightly sticky, slightly plastic; common fine roots; common fine pores; thin patchy clay films on ped surfaces and root channels; few fine volcanic fragments; few fine dark concretions; few krotovinas; extremely acid; gradual wavy boundary. 7 to 15 inches thick.

B22t -- 19-25" --Yellowish red (5YR 4/8) clay loam with common fine distinct red (2.5YR 4/6) mottles; weak fine subangular blocky structure; very friable, slightly sticky; slightly plastic; few fine roots; common fine pores; thin patchy clay films on ped surfaces and root channels common fine volcanic fragments; common fine black concretions; very strongly acid; gradual wavy boundary. 6 to 14 inches thick.

B23t -- 25-34" --Yellowish red (5YR 4/8) silty clay with common medium distinct strong brown (7.5YR 5/8) mottles; weak fine subangular blocky structure; friable, slightly sticky, plastic; very few fine roots; common fine pores; very thin patchy clay films; few fine rock fragments; few fine black concretions; few fine red concretions (2.5YR 4/8); very strongly acid; clear wavy boundary. 8 to 15 inches thick.

B24t -- 34-50" --Yellowish brown (10YR 5/6) silty clay with common medium distinct red (2.5YR 4/8) and common medium distinct yellowish red (5YR 4/8) mottles; weak fine subangular blocky structure; very friable, nonsticky, slightly plastic; common fine pores; very few patchy clay films; few fine white grains; few fine black concretions; very strongly acid; gradual wavy boundary. 10 to 20 inches thick.

B25 -- 50-62"+ --Yellowish brown (10YR 5/6) silty clay loam with common medium distinct red (2.5YR 4/8) and yellowish red (5YR 4/8) mottles; weak fine subangular blocky structure; very friable, nonsticky, slightly plastic; many fine pores; very strongly acid.

Type Location: Este SCD, Puerto Rico; municipality of Juncos; 660 feet south and 25 feet west of kilometer marker 12.1, highway 31.

Range in Characteristics: Thickness of the solum is more than 60 inches. Mean annual soil temperature at a depth of 20 inches is more than 72°F and the difference between mean summer and mean winter soil temperatures is less than 9°F. Mineralogy is oxidic. These soils are usually moist in all subhorizons. Base saturation (by sum of cations) is less than 35 percent at 50 inches below the upper boundary of the argillic horizon. Organic matter content is 1.5 percent or more in the upper 6 inches of the argillic horizon. CEC (by NH_4OAc) is less than 24 meq/100 grams of clay in the major part of the argillic horizon. Reaction of the profile ranges from strongly to extremely acid. Silty clay loam and silty clay are the dominant types. The A horizons have colors in hues of 10YR to 5YR, values of 3 and 4, and chromas of 2 and 3. The B2t horizons have textures that range from clay loam to clay and are stratified. The colors are in huer f 10YR to 5YR, values of 4 to 6, and chromas of 4 to 8. Mottles have bright chromas. Structure ranges from moderate to weak subangular blocky. Clay films vary from thin to very thin patchy. Coarse fragments, fine volcanic fragments, vary from few to common, do not exceed 20 percent by volume.

Competing Series and their Differentiae: These are the Aceitunas series in addition to the Daguao, Ejemplo, Humatas, Naranjito, Los Guineos, Lares, Limones, Aibonito, Daguey, and Cialitos series. The Aceitunas soils have higher CEC values - more than 24 meq/100 grams of clay. The Daguao, Ejemplo, Humatas, Naranjito and Los Guineos soils have thinner argillic horizons and higher CEC values. The Lares soils have mottles with chromas of 2 or less within 30 inches of the surface. The Limones, Aibonito, Daguey and Cialitos soils have thinner argillic horizons.

Setting: The Torres soils occupy gently to strongly sloping dissected terraces and alluvial fans with slope gradients of 2 to 20 percent. The regolith consists of very highly weathered, fine and moderately fine textured, stratified sediments of mixed

origin. The climate is humid tropical. The average yearly rainfall is from 80 to 90 inches. The mean annual temperature is from 77 to 80°F.

Principal Associated Soils: These are the competing Humatas, [illegible], [illegible] and Cialitos series in addition to the Consumo and Catalina series. The Humatas, Daguey and Cialitos occupy positions in the steep sideslopes of the volcanic uplands above the Torres soils. The Lares soils occur in similar terrace positions but have low chroma mottles in their profiles. The Consumo soils occupy steep sideslopes positions and have argillic horizons thinner than 16 inches. The Catalina soils occur in sideslopes and have lower CEC values - lower than 16 meq/100 grams of clay.

Drainage and Permeability: Well drained, medium runoff, moderate permeability.

Use and Vegetation: Original vegetation consists of native grasses and shrubs. Most of the acreage is used for sugarcane and pasture.

Distribution and Extent: Humid volcanic areas. The series is of small extent.

Series Established: Soil Survey of Puerto Rico, 1942.

Remarks: The Torres series was placed in the Reddish-Brown Lateritic soil group of the 1938 Soil Classification. There are no available laboratory data for these soils. Low exchange capacity is assumed because of the stability of the land forms in which the soils occur.

National Cooperative Soil Survey
USA

Cidra (Torres) Ap

Sand, 11.0% ; Silt, 23.8% ; Clay, 65.2%

Mineral Composition (untreated soil)

Mineral	< 100 mesh	Clay (< 2 μm)
Chlorite	1-10%	10-25%
Kaolinite	10-25%	> 40%
Gibbsite	1-10%	10-25%
Goethite	10-25%	10-25%
Quartz	25-40%	1-10%
Hematite	1-10%	detected
Magnetite	1-10%	detected

Unpublished data of R. C. Jones, W. Sakai, and W. Hudnall
Agronomy and Soil Science, University of Hawaii

Cidra (Torres) Ap

Discussion

The shape of the chlorite XRD peak indicates a poorly crystalline material n the less than 100-mesh soil. However, the chloite XRD peak for the clay raction was sharp. Thus, the well crystallized chlorite are concentrated in he clay fraction.

Virtually all kaolinite (K) was found in the clay fraction. Since the aolinites do not exhibit a hexagonal morphology, it is concluded that the oil has undergone extensive weathering.

Iron oxides (I) appear as dark clusters. Since only goethite was detected n the clay fraction by XRD in appreciable amounts, it must be concluded that hese features are mostly goethite. The other oxides which are present in the ay fraction were not detected by XRD in any discernible abundance because of all particle size and/or poor crystallinity.

The saturation extract of the Ap horizon (0-10 cm) contained 8.1 ppm licon as compared with 1.4 ppm silicon for the B21t horizon (10-30 cm). comparison of the micrographs of these two horizons reveal that the particles erlap and the oxide clusters appear much less distinct for the Ap horizon. ese observations indicate the presence of gel surface coatings; the source of e silicon in the saturation extract.

Unpublished data of R. C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

Cidra (Torres) B21t

Sand, 6.0%; Silt, 15.8%; Clay, 78.2%

Mineral Compostion (untreated soil)

Mineral	< 100 mesh	Clay (< 2 μm)
Chlorite	detected	1-10%
Kaolinite	25-40%	25-40%
Gibbsite	1-10%	1-10%
Goethite	10-25%	25-40%
Quartz	25-40%	10-25%
Hematite	1-10%	1-10%
Magnetite	1-10%	1-10%

Unpublished data of R.C. Jones, W. Sakai, and W. Hudnall, Department o
Agronomy and Soil Science, University of Hawaii

Cidra (Torres) B21t

Discussion

As seen in the micrographs, particle boundries and overlap in this horizon are much more distinct than those in the Ap horizon. The former suggest thin gel surface coatings.

The lack of hexagonal morphology in the kaolinite particles (K) suggest extensive weathering of minerals. These kaolinites can not be distinguished from chlorite, which normally exhibits no definite morphology.

Although goethite is the major X-ray crystalline iron oxide in both the whole soil and the clay fraction, the XRD peaks of hematite and magnetite were much sharper in this horizon than in the Ap horizon.

Quartz was not discernible in the micrographs of either the Ap or the B21t horizons.

Unpublished data of R. C. Jones, W. Sakai, and W. Hudnall, Department of Agronomy and Soil Science, University of Hawaii

TORRES SERIES - Orthoxic Palehumults

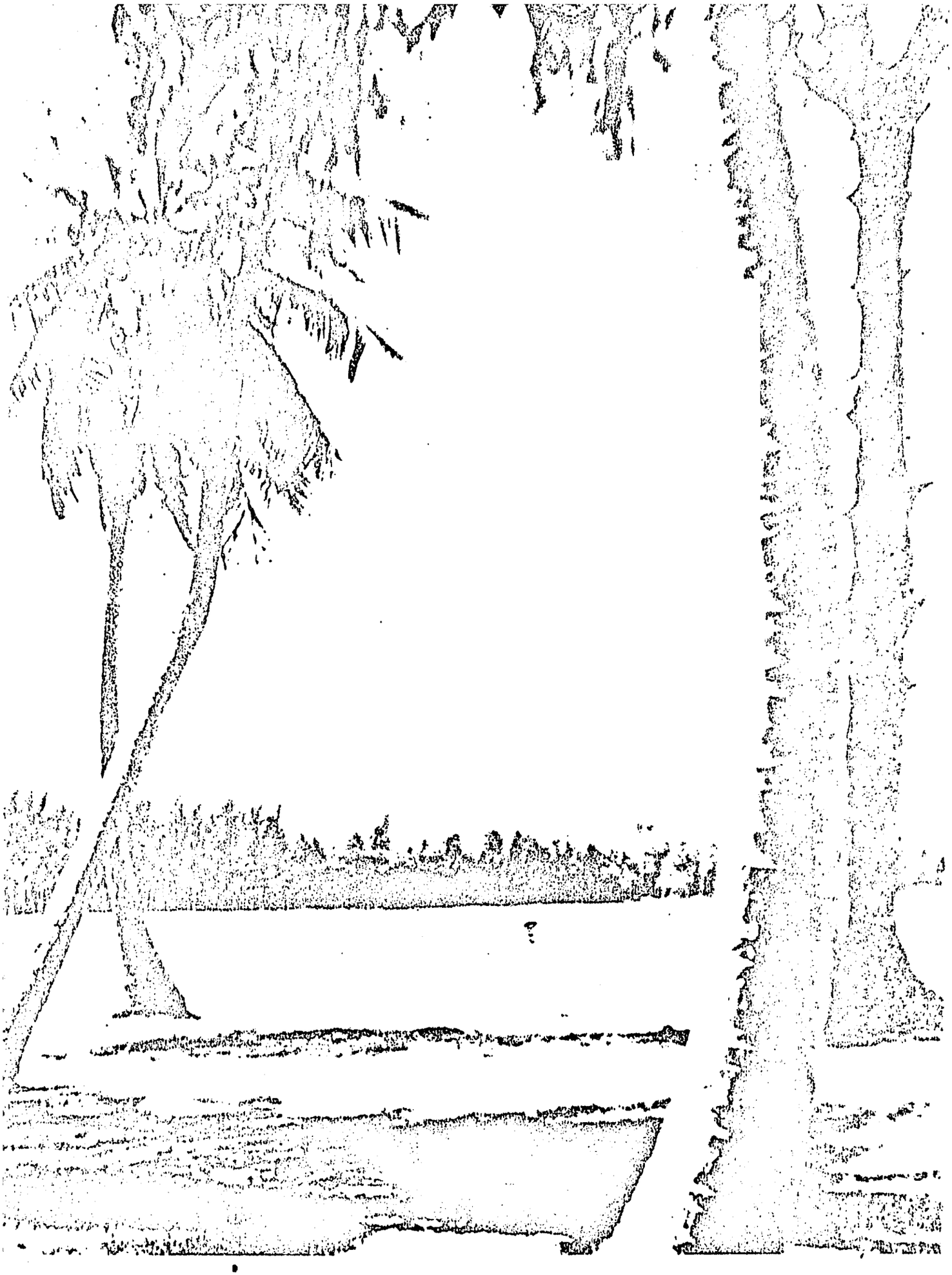
Horizon	Depth cm	Extractable SO_4S * $\mu g/g$ soil	Silicon		
			Saturation Extract	1:10 Water	1:10 Phospate
			Si, ppm, solution		Si, $\mu g/g$ soil
Ap	0-10	280	8.08	2.54	159.4
B21t	10-30	819	1.38	.78	95.5
B22	30-50	740	.96	.64	76.4
B23	50-90	589	.86	.70	102.5
B24	90-125	537	1.01	1.02	102.1

Unpublished data of R. L. Fox, Dept. of Agronomy and Soil Science, University of Hawaii

*) Repeated extraction (4 times) with 500 ppm P (CaH_2PO_4)
Soil: Extracting solution ratio was 1:5 for each extraction

:o, San Juan, Puerto Rico

Photo: F. H. Beinroth



uquillo Beach and El Yunque, Puerto Rico

Photo: F. H. Beinroth

TROPICAL SOILS INSTITUTE

Puerto Rico, July 10 - August 4, 1972

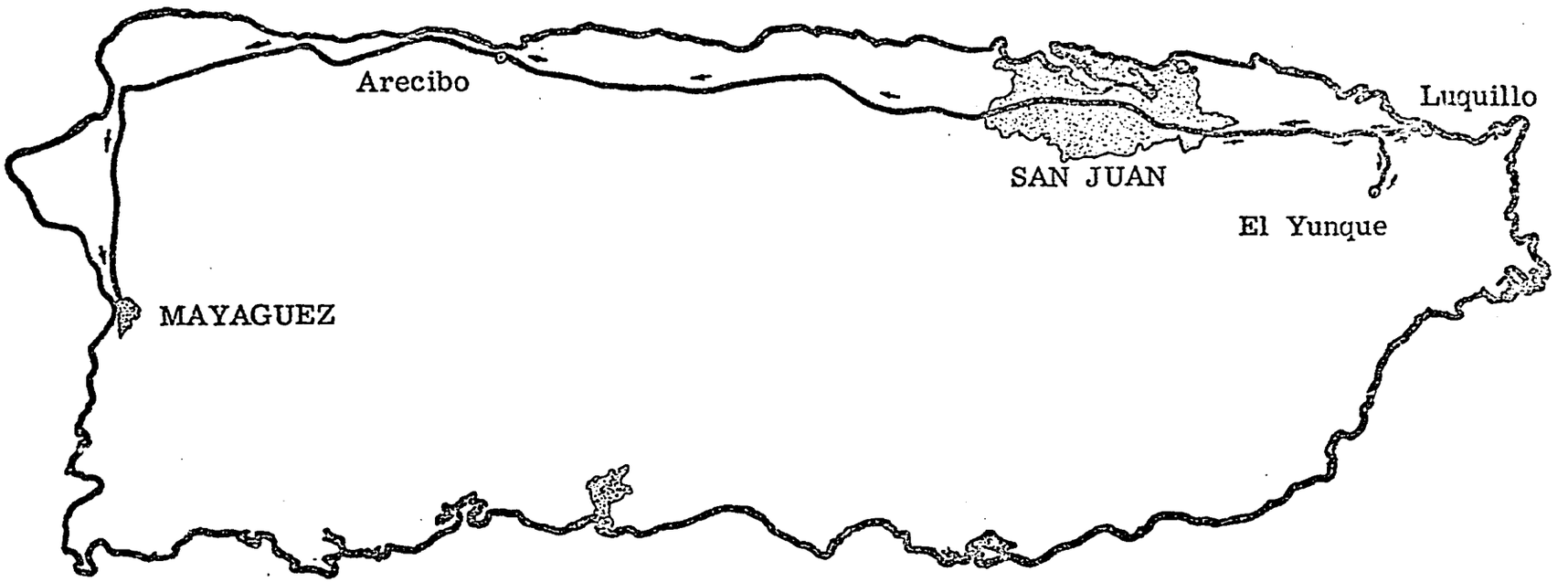
FIELD TRIP 5 - "SAN JUAN"

Third Day : "El Yunque"

Date	:	Sunday, 7/30/72
Objective	:	To see a tropical rain forest and a soil of this area
Route	:	San Juan -- El Yunque - Luquillo - San Juan - Arecibo - Mayaguez
Soil pit	:	Epiaquic Humoxic Tropohumult (Picacho Series)
Main Topics	:	Ecology of a tropical rain forest; soil formation; soil-forest nutrient cycles; land use

FHB/5-72

TROPICAL SOILS INSTITUTE PUERTO RICO, July 10 - August 4, 1972



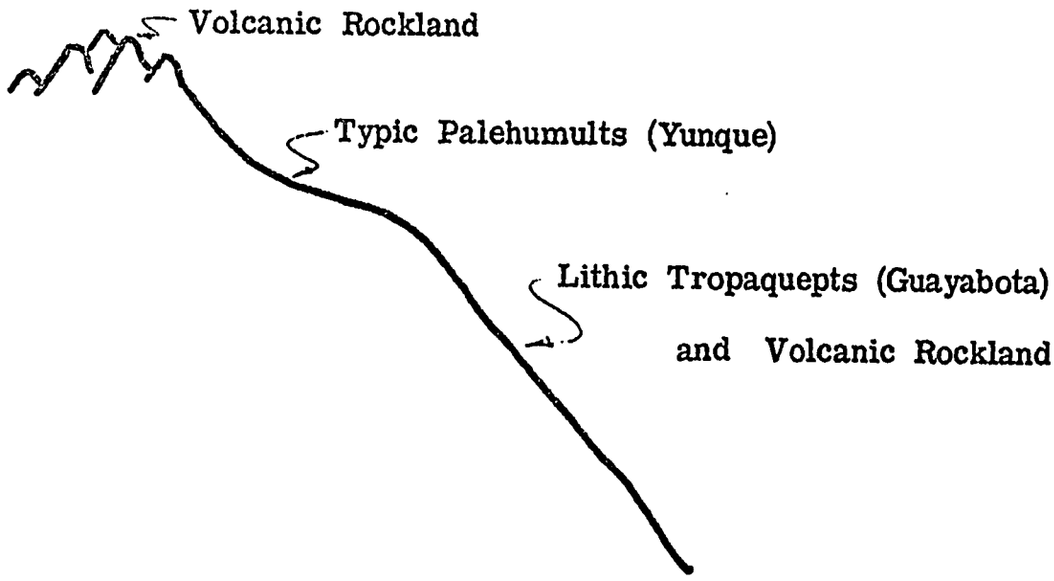
Field Trip 5 - "SAN JUAN"

Third Day: "EL YUNQUE"

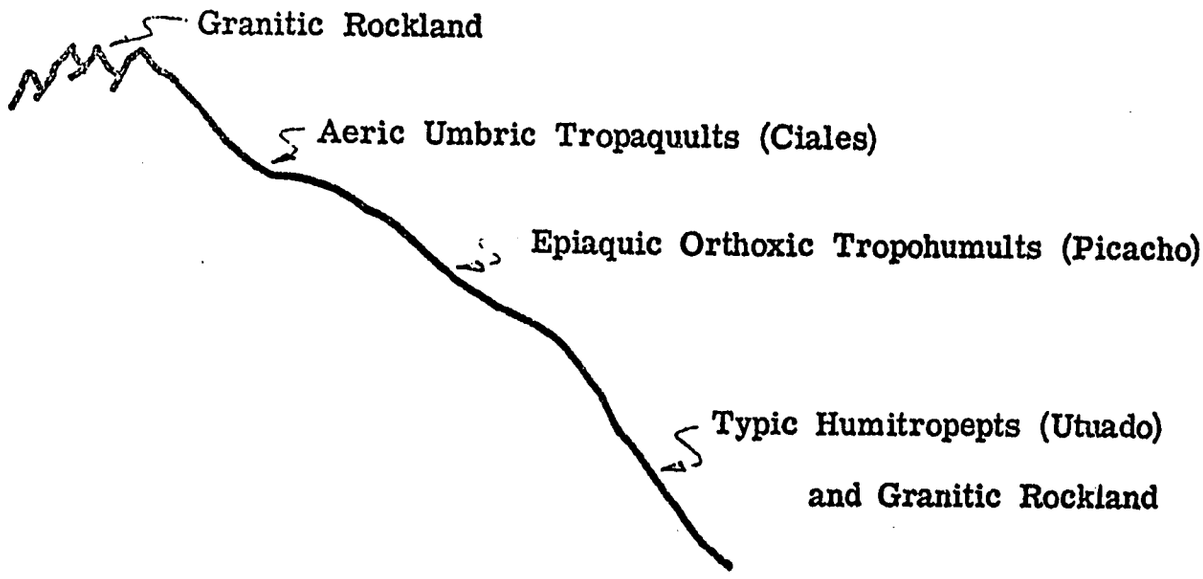
Toposequences in the El Yunque Subtropical Rainforest

Mean annual rainfall	:	400 - 500+ cm. (160 - 200+ in.)
Mean annual temperature	:	20 - 21 ° C (68 - 70 ° F)
Range in elevation	:	700 - 1070 m. (2200 - 3500 feet)

Volcanic Area



Granitic Area



SERIES: Picacho

General Characterization

Classification

Soil Taxonomy:	Subgroup:	Epiaquic Humoxic Tropohumults
	Family:	clayey, kaolinitic, isothermic
	Status :	tentative
FAO/UNESCO Legend:		Humic Acrisols
1938 Great Group:		Red and Yellow Podzolic

Location of Sample Site

Latitude: 18° 17' 45" N Longitude: 65°47' 30" W Elevation: 750m(2,460')
General Description: Luquillo National Forest ("El Yunque"), 15 m (45') W of km. 15.7 on highway 191. El Yunque Quadrangle, Municipio de Río Grande

Climate

Mean annual rainfall:	450 cm (~180")
Mean annual temperature:	~21° C (70°F)
Rainfall distribution:	less humid in January
Thornthwaite type:	AB'r - wet mesothermal

Vegetation and Land Use

Natural vegetation type:	Subtropical rain forest
Land use and crop:	national forest, ± virgin vegetation

Parent Material and Geology

Parent material:	Strongly weathered saprolite
Parent rock:	Quartz diorite
Geologic formation:	Late Cretaceous / Eocene

Geomorphology

Slope: 20%
Aspect: SW
Landform: shoulder
Geomorphic surface: Small bench - like surface in strongly dissected and steeply sloping upland

Additional Notes:

Samples from road cut

Compiled by: F.H. Beinroth Date: 2/14/72

Established Series
Rev. RAB:LHR
8/69

PICACHO SERIES

The Picacho series is a member of the clayey, mixed, isothermic family of Aquic Tropohumults. These soils have dark yellowish brown, silty clay loam A horizons; yellowish brown and reddish yellow, mottled, very strongly acid, clay B horizons over mottled saprolite.

Typifying Pedon: Picacho silty clay loam - forest. (Colors are for moist soil.)

A1 -- 0-9" -- Dark yellowish brown (10YR 4/4) silty clay loam; weak fine subangular blocky structure; firable, slightly sticky, slightly plastic; many fine through coarse roots; few fine pores; common fine silvery flakes; few fine dark minerals and quartz grains; very strongly acid; clear smooth boundary. (6 to 12 inches thick)

B21t -- 9-19" -- Yellowish brown (10YR 5/4) clay; common fine distinct gray and yellowish red mottles; weak coarse and medium subangular blocky structure; firm, slightly sticky, slightly plastic; few fine pores coated with brown; thin patchy clay films on ped surfaces and in root channels; few krotovinas 3/8 of an inch in diameter; common fine quartz grains; few fine dark minerals and silvery flakes; very strongly acid; clear wavy boundary. (8 to 12 inches thick)

B22t -- 19-28" -- Strong brown (7.5YR 5/8) clay; common fine distinct olive gray mottles; weak coarse and medium subangular blocky structure; firm, slightly sticky, plastic; few fine and medium roots; few fine pores; thin patchy clay films on ped surfaces and in root channels; many coated quartz grains; common fine dark minerals; few fine silvery flakes; few krotovinas; very strongly acid; gradual smooth boundary. (6 to 12 inches thick)

B3 -- 28-35" -- Reddish yellow (7.5YR 6/8) clay; weak fine and medium subangular blocky structure; firm, slightly sticky, plastic; few fine pores; thin patchy clay films on ped surfaces and in root channels; common fine quartz grains and silvery flakes; few krotovinas; very strongly acid; clear smooth boundary. (6 to 10 inches thick)

C1 -- 35-48" -- Yellowish red (5YR 5/6) clay loam; weak coarse and medium subangular blocky structure; friable, nonsticky, slightly plastic; few fine roots; few fine pores coated with dark material; many silvery flakes and coated quartz grains; very strongly acid; clear smooth boundary. (10 to 16 inches thick)

C2 -- 48-65" -- Yellowish red (5YR 4/6) silty clay loam; few fine faint red mottles; weak coarse subangular blocky structure; friable, nonsticky, slightly plastic; few fine roots; few fine pores; many silvery flakes; many fine quartz grains; few fine dark minerals; very strongly acid; gradual smooth boundary. (15 to 20 inches thick)

C3 -- 65-72"+-- Mottled, very pale brown (10YR 8/3), reddish yellow (7.5YR 6/8, 5YR 6/8) and red (10R 4/8) saprolite of loam; massive; texture; very friable, nonsticky, nonplastic; many silvery flakes and quartz grains; very strongly acid.

Type Location: Este SCD, Puerto Rico, El Yunque National Forest, 125 feet south and 50 feet east of kilometer marker 15.7 of Highway 191.

Range in Characteristics: Thickness of the solum is 26 to 46 inches. Reaction of all horizons ranges from extremely through very strongly acid. The A horizon is brown (10YR 4/3, 7.5YR 4/4), or dark yellowish brown (10YR 3/4, 4/4). Texture is from clay loam, silty clay loam or clay. The B horizon has dominant colors in hues of 10YR through 5YR, values of 4 through 6 and chromas of 4 through 8. Gray mottels are common in the upper B and decrease with depth. Texture ranges from clay to silty clay. Structure of the B2 horizons ranges from weak to moderate and from medium to coarse subangular blocky. The C horizon has colors

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USDA-SCS-FORT WORTH, TEX. 1969

Picacho Series

in hues of 5YR and 2.5YR, values of 4 through 6, and chromas of 4 through 8. Gray mottles are common in the upper B and decrease with depth. Texture ranges from clay to silty clay. Structure of the B2 horizons ranges from weak to moderate and from medium to coarse subangular blocky. The C horizon has colors in hues of 5YR and 2.5YR, values of 4 through 6, and chromas of 4 through 8. The lower C horizons have variegated colors of the saprolite. Texture of the C horizon is loam, clay loam, or silty clay loam.

Competing Series and their Differentiae: These are the Albonito, Cialitos, Corozal, Daguao, Deguey, Humatas, Lares, Limones, Los Guineos, and Naranjito series. Albonito, Cialitos, Deguey, and Limones soils have argillic horizons with exchange capacity of 24 meq or less per 100 grams of clay. Corozal soils have less than 1.5 percent organic matter content in the upper 6 inches of the argillic horizon. Daguao, Humatas, Los Guineos, and Naranjito soils lack mottles of chromas 2 or less within 30 inches of the soil surface. Lares soils have soil temperatures of more than 72°F.

Setting: The Picacho soils occur on steep upper sideslopes of strongly dissected uplands. Slope gradients range from 20 to 50 percent. The regolith consists of weathered residuum of igneous rocks. The climate is that of tropical rain forest. Near the type location the average annual precipitation is 185 inches and the mean annual air temperature is 72°F.

Principal Associated Soils: These are the Los Guineos soils of the competing series and Ciales, Guayabota, Utuado, and Yunque soils. Ciales soils have argillic horizons with gray colors. Guayabota soils have dominant low chroma colors and are shallow to hard volcanic rock. Utuado and Yunque soils lack low chroma mottles and Utuado soils lack argillic horizons.

Drainage and Permeability: Moderately well drained. Runoff is medium to rapid. Permeability is moderately slow.

Use and Vegetation: These soils are in hardwood forest.

Distribution and Extent: Tropical rain forests of Puerto Rico. The series is of minor extent

Series Established: Puerto Rico; 1942.

Remarks: This revision of the Picacho series restricts the concept to soils that have sola thickness of 26 to 46 inches. These soils were formerly classified in the Lithosols great soil group.

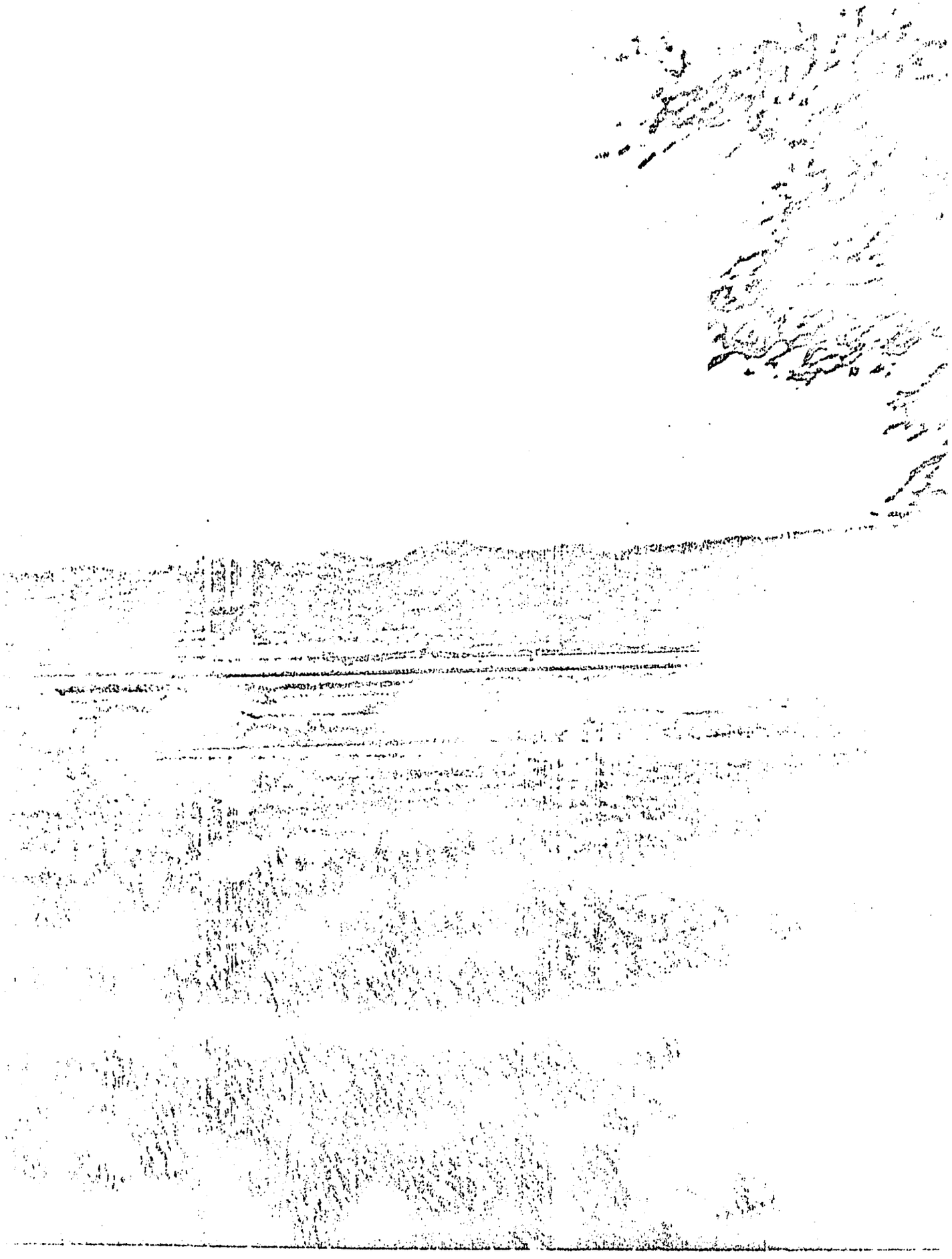
National Cooperative Soil Survey
U. S. A.

PICACHO SERIES - Epiaquic Humoxic Tropohumults

Horizon	Depth cm	Extractable SO_4S * $\mu g/g$ soil	Silicon		
			Saturation Extract	1:10 Water	1:10 Phospate
			Si, ppm, solution		Si, $\mu g/g$ soil
A	0-18	0	2.16	.80	34.0
B21	18-35	0	2.05	.86	47.3
B22	35-60	60	2.88	1.06	52.3
B3	60-85	340	.74	.66	109.6
C1	85-130	597	1.09	1.47	156.0
C2	130-165	392	1.09	.99	157.7

Unpublished data of R. L. Fox, Dept. of Agronomy and Soil Science, University of Hawaii

*) Repeated extraction (4 times) with 500 ppm P (CaH_2PO_4)
Soil: Extracting solution ratio was 1:5 for each extraction



Lajas Valley, SW Puerto Rico

Photo: F. H. Beinrot

TROPICAL SOILS INSTITUTE

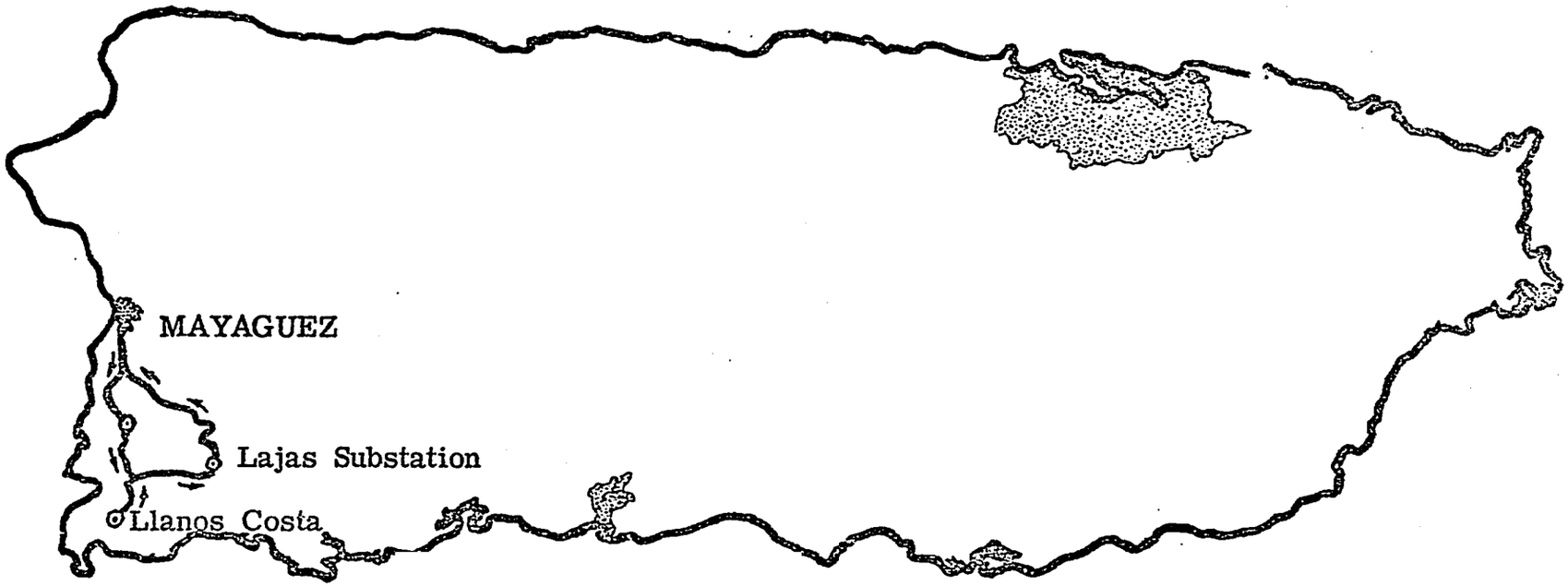
Puerto Rico, July 10 - August 4, 1972

FIELD TRIP 6 - "LAJAS"

Date	:	Wednesday, 8/2/72
Objective	:	To study geomorphology, genesis, classification, and management of Vertisols
Route	:	Mayaguez - Cabo Rojo - Llanos Costa - Lajas Agr. Experiment Substation - Mayaguez
Soil pits	:	Typic Calciustoll (Aguilita Series) - Llanos Costa Udic Chromustert (Fraternidad Series) - Lajas
Main Topics:		Geomorphology, morphology and classification of P.R. Vertisols; management (irrigation and drainage) of Vertisols; paddy rice experiments

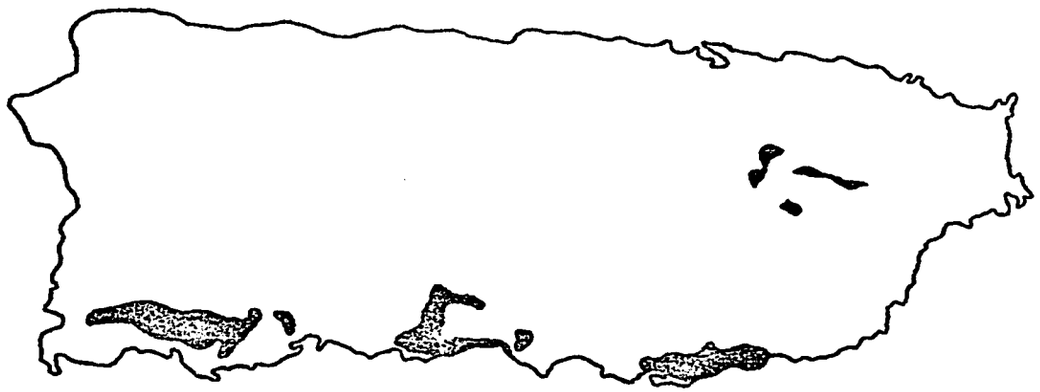
FHB/5-72

TROPICAL SOILS INSTITUTE Puerto Rico, July 10 - August 4, 1972



Field Trip 6 - "LAJAS"

Occurrence of VERTISOLS in Puerto Rico



FHB/68

Fraternidad clay - Udic Chromustert (formerly classified as Grumusol)

Location

On Lajas Agricultural Experiment Substation located on kilometer 20.9 on highway No. 101; about 400 m (1,200 feet) ENE of headquarters; approximately 32 km (20 miles) SE of Mayagüez. Elevation is about 30 m (100 feet) above sea level. This is the type location of the Fraternidad series.

Setting

The Lajas soils occur mainly on the nearly level to gently undulating (1-5%) higher terraces in the Lajas Valley in SW Puerto Rico. This valley is an elongated depression about 28 km (17 miles) long and 5 km (3 miles) wide. It is cut in rocks of Cretaceous age and filled with unconsolidated alluvial, deltaic and lagoonal deposits of a maximum recorded depth of 65 m (200 feet).

Climate

The climate is moist to subhumid tropical. The average annual precipitation is 112 cm (44 inches) and the mean annual air temperature 25°C (77°F).

Principal Associated Soils

In addition to the slightly alkaline Cartagena soils which are in the same subgroup, these are the Santa Isabel, Aguirre and Guánica soils (Chromudic Pellusterts) which occur on low-lying parts of the valley. Further associated with the Fraternidad soils are the San Antón soils (Cumulic Haplustolls) that are found in stream channels and the Jacana soils (Vertic Haplustolls) which occur on the footslopes of the mountains bordering the valley to the north.

Distribution and Extent

Fraternidad soils occur only in the semi-arid south of Puerto Rico. The series is of moderate extent.

Use

Most of the Fraternidad soils are irrigated and planted to sugarcane; some areas are in rain-fed crops such as sorghum or in pasture. Land capability class is IIIe.

Soil Classification: Udic Chromustert; very fine, montmorillonitic, isohyperthermic
Soil Type: Montmorillonite clay
Soil Nos.: S61PR-14-9
Location: Lajas Valley, Puerto Rico, On Lajas Experiment Station, 690 feet north and 150 feet east of junction of roads to poultry farms and to Lajas railroad station, east of Experiment Station headquarters. Aerial photograph 63-LR-6-66. Sarasota Soil Conservation District.
Vegetation and Use: Lila, weeds on old cultivated field.
Slope and Land Form: Nearly level (1 percent slope) at top of low convex alluvial fan above valley floor.
Drainage and Permeability: Moderately well drained, moderately slow permeability, slow to medium rate of runoff.
Parent Material: Alluvial or valley-fill sediments derived from volcanic and limestone rocks.
Collected by: R. B. Grossman, W. E. McKinzie, O. R. Carter, L. H. Rivera, March 21, 1961.
Described by: O. R. Carter.

Horizon and Lincoln Lab. No.	
Ap 14856	0 to 7 inches. Very dark grayish brown (10YR 3/2) clay; weak medium granular structure; firm, slightly sticky, plastic; many fine roots; common fine volcanic fragments; medium acid; clear smooth boundary.
A12 14857	7 to 14 inches. Very dark grayish brown (10YR 3/2) and 20 percent dark brown (10YR 3/3) clay; massive wet, upon drying breaks to weak medium and coarse angular blocky with many pressure faces; slickensides one inch wide; firm, sticky, plastic; few fine roots; common fine brown volcanic fragments, few up to 1 inch across; medium acid; clear wavy boundary.
A13 14858	14 to 23 inches. Dark brown (10YR 3/3) clay with tongues and pockets of very dark grayish brown (10YR 3/2) clay; massive wet, upon drying breaks to weak medium and coarse angular blocky with pressure faces and slickensides 6 inches in width and less; firm, sticky, plastic; common fine volcanic pebbles, common fine black aggregates; calcareous; gradual wavy boundary.
C1 14859	23 to 34 inches. Dark yellowish brown (10YR 4/4) clay with tongues and pockets of very dark grayish brown (10YR 3/2) clay; massive wet, upon drying breaks to weak medium and coarse angular blocky with pressure faces; slickensides 6 inches in width and less; firm, sticky, plastic; common fine black aggregates; calcareous; clear wavy boundary.
C2 14860	34 to 51 inches. Dark yellowish brown (10YR 4/4) clay; massive wet, upon drying breaks to weak coarse subangular blocky bounded by very dark brown (10YR 2/2) pressure faces in wedge shape; slickensides from 1 to 12 inches wide, 30 degrees to horizontal; very firm, sticky, plastic; common fine black concretions or aggregates; mildly alkaline except for common calcareous seams; clear wavy boundary.
C3 14861	51 to 60 inches. Dark yellowish brown (10YR 4/4) clay, appears to contain less clay than above horizons; massive wet, upon drying breaks to weak fine angular blocky bounded by very dark brown (10YR 2/2) pressure faces; many slickensides less than 1 inch; friable, slightly sticky, slightly plastic; slightly calcareous.

Remarks: Colors given are for moist soil. When sampled, A11, A12, A13, estimated to be below field capacity; C horizons at field capacity. Prominent cracks extend down to 23 inches.

Mineralogy (Methods 7A1, 7A2): C1 horizon. Fairly well ordered montmorillonite dominates the clay. A small amount of kaolinite is present.

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

SOIL CLASSIFICATION: Udic Chromuster; very fine, montmorillonitic, isohyperthermic

SOIL Fraternidad clay SOIL Nos. S61PR-14-9 LOCATION Lajas Valley, Puerto Rico

SOIL SURVEY LABORATORY Lincoln, Nebraska LAB. Nos. 14856-14861 December 1966

General Methods: 1A, 1B1b, 2A1, 2B

Depth (in.)	Horizon	Size class and particle diameter (mm) 3A1 — Total: Sand (2-0.05)	Total: Silt (0.05-0.002)	Total: Clay (< 0.002)	Sand: Very coarse (2-1)	Sand: Coarse (1-0.5)	Sand: Medium (0.5-0.25)	Sand: Fine (0.25-0.1)	Sand: Very fine (0.1-0.05)	Silt: 0.05-0.02	Silt: Int. III (0.02-0.002)	Int. II (0.2-0.02)	(2-0.1)			Coarse fragments 2A2: > 2 (<19) Pct.	2-19	19-76
		Pct. of < 2 mm															Pct. of < 76mm	
0-7	Ap	17.7	30.7	51.6	1.8	2.4	1.9	5.1	6.5	11.5	19.2	21.0	11.2			tr		
7-14	A12	16.7	28.3	55.0	2.0	2.3	1.7	4.5	6.2	10.7	17.6	19.5	10.5			tr		
14-23	A13	13.6	24.8	61.6	1.7	1.8	1.3	3.7	5.1	8.9	15.9	16.2	8.5			tr		
23-34	C1	12.4	24.6	63.0	1.0	1.6	1.2	3.5	5.1	9.3	15.3	16.5	7.3			tr		
34-51	C2	13.3	28.5	58.2	1.0	1.5	1.2	3.8	5.8	10.8	17.7	19.0	7.5			tr		
51-60	C3	15.1	27.6	57.3	1.5	1.5	1.4	4.5	6.2	10.6	17.0	19.6	8.9			tr		

Depth (in.)	6A1a Organic carbon b Pct	6B1a Nitrogen Pct	C/N		6E2a 6F1c Carbonate as $CaCO_3$ Pct.	6C2a Ext. Iron as Fe Pct.	Bulk density: 4A1a Field-State g/cc	4A1c 30-cm. g/cc	4A1b Air-Dry g/cc	4D1 COLE	Water content: 4D4 Field-State Pct.	4B3 30-cm Pct.	4B1b 1/3-Bar Pct.	4B2 15-Bar Pct.	4C1 1/3-to 15-Bar in/in.		pH: 8C1a (1:1) H_2O
0-7	1.64	0.138	12			3.4	1.36		1.60		22.3		32.4	20.4			5.8
7-14	1.29	0.118	11			3.4	1.41	1.22	1.79	0.14	28.7	39.9	40.6	23.5	0.21		5.9
14-23	0.63	0.063	10			3.1	1.36	1.18	1.78	0.15	30.5	42.0	40.8	27.1	0.16		6.3
23-34	0.37	0.040	9		-(a)	2.7	1.41		1.84d		29.1		38.6	26.2			6.8
34-51	0.12				1	2.5	1.48	1.25c	1.79	0.13	27.0	37.6	36.9	24.6	0.15		7.8
51-60	0.07				tr(a)	2.7								24.2			7.8

Depth (in.)	Extractable bases 5H1a: 6N2b Ca	6O2b Mg	6P2a Na	6Q2a K	Sum	6H1a Ext. Acidity	Cat. Exch. Cap.: 5A3a Sum Cations	5A1a NH_4OAc						8D3 Ca/Mg		Base saturation: 5C3 Sum Cations	5C1 NH_4OAc
	meq/100 g															Pct.	Pct.
0-7	23.3	16.4	0.3	0.5	40.5	10.2	50.7	41.7						1.4		80	97
7-14	23.6	17.5	0.5	0.5	42.1	10.0	52.1	41.2						1.3		81	102
14-23		22.8	1.0	0.7				43.5									
23-34		24.0	1.6	0.7				43.3									
34-51		24.4	2.1	0.7				39.5									
51-60		23.5	2.6	0.8				38.2									

Depth (in.)	Ratios to Clay 8H1: NH_4OAc CEC	Ext. Iron	15-Bar Water
0-7	0.81	0.07	0.40
7-14	0.75	0.06	0.43
14-23	0.71	0.05	0.44
23-34	0.69	0.04	0.42
34-51	0.68	0.04	0.42
51-60	0.67	0.05	0.42

a. Carbonate grains: 5-25 percent (2-0.05 mm.).
b. 11 kg/m² to 60 inches (Method 6A)
c. One clod.
d. Range in duplicate clods is 0.12 g/cc.

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Zur Kenntnis des Gilgai-Reliefs

Von *F. H. Beinroth*[*])

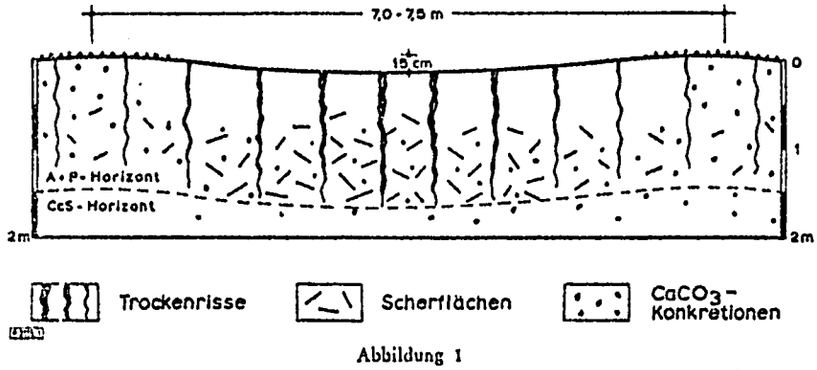


Abbildung 1
Schematisches Querprofil eines welligen Gilgai-Reliefs
(Nuba Mts. District, Provinz Kordofan, Sudan)
Schematic cross section of wavy gilgai

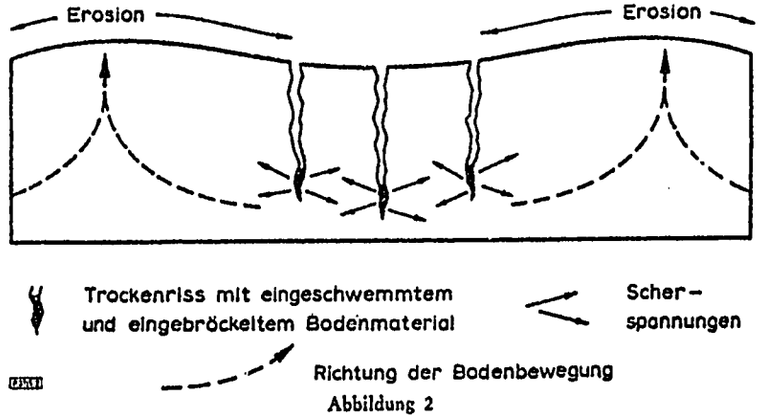
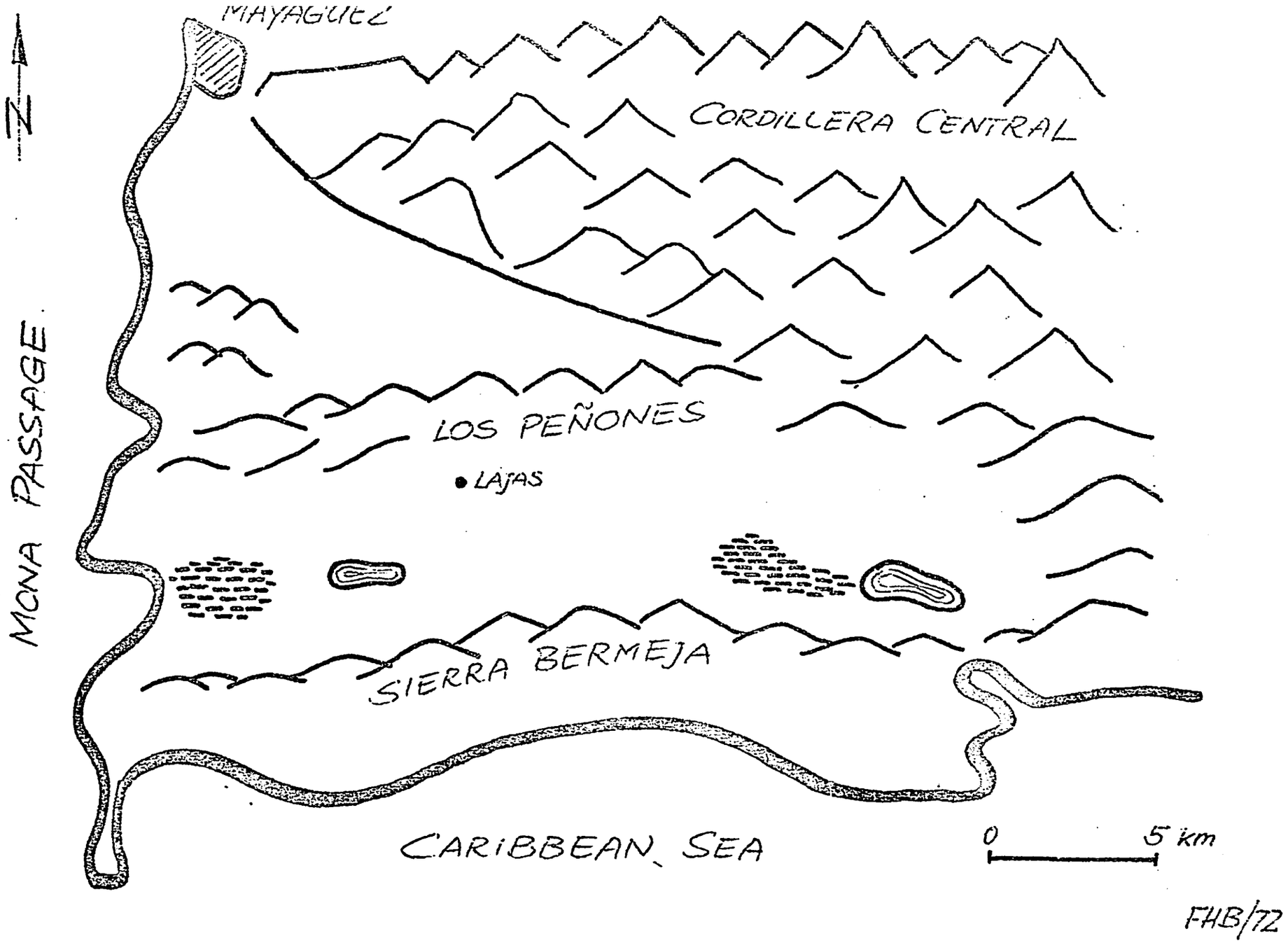


Abbildung 2
Skizze zur Kinematik des welligen Gilgai-Reliefs
Sketch showing the kinematics of wavy gilgai


MAYAGUEZ
N
CORDILLERA CENTRAL
MONA PASSAGE
LOS PEÑONES
LAJAS
SIERRA BERMEJA
CARIBBEAN SEA
0
5 km
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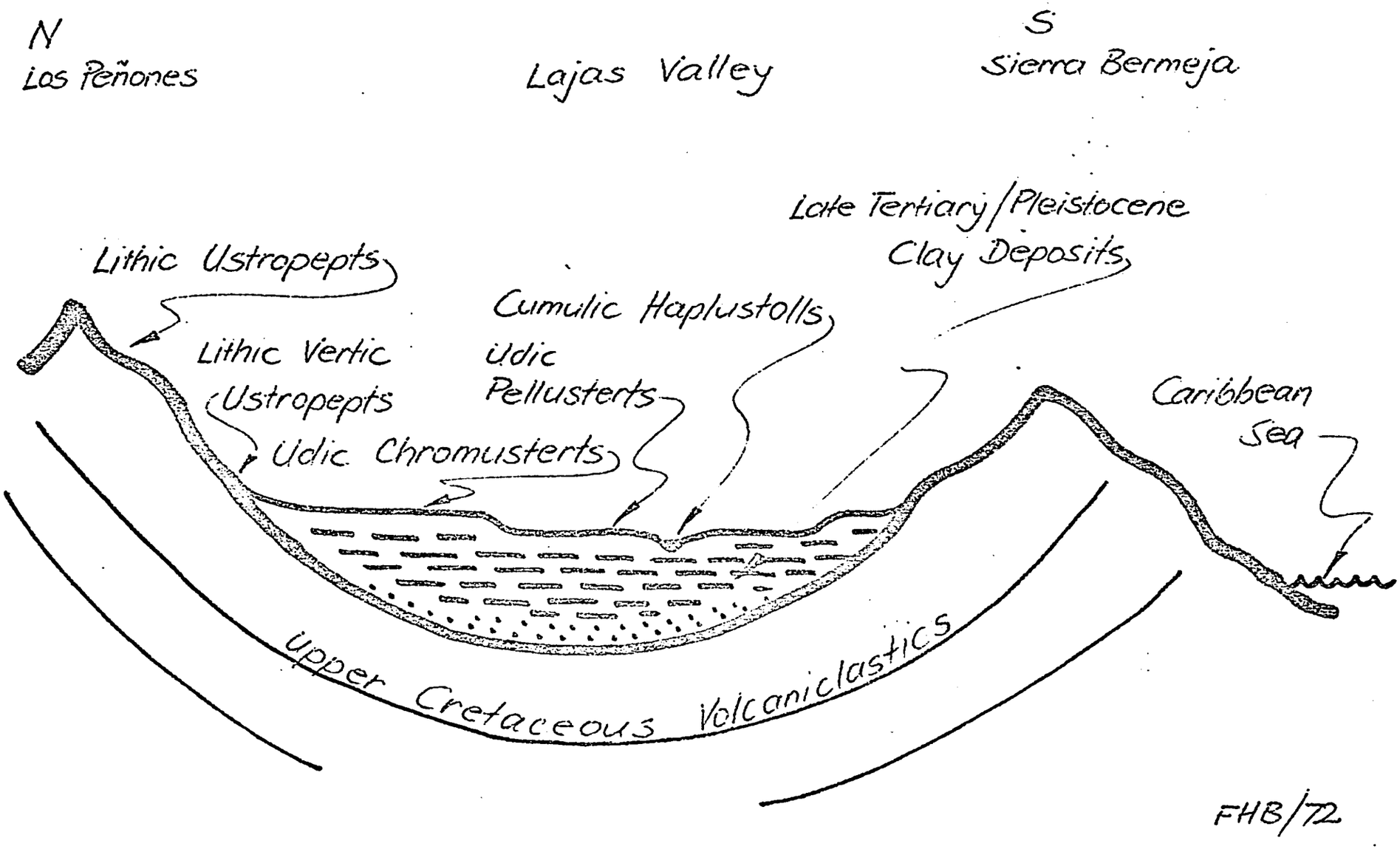
Schematic Cross-Section of the Lajas Valley



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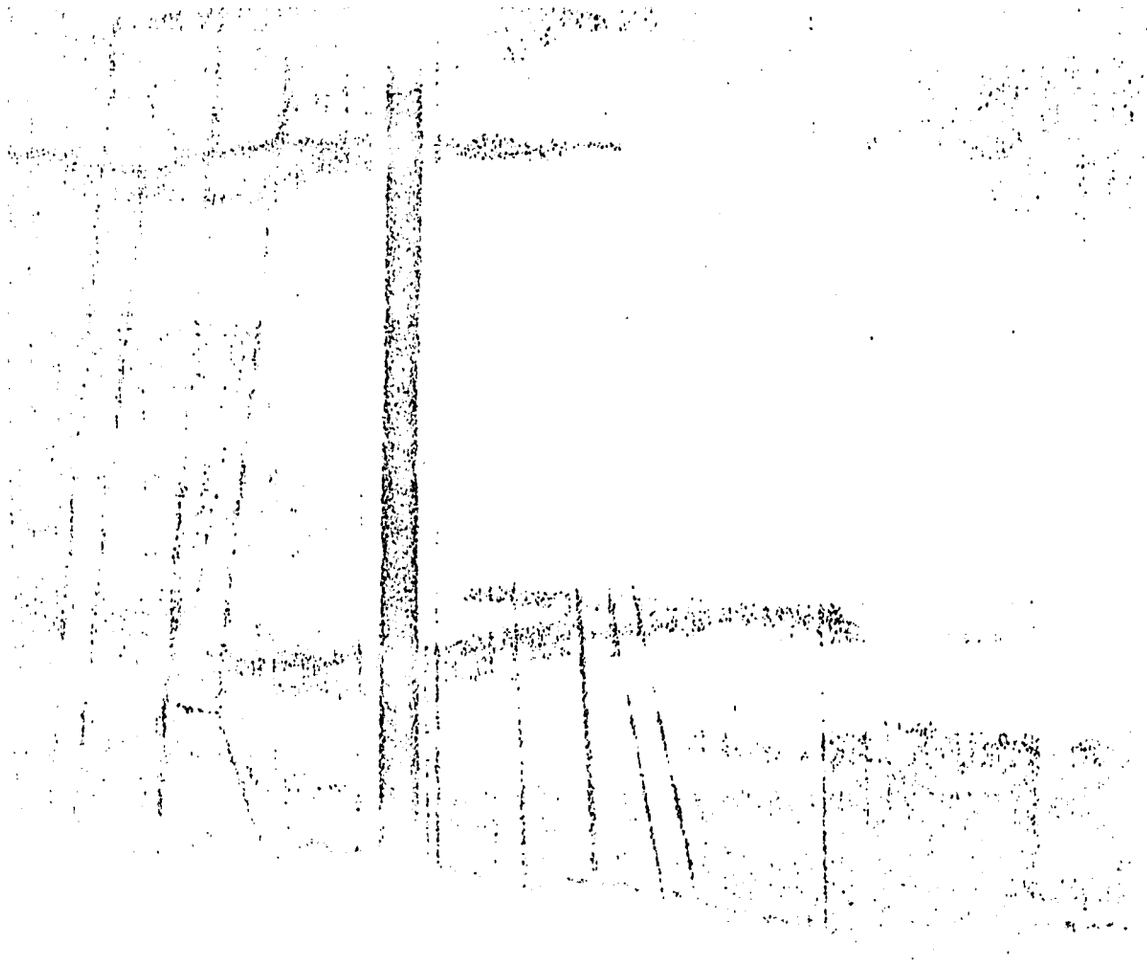

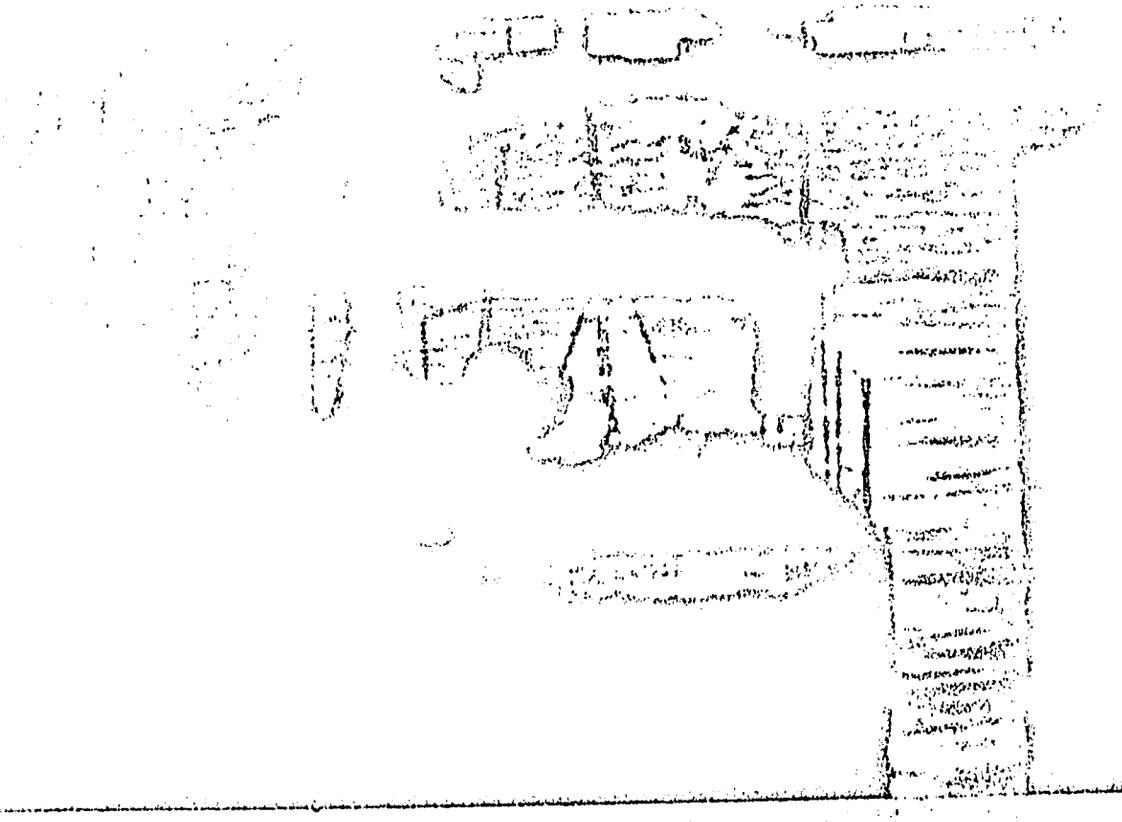

Tropical Sunset, Fajardo, Puerto Rico . Photo: F. H. Beinroth