Report of Caribbean and Tropical America Soils Conference

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by

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A conference on soils of the Caribbean and Tropical America was held at the University of the West Indies, St. Augustine, Trinidad, from 8 to 18 January 1973 in recognition of the Fiftieth Anniversary of the Department of Soil Science of the University. The guest of honor of the conference was Professor F. Hardy who had served continuously with great distinction the Department since its founding in 1922. The conference was attended by delegates from most areas of the Caribbean, from Mexico, from South America, from Great Britain, and from the United States and Canada.

The conference was divided into paper reading sessions at the University and into field tours. Field tours on the Island of Trinidad consisted of two one-half day tours and one full day tour to view the important soils and agriculture of the island. Two full day field tours were made on Barbados to examine soils developed on coral materials. One day field tours were made on each of the islands of Grenada and St. Vincent to examine soils developed on volcanic ash materials. Since the papers presented at the conference will be published, this report will concern itself with a discussion of some of the important soils studied during the field tours.

Profile descriptions as provided in the field tour guide are given in this report. Physical and chemical properties of the soils are also given. The particle size distribution of the various soils was determined by the pipette or the hydrometer method. Cation-exchange capacity and

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exchangeable cations were determined by the ammonium acetate method. Further details may be found by referring to the bibliography at the end of the discussion.

Soils of Trinidad

Soils of the Northern Range: The areas visited on the Island of Trinidad can be divided into three parts, the first of which is the Northern Range. The Northern Range is an extension of the Coast Range of Venezuela and is part of the eastern branch of the Andean Mountain system. Three soils developed in this area were examined and their characteristics given. The River Estate loams are well drained soils developed from micaceous phyllite alluvium. The soil is likely an Inceptisol. This soil is found in the broad valleys and river basins in the Northern Range, and is among the most productive of the Island. Some properties of this soil are given in Table 1. A soil profile description follows:

Depth (cm)	
0 - 8	Dark olive grey (5Y 3/2) sandy loam; weak medium crumbs; numerous roots at the top interlaced with each other; loose; micaceous; smooth feel; with some dark brown stains due to organic matter; smooth clear boundary to:
8 - 24	Yellow brown (10YR 5/4) sandy loam; micaceous; breaking into weak angular and sub-angular blocky peds; some small flat dark particles; small amount of fine fragments; numerous roots; clear wavy boundary to:
24 - 56	Dark yellow brown (10YR 3/4) and olive grey (5Y 4/2) gravelly loam; small flat sandstone; many roots; the dark colour may be due to organic matter; smooth clear boundary to:
56 - 80	Brown (7.5YR 3/2) and greyish brown (2.5Y 5/2) silty loam; micaceous; many roots; soil very smooth to the feel; no gravel; gradual wavy boundary to:
80 - 125	Light olive grey (5Y 6/2) and dark yellowish brown (10YR 3/4) loam; micaceous; smooth to the feel; very moist; few roots; dark streaks of manganese dioxide; no gravel; smooth clear boundary to:

TABLE 1: Some chemical properties and particle-size distribution: - River Estate Loam.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. p
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 8	6.6	12	54	16	18	9.3	10.3	10.3	1.1	0.05	0.05	100	2.0	0.26	7.7	114*
8 - 24	6.6	20	56	9	16	3.2	3.8	3.4	0.4	0.02	0.01	100	0.7	0.08	8.0	35
24 - 56	6.6	19	58	8	15	2.4	2.2	1.8	0.3	0.01	0.01	92	0.7	0.07	10.0	15
56 - 80	6.3	2	49	18	34	5.8	4.8	4.7	0.3	0.03	0.01	87	1.1	0.13	8.5	6
80 -125	6.3	1	48	18	34	4.6	3.9	4.0	0.3	0.02	0.09	85	-	-	-	5
125 +	6.5	3	55	18	30	-	2.7	2.9	0.3	0.00	0.01	75	-	-	-	6

*Phosphate recently added

Depth (cm)

125+ Pale olive (5Y 6/4) and dark brown (10YR 3/3) sandy loam; micaceous; smooth to the feel; very moist; few roots; absence of gravel; coarse sand grains.

The Maraval series is a soil developed on limestone of the Northern range. These soils are characterized by their reddish color and high base status. The soils may be Alfisols as there is a slight increase in clay content in the B horizon. These soils are productive and are used for food crops by small landholders. Some properties of the Maraval series are given in Table 2. The soil profile description follows:

Depth (cm)

0 - 5 Dark brown (7.5YR 3/2) silt loam; numerous thin roots; fine and medium crumbs; aggregates easy to crush; smooth clear boundary to:

5 - 12 Reddish brown (5YR 4/4) to yellowish red (5YR 4/8) sandy loam breaking into weak medium and coarse crumbs; numerous thin roots; easy to crush; some very small schist particles; smooth to the feel; smooth clear boundary to:

12 - 27 Dark reddish brown (2.5YR 2/5) silty clay loam; breaking into weak fine and medium sub-angular blocky peds; few roots; schistose fragments; abrupt smooth boundary to:

27 - 68 Yellowish red (5YR 4/8) silty clay loam; few fine roots; smooth feel due to schist particles; smooth clear boundary to:

68 - 110 Yellowish red (5YR 4/6) mottled reddish brown (2.5YR 4/4) silty clay loam; very few fine roots; few dead roots; small dark coloured schist particles; clear wavy boundary to:

110 - 150 Yellowish brown (10YR 5/6) mottled pale brown (10YR 7/3) loam; increase in sand content; very few roots; dead roots; thin gravel layer composed of schist and quartz and a few bits of sandstone; gradual wavy boundary to:

TABLE 2: Some chemical properties and particle-size distribution: - Maraval Series.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 5	6.5	10	23	26	34	22.9	29.0	22.4	7.7	0.40	0.52	100	2.7	0.54	5.0	17
5 - 12	6.5	12	24	24	38	15.3	16.2	12.5	4.6	0.08	0.18	100	2.5	0.35	7.1	6
12 - 27	6.7	13	27	21	42	7.6	6.0	5.0	1.4	0.04	0.09	79	0.9	0.18	5.0	6
27 - 68	6.6	14	30	12	50	5.1	4.0	3.4	0.9	0.00	0.04	78	0.5	0.11	4.5	Trace
68 -110	6.8	15	28	10	44	4.1	2.9	2.5	0.4	0.00	0.00	72	-	-	-	1
110 -150	6.8	16	26	16	43	3.6	2.5	2.3	0.2	0.01	0.04	69	-	-	-	1
150 +	7.2	18	34	26	26	3.3	3.8	3.5	0.2	0.01	0.13	100	-	-	-	31

Depth (cm)

150++ Very pale yellow (10YR 7/3) mottled white (10YR 8/2) and black (N2/); weathered micaceous schist; bits of limestone some roots; a large block of limestone at the bottom.

The Maracas series appeared to be somewhat more weathered than the previous two soils. The profile was more acid with a lower degree of base saturation. These soils were formed on steep slopes and were largely in forest; they appeared to be of limited agricultural use.

Soils of the Terraces and Intermediate Uplands, North Trinidad: The second area visited consisted of the terraces and intermediate uplands of North Trinidad. The soils found in this area show a marked developmental sequence from West to East as the material increases in age and the rainfall is higher. The St. Augustine loam soils are characterized by good drainage on gently sloping topography. The soil is likely an Inceptisol although it has some of the characteristics of an Ultisol. These soils have been under shifting cultivation growing food crops although much of the area has now been given over to housing developments and the like. The characteristics of the St. Augustine soil are given in Table 3. The profile description of this soil follows:

Depth (cm)

0 - 8 Very dark greyish brown (10YR 3/2) loam; numerous fine and medium roots; weak fine and medium crumbs; root traces and few fine insect casts; smooth clear boundary to:

8 - 15 Dark brown (10YR 3/3) mottled few fine faint dark greyish brown (10YR 4/4) loam; many fine and medium roots; root traces; root channels; structure of weak and medium subangular blocky peds; slightly hard; smooth clear boundary to:

TABLE 3: Some chemical properties and particle-size distribution; - St. Augustine Loam.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 8	6.4	6	18	24	42	11.4	15.6	14.0	1.6	0.13	1.33	100	2.2	0.43	5.1	11
8 - 15	6.2	5	23	26	47	11.3	10.8	10.5	1.1	0.04	0.45	96	2.7	0.34	7.9	4
15 - 50	6.1	5	21	26	51	7.8	6.2	6.4	0.7	0.03	0.75	79	1.3	0.23	5.7	0
50 - 105	5.8	6	17	22	58	6.3	3.6	3.9	0.3	0.02	0.17	57	-	-	-	0
105 - 150	5.6	13	19	22	51	4.6	2.8	2.9	0.3	0.02	0.17	61	-	-	-	0
150 +	6.0	12	24	20	45	4.4	2.8	3.0	0.3	0.02	0.15	64	-	-	-	0

Depth (cm) (Cont'd.)

15 - 50	Light reddish brown (2.5YR 6/4) mottled few fine faint dark greyish brown (10YR 4/2) and few fine faint light brownish grey (2.5Y 6/2) loam; many fine roots; few dark gray (5Y 4/1) infilled tunnels; structure of weak medium sub-angular blocky peds; few fine tubular pores; slightly hard; gradual wavy boundary to:
50 - 105	Red (2.5YR 4/6) mottled few fine distinct light olive grey (5Y 6/2) loam; few fine roots; root channels; few dead roots; few black (N2/) stains; structure of weak medium sub-angular blocky peds; few fine sandstone and quartz grains; slightly hard; gradual wavy boundary to:
105 - 150	Red (2.5YR 4/8) and olive grey (5Y 4/2) clay loam; few fine roots; dead roots; few root channels; medium sandstone and quartz rocks; structure of weak medium and coarse crumbs; few streaks of olive grey (5Y 3/2) and black (5Y 2/1) stains in red matrix; smooth clear boundary to:
150 +	Weak red (10R 4/3) and olive grey (5Y 5/2) loam; few fine roots; few root channels; dead roots; few fine tubular pores; few schist particles; few sandstone and quartz rocks; structure of weak medium sub-angular blocky peds; compact in pit; easy to crush when taken out; black (5Y 2/1) stains on ped faces.

The Piarco Fine Sand was the most developed of the soils seen in Trinidad. This soil was highly acid and of low percent base saturation. It was found on gently sloping topography and had definitely impeded drainage in the subsoil. It is likely an Ultisol. The particular site visited was being used to grow pineapples and a few tree crops. The soil is almost devoid of plant nutrients and is water-logged during much of the wet season thus limiting severly its agricultural potential. Characteristics of the Piarco soil are given in Table 4, and the profile description follows:

TABLE 4: Some chemical properties and particle-size distribution:- Piarco Fine Sand.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 12	4.3	13	60	9	18	2.0	0.4	0.0	0.5	0.05	0.71	20	1.0	0.09	11.1	2
12 - 36	4.4	14	49	11	20	1.9	0.8	0.0	0.0	0.03	0.24	42	0.2	0.03	6.7	1
36 - 94	4.3	12	41	9	40	3.7	0.6	0.0	0.2	0.06	1.03	16	-	-	-	1
94 - 135	4.4	5	32	9	52	5.7	0.8	0.0	0.2	0.07	1.20	14	-	-	-	Trace
135 - 165	4.6	13	48	11	28	2.9	0.2	0.0	0.2	0.05	1.09	7	-	-	-	1
165 +	4.6	24	33	13	30	1.9	0.4	0.0	0.2	0.07	2.50	21	-	-	-	Trace

Depth (cm)	
0 - 12	Greyish brown (2.5Y 5/2) mottled few fine faint dull dark brown (10YR 3/3) sandy loam; many fine and medium roots; few dead root traces; weak fine granular peds; loose; slightly sticky; non-plastic; smooth clear boundary to:
12 - 36	Light grey (N7/) mottled few fine distinct strong brown (7.5YR 5/8) and few fine distinct reddish brown (2.5YR 4/4) sandy loam; few fine roots; few medium flutes of dark grey (5YR 4/1) humic matter; loose; slightly sticky; non-plastic; abrupt smooth boundary to:
36 - 94	Light grey (10YR 7/1) mottled few fine distinct brown (7.5YR 5/4) loam; few fine roots; moderately compact; difficult to dig; easy to crush; slightly sticky; non-plastic; clear wavy boundary to:
94 - 135	Light grey (5Y 7/1) mottled few fine distinct light brown (7.5YR 6/4) and few fine distinct red (2.5YR 4/6) loam; few roots; structure of weak medium sub-angular peds; weakly cemented; dead reddish brown (2.5YR 4/4) root traces; smooth boundary to:
135 - 165	Light grey (N7/) mottled few fine distinct reddish yellow (7.5YR 6/8) and few fine distinct red (2.5YR 4/8) sandy loam; very few fine roots; compact in pit; easy to crush; few dead roots; weakly cemented; slightly sticky; slightly plastic; clear irregular boundary to:
165 +	Red (2.5YR 4/8), yellowish brown (10YR 5/6) and dark greyish brown (2.5Y 4/2) sandy clay loam; very few fine roots; compact; strongly cemented; structure of irregular sub-angular peds; slightly sticky; slightly plastic; water seeping into pit from sides.

Among the more unusual soils I have had the opportunity to see is the Aripo sand. This soil is located in Aripo Savanna on flat land. Drainage is severely restricted. The surface horizon is dominated by fine sand that is colored grey by organic matter with encrustations of Fe_2O_3. Underlying this layer there is an abrupt textural change to an intensely mottled

argillic horizon. The mottles are red on an almost white matrix. Under natural conditions these mottles are soft but when exposed and allowed to dry for a season, they harden irreversibly to form nodules or ironstone. This soil is an Ultisol and may be classified as a Plinthaquult.

Water imbalance is a characteristic of these soils. The extreme edaphic conditions have a major effect on vegetation. In the flat areas it consists mainly of small sedges and hardy grasses with a few small scattered shrubs. Insectivorous herbs and parasitic plants are also widespread. Obviously the agricultural potential of this soil is nil. The particle-size distribution and chemical properties of the Aripo sand are given in Table 5. The profile description follows:

Depth (cm)	
0 - 18	Grey (5Y 6/1) fine sand; numerous fine roots and earthworm casts; single-grain structure; clear smooth boundary.
18 - 25	White (5Y 8/1) fine sand with frequent grey (5Y 6/1) earth-worm casts; old root channels coated with strong brown (7.5YR 5/8) mottles; structure as above; abrupt smooth boundary.
25 - 35	White (5Y 8/1) silty clay (gleyed); intensely mottled; reddish yellow (7.5YR 7/8) to strong brown (7.5YR 5/8) coatings along old root channels; weak platy structure; clear smooth boundary.
35 - 60	White (5Y 8/1) silty clay; intensely mottled yellow (10Y 8/6) to dark red (10YR 3/6); weak platy structure; gleyed; clear smooth boundary.
60 - 180	Much less mottled dark red (10R 8/6) and much more gleyed white (5YR 8/1) silty clay; mottles more distinct and larger (up to 5cm diameter) structure as above; gradual smooth boundary.
180 - 250	White (5Y 8/1) silty clay with frequent distinct dark red (10R 8/6) mottles up to 5cm diameter; same continues to undetermined depth, becoming progressively more gleyed with fewer red, but more clearly defined and firmer mottled areas.

The group of soils described thus far is formed from materials dominated by micaceous and carbonaceous schists. The clay minerals present in the

TABLE 5: Some chemical properties and particle-size distribution:- Aripo Sand.

Depth (cm)	Particle-size Analysis % Oven dry soil				pH	Meq/100 g oven dry soil Exchangeable cations					% Oven dry soil		C/N ratio	ppm (Troug)
	Crse. sand 0.02-2 mm	Fine sand 0.05-0.2 mm	Silt 0.002 0.05 mm	Clay 0.002 mm		Cation Exchange capacity	Ca	Mg	K	Na	C	N		
0 - 18	0	66	25	12	5.0	2.0	0.5	0.2	0.03	0.00	0.51	0.048	10.6	2
18 - 25	0	60	22	20	5.0	2.7	0.5	0.6	0.02	0.00	0.22	0.019	11.6	2
25 - 35	0	42	22	40	4.8	4.2	0.8	0.3	0.02	0.00	0.11	0.012	9.2	1
35 - 60	0	29	20	53	4.6	6.9	0.5	0.5	0.04	0.06	-	-	-	Trace
60 - 180	2	30	18	52	4.8	10.2	0.4	0.7	0.07	0.01	-	-	-	Trace
180 - 250	4	19	21	57	4.8	10.6	0.4	0.8	0.12	0.02	-	-	-	6

soils are largely kaolinite and some mica. Little amorphous material is generally present in these soils. The fertility status of these soils is variable with the younger soils on alluvial materials appearing quite productive while the older more highly leached soils appear quite infertile. The agriculture on these soils is variable with some plantation crops such as cocoa being grown, but for the most part the cropping appears to be done by small holders and subsistance farmers.

Soils of Central Trinidad: The central area of Trinidad is composed of sedimentary materials and consists of recent alluvial and terrace deposits of the river systems of the Central Range. The Central Range is made up of many different kinds of rocks among which are various calcareous silts and clays, limestones and marls, Pliocene age sands and gravels, and alluvial materials laid down over flood plains and river flats. Included in the northern part of the Central Range is a sandy limestone containing a high proportion of glauconite. The soil sites we visited were in the Western half of the island and subjected to a dry season varying in length from one month to 4 or more months. In addition several sites were in low-lying poorly drained areas.

The Frederich Clay soil was characterized by a flat topography with impeded drainage. The ground water was saline or brackish due to infiltration along laminated bands in the subsoil. The nutrient status of this soil is fair. The subsoil is acid and has cat-clay features. This particular soil is probably an Inceptisol. Its characteristics are given in Table 6. A profile description follows:

TABLE 6: Some chemical properties and particle-size distribution:- Frederick Clay.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 5	6.0	1	6	28	64	28.6	26.6	21.6	4.6	0.89	0.97	93	3.1	0.26	11.9	47
5 - 48	5.6	0	6	25	66	28.0	26.6	21.1	6.0	0.26	1.46	95	1.6	0.20	7.9	24
48 - 90	5.7	0	3	19	80	25.1	27.5	20.7	6.2	0.23	2.75	100	-	-	-	27
90 -125	5.4	0	3	38	63	24.4	26.0	17.1	7.7	0.20	3.17	100	-	-	-	15
125 -150	5.1	4	14	19	62	26.8	22.0	13.3	7.2	0.27	3.53	82	-	-	-	12
150 +	4.6	9	15	10	63	24.4	23.8	12.9	8.7	0.42	5.35	98	-	-	-	12

Depth (cm)	
0 - 5	Dark greyish brown (10YR 4/2), mottled few medium faint dark grey (N4/) clay; many roots; few reddish brown (5YR 4/4) root traces; slightly sticky; slightly plastic; few earth worms; vertical cracks; smooth clear boundary to:
5 - 48	Dark grey (N4/) mottled few medium distinct dark yellow brown (10YR 4/4) clay; few roots; some of which are dead; vertical cracks stained red (2.5YR 4/6); sticky; plastic; compact; very firm; smooth clear boundary to:
48 - 90	Dark grey (N4/) mottled few medium faint dark brown (7.5YR 4/4) and few medium distinct strong brown (7.5YR 5/8) clay; few roots; some of which are dead; sticky; plastic; very compact; very firm; clear irregular boundary to:
90 - 125	Dark grey (N4/) mottled few coarse prominent yellowish brown (10YR 5/8) clay; very few fine roots; some of which are dead; sticky; plastic; compact; firm; clear wavy boundary to:
125 - 150	Grey (N6/) mottled few coarse prominent strong brown (7.5YR 6/6) clay; very few fine roots; very sticky; very plastic; compact; firm; bits of dark greyish brown (10YR 4/2) peat; gradual irregular boundary to:
150 +	Grey (N5/) and dark greyish brown (10YR 4/2) mottled few medium prominent yellowish red 5YR 5/8 and few fine distinct dark brown (10YR 3/3) clay; very few fine roots; many dead roots; smooth crack faces; slightly sticky; plastic; bits of black (10YR 2/1) peat; black stains N2/ intermixed with clay.

Another soil characterized by flat topography and impeded drainage is the Cacandee Clay. This soil remains submerged during wet seasons without water control. The soil is well supplied with nutrients except for P. Mg and Na are important cations. In the deep subsoil, semi-cat-clay conditions exist. The soil cracks widely and deeply during the dry season. This soil is undoubtedly a Vertisol. The properties are given in Table 7, and a profile description follows:

TABLE 7: Some chemical properties and particle-size distribution:- Cacandee Clay.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 17	5.3	0	6	11	85	28.1	24.2	16.8	6.9	0.43	1.22	-	2.6	0.33	7.9	7
17 - 32	5.6	0	5	6	91	28.4	25.1	18.9	8.9	0.24	3.59	-	1.8	0.29	6.2	7
32 - 90	6.0	0	1	4	96	26.9	23.7	14.6	8.4	0.16	2.98	-	-	-	-	8
90 - 135	6.7	0	1	2	98	26.6	30.1	16.7	12.4	0.23	5.40	-	-	-	-	7
135- 170	7.5	0	1	4	96	25.3	30.7	16.8	12.0	0.37	6.38	-	-	-	-	8
170 +	7.7	0	2	4	98	-	-	-	-	-	-	-	-	-	-	29

Depth (cm)

0 - 17 Black (N2/) clay; many roots; yellowish red (5YR 5/8) root traces; sticky; plastic; compact; hard; vertical cracks; smooth clear boundary to:

17 - 32 Dark grey (2.5YR N3/) mottled few fine distinct grey (N5/) and few fine distinct strong brown (7.5YR 5/8) clay; few roots; few dead roots; sticky; plastic; compact; hard; clear irregular boundary to:

32 - 90 Bluish grey (5BG 7/1) mottled few medium distinct dark grey (N4/) and few coarse distinct strong brown (7.5YR 5/8) clay; few roots; few dead roots; very sticky; very plastic; compact; firm; gradual irregular boundary to:

90 - 135 Greenish yellow (5GY 5/1) and grey (5Y 5/1) mottled few coarse prominent yellow brown (10YR 5/8) clay; few roots; few dead roots; smooth fracture planes; sticky; plastic; compact; firm; few dark grey (10YR 4/1) infilled tunnels; clear irregular boundary to:

135 - 170 Greenish yellow (5GY 5/1) mottled few medium distinct brownish yellow (10YR 5/8) and few medium distinct yellowish brown (10YR 4/4) clay; very few fine roots; root traces; sticky; plastic; compact; firm; smooth fracture planes; few dark grey (10YR 4/1) infilled tunnels; clear irregular boundary to:

170 + Grey (N5/) and greenish yellow (5GY 5/1) mottled few fine faint light olive brown (2.5Y 5/4) clay; very few fine roots; root traces; fine black (N2/) infilled tunnels; sticky; plastic; compact; firm.

Among the more interesting soils of Trinidad is the Montserrat Clay which occurs on sloping topography and is well drained. This soil occurs on the glauconite sandstone of the Central range. This material weathers rapidly and the soil is well supplied with nutrients. $CaCO_3$ is usually present throughout the profile. The soil has good physical condition. This soil has the characteristics of a Mollisol. Its properties are given in Table 8 and the profile description follows:

Depth (cm)

0-15 Very dark grey (5YR 3/1) to dark red-brown (5YR 3/2) clay with stable crumb structure; roots throughout with fine fibrous roots concentrated in the surface 5 cm.; earthworm casts plentiful.

TABLE 8: Some chemical properties and particle-size distribution: Montserrat Clay

Depth (cm)	Mechanical Analysis % oven-dry soil				$CaCO_3$ %	pH	me/100g oven-dry soil						% oven dry soil	
	Coarse sand 2-0.2 mm	Fine sand 0.2-0.05mm	Silt 0.05-0.002mm	Clay 0.002mm			CEC	TEB	Ca	Mg	K	Na	C	N
0- 15	4	27	12	54	0	6.8	26.9	30.0	25.5	6.0	0.48	0.76	2.4	0.27
15- 30	5	27	12	54	0	6:4	25:1	25:5	21:6	5:4	0:31	0:52	1:4	0:16
30- 60	1	23	9	65	0	6.0	26.5	28.1	24.2	5.5	0.28	0.52	1.2	0.12
60- 90	3	17	13	57	0	6.7	25.7	29.4	26.1	4.4	0.30	0.56	1.4	0.11
90- 120	3	16	13	63	0	6.7	32.2	32.6	28.9	4.8	0.42	0.84	2.0	0.14

15-30 Dark red-brown (5YR 3/4) clay with features as above; thick roots abundant.

30-60 Dark red-brown (5YR 3/3) clay somewhat denser than above; well aggregated; some thick clay coatings; roots plentiful; shell fragments and weathering fragments of sandstone common.

60-90 Dark reddish-brown (5YR [illegible]) clay; pieces of weathering sandstone more common; well aggregated and roots common.

90-120 Fragmented yellowish-red (5YR 4/5) calcareous sandy clay grading into yellowish-brown (10YR 5/4), and reddish-yellow (10YR 6/6) friable sandstone; roots rare; crumb structure very stable with very high permeability. Profile continues as weathering rock to undetermined depth.

The Brasso Clay is the most widespread soil of the higher parts of the central range. It occurs on hilly topography and has restricted drainage. This soil is slightly acid in the surface but alkaline in the lower horizons. This soil appears to have at least some of the characteristics of a Vertisol. The clay fraction is about 40 percent kaolinite with the remainder montmorillonite. The result is that erosion in the form of land slips is severe. The soil has serious limitations in use due to its slipping character. Properties of the soil are given in Table 9. The profile description follows:

Depth (cm)

0 - 8 Dark grey (5Y 4/1) clay; numerous fine, medium and coarse roots; worms and worm casts; weak medium and coarse crumbs; slightly sticky; slightly plastic; abrupt smooth boundary to:

8 - 22 Olive grey (5Y 5/2) mottled few fine distinct brownish yellow (10YR 6/6) clay; many fine and medium roots; weak medium and coarse sub-angular blocky peds; many fine and medium root channels; worms and worm casts; slightly sticky; slightly plastic; few very dark grey (N3/) infilled tunnels; gradual smooth boundary to:

22 - 52 Strong brown (7.5YR 6/6) and yellow brown (10YR 5/6) mottled few medium distinct grey (N6/) clay; many fine roots and root channels; few dead roots; weak coarse sub-angular blocky peds; slightly sticky; plastic; compact; firm; gradual smooth boundary to:

52 - 85 Grey (N5/) and yellow brown (10YR 5/6) clay; few fine and medium roots and root channels; tubular pores; weak medium columnar peds; weak coarse crumbs; slightly sticky; plastic; compact; firm; calcareous; smooth clear boundary to:

TABLE 9: Some chemical properties and particle-size distribution:- Brasso Clay.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 8	6.3	1	14	24	59	38.4	24.1	23.3	2.1	0.27	0.54	63	4.6	0.38	12.1	11
8 - 22	5.7	0	18	19	64	19.0	15.0	14.4	2.1	0.17	0.36	79	1.8	0.23	7.8	5
22 - 52	5.7	0	12	18	72	17.3	15.0	14.8	3.2	0.16	0.75	90	-	-	-	4
52 - 85	6.9	0	5	23	73	17.1	17.8	16.2	5.7	0.10	0.95	100	-	-	-	84
85 -125	7.4*	5	6	20	70	13.1	-	-	3.1	0.03	0.38	-	-	-	-	43
125 +	7.9	5	11	19	62	10.9	-	-	1.3	0.05	0.81	-	-	-	-	155

* Free lime from this depth.

Depth (cm)

85 - 125 Dark grey (N4/) mottled few medium distinct dark brown (10YR 3/3) and few medium distinct brownish yellow (10YR 6/6) clay; few fine roots and root channels; many fine tubular pores; slightly sticky; slightly plastic; compact; firm; calcareous; smooth clear boundary to:

125 + Very dark grey (N3/) mottled few fine faint yellow brown (10YR 5/6) and few medium distinct olive brown (2.5Y 4/4) siltstone; very few fine roots; few dead roots; weak irregular peds; fine white (2.5Y 8/2) films on ped faces; nests of gypsum; non-sticky; slightly plastic; calcareous.

Three soils of the Southern Plains area were examined. The Sevilla Clay occurs on sub-recent alluvium on a flat topography with imperfect drainage. Perched water tables occur near the surface during the wet season. The soil is slightly acid to near neutral in reaction and plant nutrients are in moderate supply. The soil is likely an Inceptisol. Some properties of the soil are given in Table 10 and the profile description follows:

Depth (cm)

0 - 8 Dark greyish brown (10YR 4/2) clay; numerous fine and medium roots; weak coarse sub-angular blocky peds; coarse crumbs; slightly sticky; slightly plastic; bits of burnt material at the top; smooth clear boundary to:

8 - 30 Brown (10YR 4/3) mottled few medium faint grey (10YR 5/1) clay; many fine and medium roots; dead roots; few root channels; weak coarse columnar and weak coarse sub-angular blocky peds; fine medium tubular pores; slightly sticky; slightly plastic; compact; firm; smooth clear boundary to:

30 - 75 Olive (5Y 5/4) mottled dark grey (5Y 4/1) clay; few fine roots; root channels; few fine tubular pores; sticky; plastic; compact; firm; gradual smooth boundary to:

75 - 120 Grey (5Y 5/1) and brown (10YR 4/3) clay; few fine roots; fine and medium root channels; irregular blocky peds; few tubular pores; sticky; plastic; compact; firm; gradual irregular boundary to:

120 - 150 Greenish grey (5G 5/1) and dark yellowish brown (10YR 4/4) clay; very few fine roots; few dead roots; root channels

TABLE 10: Some chemical properties and particle-size distribution:- Sevilla Clay

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 8	6.2	3	26	20	55	21.6	19.9	14.5	6.4	0.25	0.41	92	1.4	0.17	8.2	6
8 - 30	6.1	3	27	16	53	22.8	19.9	14.7	6.0	0.18	0.65	87	1.2	0.15	8.0	5
30 - 75	6.0	0	18	17	67	23.7	24.6	18.3	6.4	0.23	1.60	100	-	-	-	3
75 - 120	6.0	0	21	12	68	21.8	22.9	17.3	6.7	0.19	1.7	100	-	-	-	3
120 - 150	6.3	0	21	14	64	20.5	21.4	15.5	6.7	0.18	1.44	100	-	-	-	3
150 +	6.1	0	27	17	63	23.1	23.3	17.1	6.3	0.18	2.58	100	-	-	-	5

Depth (cm)

120 - 150 (Cont'd.)

few fine tubular pores; few fine specks of manganese dioxide; sticky; extremely plastic; compact; firm; gradual irregular boundary to:

150 + Dark brown (10YR 3/3) and greenish grey (5G 5/1) clay; very few fine roots; few dead roots; few root channels; sticky; plastic; compact; firm.

The Talparo Clay is widespread in central Trinidad. The soil is found on rolling topography and has impeded drainage. It is derived from Pliocene clay shales. The soil is extremely acid and generally has low levels of available nutrients. Al toxicity is a problem on this soil. This soil may be classed as an Inceptisol although this is by no means certain. Its properties are found in Table 11 and its profile description follows:

Depth (cm)

0 - 5 Very dark grey (10YR 3/1) clay; numerous fine and medium roots; fine medium and coarse crumbs; fine medium tubular pores; slightly sticky; slightly plastic; few worm casts; smooth clear boundary to:

5 - 25 Yellowish brown (10YR 5/4) and dark greyish brown (10YR 4/2) clay; many fine and medium roots; weak coarse angular and sub-angular peds; very dark grey (10YR 3/1) skins on ped faces; few root traces; slightly sticky; slightly plastic; compact; firm; smooth clear boundary to:

25 - 55 Greenish yellow (5GY 6/1) mottled few medium distinct red (10R 4/8) clay; many fine and medium roots; few dead roots; few root channels; weak coarse sub-angular blocky peds; skins of dark grey (10YR 4/1) on ped faces; sticky; plastic; compact; firm; smooth clear boundary to:

55 - 100 Greenish yellow (5GY 5/1) and red (7.5YR 4/6) clay; many fine and medium roots; dead roots; few root channels; sticky; plastic; firm; compact; gradual irregular boundary to:

100 - 150 Greenish yellow (5GY 7/1) and strong brown (7.5YR 5/8) clay; few fine roots; few dead black (N2/) roots; manganese dioxide stains; live roots along crack faces; coarse plate-like structure; weak medium angular peds; smooth clear boundary to:

TABLE 11: Some chemical properties and particle-size distribution:- Talparo Clay.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 5	6.1	4	18	15	65	34.4	36.3	18.7	16.1	2.21	0.88	100	6.2	0.61	10.2	50
5 - 25	5.4	3	8	10	82	29.8	24.0	8.8	13.5	1.64	1.43	81	2.6	0.28	9.3	32
25 - 55	5.0	0	1	4	97	35.4	24.2	5.6	17.4	1.09	2.68	68	-	-	-	21
55 - 100	4.3	1	1	4	96	34.5	23.1	3.1	19.1	0.82	6.27	67	-	-	-	9
100 - 150	4.8	3	2	10	94	33.6	29.7	5.7	26.3	0.65	11.70	68	-	-	-	61
									Gypsum							

Depth (cm)

150 + Greenish yellow (5GY 5/1) mottled few distinct yellowish brown (10YR 5/6) shaly clay; very fine roots; few dead roots; coarse and medium plates; nests of gypsum; manganese dioxide stains along planes; slightly sticky; slightly plastic; compact; firm.

The Princes Town Clay is found on rolling topography and has imperfect drainage. It is found on calcaceous clay. The soil has all plant nutrients in good supply. The soil does compact and cracks upon drying. The profile in most instances cracks to sufficient depth to be a Vertisol. The properties of this soil are given in Table 12 and a profile description follows:

Depth (cm)

0 - 7 Very dark grey (5Y 3/1) clay; many roots and root traces; moderate medium and coarse crumbs; slightly sticky; slightly plastic; smooth clear boundary to:

7 - 30 Dark (5Y 4/1) and olive grey (5Y 5/2) clay; many fine roots; few dead roots; root channels; weak coarse subangular blocky peds; sticky; plastic; compact; firm; smooth clear boundary to:

30 - 75 Grey (5Y 6/1) and yellowish brown (10YR 5/8) clay; many fine roots; dead roots; fine dark grey (5Y 3/1) flutes; angular blocky peds; ped faces stained very dark grey (5Y 3/1); sticky; plastic; slightly calcareous irregular clear boundary to:

75 - 125 Dark greyish brown (10YR 4/4) and bluish grey (5BG 6/1) clay; fine roots; many dead roots; root channels; very dark grey (N3/) flutes; few black (N2/) stains; sticky; plastic; compact; firm; ped faces smooth clear boundary to:

125 - 162 Bluish grey (5BG 6/1) mottled few coarse distinct yellowish brown (10YR 5/4) clay; few roots; few dead roots; root channels; irregular angular blocky peds; sticky; plastic; compact; very firm; calcareous; smooth clear boundary to:

162 + Bluish grey (5BG 5/1) mottled few coarse distinct strong brown (7.5YR 5/6) and few fine distinct olive yellow (2.5Y 6/6) clay; very occasional fine roots; black (N2/) stains; compact; firm concretions of $CaCO_3$.

Most of the soils of Central Trinidad visited appear to be dominated by montmorillonitic clay minerals and these soils shrink and swell upon

TABLE 12: Some chemical properties and particle-size distribution:- Princes Town Clay.

Depth (cm)	pH	Particle-size Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P
		Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na		C	N		
0 - 7	6.3	1	2	8	90	35.0	37.9	35.9	2.1	0.47	0.83	100	2.6	0.23	11.3	13
7 - 30	6.4	1	2	9	91	33.2	37.7	33.2	4.4	0.43	0.93	100	2.5	0.23	10.9	8
30 - 75	6.7	0	2	6	90	33.9	36.9	32.3	4.8	0.39	2.58	100	-	-	-	4
75 - 125	8.3	0	3	8	92	34.2	36.3	30.6	4.2	0.23	2.92	-	-	-	-	32
125 - 162	8.2	0	2	10	91							-	-	-	-	18
162 +	7.8	3	4	5	90	CALCAREOUS - about one percent $CaCO_3$						-	-	-	-	17

wetting and drying. The materials are relatively young and have restricted drainage. Problems of physical condition apparently dominate many of these soils. This is particularly true of the Frederich, Cacandee, Brasso, Sevilla, Talparo, and the Princes Town Clays. Land slippage was noticed as a problem in the Brasso, Talparo, and Princes Town Clays and was a particular problem in the widespread Brasso Clay.

The clay fraction of the Monserrat Clay was dominated by vermiculite, kaolin, and geothite. This soil was derived from glauconite sandstone which weathers very rapidly in this environment. This soil had excellent physical condition and high fertility.

The Frederich and Cacandee Clays were cropped mainly to sugarcane and rice. Artificial drainage was required to grow sugarcane; the crop appeared only fair. Rice for the most part appeared to be grown under rain-fed conditions. The potential for rice with adequate water control appeared quite good on these soils. Some food crops were grown during the dry season with varying success. These soils appeared to have reasonable potential with good management. For the most part it did not appear that their potential was being reached.

The Montserrat Clay appeared to be the most productive soil we saw in Trinidad. It is almost entirely cultivated to cacao and a high quality crop is produced. The Brasso Clay also located in the uplands is of much more limited potential. A fair crop of cacao can be grown with careful management. Due to the extent of the soil in the central highlands of Trinidad, all food crops are grown with limited process. Teak grows well on the Brasso Clay and much of the land is presently being returned to teak.

Sugarcane is the chief crop grown on the Sevella, Talparo, and Princes Town Clays. The Sevilla Clay is considered to be the most suited

of the soils in Trinidad for sugarcane. The Talparo Clay is widespread in central Trinidad and therefore many of the food crops also are grown on this soil. Both its inferior physical properties and its low fertility limit its productivity. Sugarcane yields of from 25 to 35 tons per acre were reported during the tour. The 35 ton yields were reported on the Sevilla clay while yields reported for the other soils were usually less than 30 tons per acre. By most criteria one may wish to use, these yields are marginal. The larger operations appeared to be remaining fairly stable but the smaller operations seemed to be in trouble. What the future of the sugar industry may be in a situation such as this was not apparent to one on such a tour as ours. There does seem to be unrealized potential on many of these soils. The staff at the University of the West Indies are well aware of this potential and are directing their efforts towards realizing the potential of these soils.

Soils of Barbados

Soils of the coral regions: Barbados is a coral island rising to a height of 305 meters. Of most importance to the soils on the island was the final phase of building of the island, when corralline limestone to a maximum thickness of 120 m. accumulated. The lowest layer consists of coral reef debris and algal and foraminiferal limestone while the higher strata are made up of massive coral with interstitial reef debris and coral sand. Several soils were viewed that had developed on this coral material. The soils were described as Associations although the descriptions correspond to series descriptions. Tentative placement of the soil associations into Soil Orders was made during the course of the tour. The first association examined was the Black Soil Association. This soil occurred on rolling topography at low elevations. The drainage of the

soil appears to be good. The soil is a black clay to the parent rock. $CaCO_3$ is present in small quantities throughout. The soil is likely a Mollisol and further is a Rendoll. Its properties are given in Table 13. The profile description follows:

Depth cm	Description (moist)
0-15	Black (N 2/0) clay; strong changing to moderate subangular blocky structure with depth; friable to firm with depth; sticky when wet; roots plentiful; fragments of marl up to 1.5 cm diameter common; gradual smooth boundary.
15-30	Black (N 2/0) compact clay; moderate medium subangular blocky structure; firm; sticky and plastic when wet; roots common; gradual smooth boundary.
30-60	Black (N 2/0) compact clay; structureless; firm, very sticky and plastic when wet; clear smooth boundary.
60-75	Gritty coral intermixed with grey (2.5YR 5/1) clay; structureless; transition to hard grey coral mass with wavy surface.

The St. George's Valley Association soil occurs on gently sloping topography at very low elevations. The Valley where this soil occurs was once occupied by a shallow arm of the sea where sediments were deposited on preformed coral. The internal drainage of this soil is restricted as evidenced by mottles at deeper depths in the profile. $CaCO_3$ occurs in this soil only in the surface layers. The soil is likely a Vertisol and the Suborder is an Udert. The properties of this soil are given in Table 14 and the profile description follows:

Depth cm	Description (moist)
0-15	Dark brown (7.5YR 3/2) clay; strong to moderate medium subangular blocky structure; common gravel to pebble-size pieces of limestone; very common roots; moderate cracking on exposure; gradual smooth boundary.
15-30	Dark brown (7.5YR 3/2) compact clay; weak medium subangular blocky structure; sticky when wet; few roots; gradual smooth boundary.
30-61	Brown (7.5YR 4/4) compact clay; very weak massive blocky structure; few diffuse brownish yellow (10YR 6/8) mottles; gradual smooth boundary.

TABLE 13: Particle-size and chemical analyses:- Black Soil Association

Depth (cm)	Particle-size analyses				pH	$CaCO_3$	m.e. per 100gm. Oven dry soil						C	N	C/N
	CsSand 2-0.2mm %	F. Sand 0.2-0.05mm %	Silt 0.05 0.002mm %	Clay 0.002mm %		%	CEC	TEB	Ca	Mg	K	Na	%	%	
0-15	12	18	5	66	7.0	0	44.2	47.5	45.0	2.3	0.17	1.22	1.5	0.10	15.0
15-30	10	18	7	71	7.1	0.3	41.2	40.8	38.3	1.2	0.11	1.40	1.2	0.08	15.0
30-60	10	15	7	74	7.0	0.4	39.4	41.0	37.4	2.1	0.11	1.70	-	-	-
60-75	7	10	5	82	7.4	0.8	43.3	45.6	40.1	2.8	0.12	2.01	-	-	-

TABLE 14: Particle-size and chemical analyses:- St. George's Valley Soil Association

Depth (cm)	Particle-size analyses				pH	$CaCO_3$	m.e. per 100gm. Oven dry soil						C	N	C/N
	CsSand 2-0.2mm %	F. Sand 0.2-0.05mm %	Silt 0.05 0.002mm %	Clay 0.002mm %		%	CEC	TEB	Ca	Mg	K	Na	%	%	
0-15	5	10	12	73	7.7	7.5	36.2	39.3	42.8	4.7	0.14	3.86	1.3	0.12	10.8
15-30	6	10	12	75	8.1	8.8	34.6	39.5	46.3	5.2	0.12	3.62	1.3	0.11	11.8
30-60	6	12	12	71	7.9	8.0	35.6	36.6	45.7	4.9	0.12	3.69	-	-	-
60-90	1	3	8	93	7.8	0.9	36.9	38.1	38.4	4.3	0.12	3.34	-	-	-
90-120	0	4	7	90	7.5	0	36.8	38.5	38.3	4.5	0.13	3.43	-	-	-

Depth cm	
61-122	Brown (7.5YR 5/2) very compact structureless clay with few fine brownish yellow (10YR 6/8) mottles; cracks intensely on exposure and desiccation; sticky and plastic when wet; gradual smooth boundary.
122 +	Profile continues as brown (7.5YR 4/4) compact clay.

The Yellow Brown Association soil occurs at medium elevations on the island on rolling topography. The clay content of this soil is very high but the physical condition of the soil is very good. Drainage of this soil is generally good and water relations appear to be good. The soil is likely a Mollisol. The characteristics of this soil are given in Table 15. The profile description follows:

Depth cm	Description (moist)
0-15	Dark reddish brown (5YR 3/4) clay; strong medium crumb structure on surface changing to weak to moderate fine subangular blocky structure; friable; slightly sticky when wet; sparse cobble to gravel-size marl; roots common; gradual smooth boundary.
15-30	Dark reddish brown (5YR 3/4) clay; weak medium subangular blocky structure; friable to firm; slightly sticky when wet; pieces of marl rare; roots common; gradual smooth boundary.
30-46	Same, gradual change to
46-107	Yellowish red (5YR 5/8) clay; weak coarse blocky structure; friable; sticky and plastic when wet. At 105 cm profile ends abruptly with wavy surface hard blocky coral limestone.

The St. John Valley Association soil occurs at higher elevations on the island where the highest rainfall amounts occur. This soil is found on rolling topography and has restricted internal drainage as evidenced by mottling in the subsoil. This soil is probably an Inceptisol although it appeared to be the most highly weathered soil we observed on Barbados. It cannot be an Oxisol as it still contains some weatherable minerals in the profile even though it appears to have many of the characteristics of an

TABLE 15: Particle-size and chemical analyses:- Yellow Brown Association

Depth (cm)	Particle-size analyses				pH	$CaCO_3$	m.e. per 100gm. Oven dry soil						C	N	C/N
	CsSand 2-0.2mm %	F. Sand 0.2-0.05mm %	Silt 0.05 0.002mm %	Clay 0.002mm %		%	CEC	TEB	Ca	Mg	K	Na	%	%	
0-15	3	10	12	79	7.6	0.9	24.9	26.8	27.6	3.7	0.15	0.81	2.5	0.23	10.9
15-30	2	7	12	81	8.0	2.8	22.9	24.9	23.5	5.3	0.17	1.49	1.9	0.18	10.6
30-60	0	2	6	96	8.0	0.5	19.1	18.5	20.0	2.5	0.16	0.76	-	-	-
60-90	0	1	2	99	7.5	0.3	20.0	18.1	19.1	2.0	0.12	0.84	-	-	-

Oxisol. Its properties are given in Table 16. The profile description follows:

Depth cm	Description (moist)
0-15	Dark reddish-brown (5YR 3/4) clay; fine to medium moderate subangular blocky structure; friable common gravel-size pieces of marl; sugar-cane roots common; gradual smooth boundary.
15-30	Same, gradual smooth boundary.
30-46	Light grey (5YR 7/1) compact clay with diffuse faint reddish yellow (5YR 5/8) mottles; firm; weak to moderate fine subangular blocky structure; very few roots; gradual smooth boundary.
46-61	Light grey (5YR 7/1) compact clay with common distinct red (10YR 4/8) and few faint reddish yellow (YR 6/8) mottles; weak thin to medium platy structure; firm; slightly sticky when wet; no roots seen; discontinuous clay coatings present.
61-122	Same, with common faint reddish-yellow (5YR 6/8) mottles ending abruptly on hard limestone with wavy surface.

The clay fraction of the soils developed on coral in Barbados are dominated by mixtures of montmorillonite and kaolinite (Table 17). These soils shrink and swell upon wetting and drying, some of them sufficiently to be Vertisols. The soils at the higher elevation and in the higher rainfall regions are more weathered as evidenced by their greater kaolinite content and decreased montmorillonite content. Even so, however, the base status of all of these soils is high and the fertility status of all the soils appears high.

Sugar-cane is the dominant crop grown on the island. Of the 70,000 acres of cultivated land about 60,000 is in sugar-cane. Food crops are grown mainly by small holders, although by law 12 percent of area of plantations must be planted to food crops. Vegetables of various kinds were grown successfully at many places on the island. Sugar-cane was well managed and yields were high; 50 to 70 tons per acre were obtained at the best locations.

TABLE 16: Particle-size and chemical analyses:- St. John's Association

Depth (cm)	Particle-size analyses				pH	$CaCO_3$	m. e. per 100gm. Oven dry soil						C	N	C/N
	CsSand 2-0.2mm %	F. Sand 0.2-0.05mm %	Silt 0.05 0.002mm %	Clay 0.002mm %		%	CEC	TEB	Ca	Mg	K	Na	%	%	
0-15	3	7	10	79	7.3	1.3	23.8	29.7	30.5	3.3	0.28	1.24	2.1	0.21	10.0
15-30	3	7	8	83	7.9	1.6	20.8	26.0	23.7	3.7	0.15	1.08	1.7	0.16	10.6
30-60	1	10	8	83	7.7	0.3	14.5	13.3	16.5	0.7	0.15	0.57	-	-	-
60-90	1	4	8	90	7.7	Tr	16.7	18.0	19.3	3.0	0.09	0.35	-	-	-
90-150	1	4	6	91	7.1	Tr	17.3	18.4	19.5	2.9	0.09	0.46	-	-	-

TABLE 17. Clay mineralogy of surface horizons

Soil Association	Amorphous SiO_2	Amorphous Al_2O_3	Kaolinite	Montmorillonite	Fe_2O_3
	%		%	%	%
Black Soil	15	5.8	29	48	2.26
St. George's Valley	4.2	2.8	42	48	3.25
Yellow Brown	9.9	5.8	43	30	11.09
St. John's Valley	9.8	4.1	58	20	7.51

The best sugar-cane I have seen in the Caribbean area was at some of the sites we visited in Barbados. In general the agriculture of Barbados was impressive.

Soils of the Scotland District: The soils of the Scotland District are quite unlike those of the coral region of Barbados. Much of the area consists of steep irregular surfaces highly subject to erosion. Some of the areas contain oil bearing materials and the concentration of sodium salts is relatively high. The oil and salt are widely distributed in the clay and sand strata. Landslips in the area result from spring water which lubricates slip planes between pervious and underlying impervious strata. The slip planes are often deep and trees, crops, houses, and roads are frequently destroyed.

The Joes River Mud soil is found on steep, often eroded slopes. The soil has restricted internal drainage. The Joes River muds range from dark grey sandy and argillaceous silts, to silty and sandy clays, and fragments and boulders of dark brown to black tar sand. The formation is impregnated with oil. This soil is likely an Inceptisol. Some characteristics of the soil are given in Table 18. The profile description follows:

Depth cm	Description
0-15	Very dark grey-brown (2.5Y 3/2, moist); sandy clay loam; weak to moderate fine to medium subangular blocky structure; friable, slightly plastic, slightly sticky consistence; gradual, slightly wavy boundary to:
15-45	Dark grey-brown (2.5Y 4/2, moist), mottled with olive brown; sandy clay; moderate medium subangular blocky structure; firm, slightly plastic, slightly sticky consistence; diffuse, slightly wavy boundary to:
45-102	Dark grey brown (2.5Y 4/2, moist), with varying colours due to weathering rock fragments; stony sandy clay; structureless; very firm, slightly sticky, slightly plastic consistence.

The Scotland Sandstone soil is formed from soft, friable sandstone. It consists of a vari-colored banded and laminated sandstone and siltstone sequence

TABLE 18: Routine chemical and physical analysis of soil: Joes River Mud Soil

Depth (ins)	pH	% Free $CaCO_3$	Elec. cond. mho x 10^{-6}	m.e. per 100gm. Oven dry soil							% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P_2O_5
				C.E.C.	T.E.B.	Ca	Mg	K	Na	H		C	N		
0-5	5.8	0.0	97	18.5	22.5	20.1	2.4	0.75	0.53		100	2.1	0.17	12.4	-
7-12	7.0	0.0	129	20.5	22.5	22.6	4.1	0.57	0.45		"	2.0	0.16	12.5	-
13-18	6.7	0.0	83	17.8	20.1	17.7	5.1	0.32	0.31		"	2.4	0.11	21.8	-
25-30	7.7	0.0	244	17.4	26.2	20.7	8.8	0.24	1.02		"	1.6	0.08	20.0	-

with a grey silty claystone. These are occasional beds and lenses of calcaceous sandstone and sandy limestone. The soil profiles are shallow and poorly structured; drainage is usually good. Texture is highly variable due to the graded nature of the beds. This soil is probably an Inceptisol. Some characteristics of one example of this soil are given in Table 19. The profile description follows:

Depth cm	Description
0-10	Brown (10YR 5/3, moist); fine sandy loam; weak to moderate fine angular blocky structure; friable, very slightly sticky, non-plastic consistence; gradual, smooth boundary to:
10-45	Brown (10YR 5/3, moist); fine sandy loam; moderate to strong medium and coarse angular blocky structure; firm non-plastic, non-sticky consistence; clear, slightly wavy boundary to:
At 45	An intimate mixture of horizon II material with powdery fragments of weathering white sandstone.

There are other materials found in the Scotland district leading to a great diversity of soils in a small area. Most of them are of oceanic origin. Both of the soils described contain montmorillonite, illite, and kaolinite in the clay fraction. Usually montmorillonite is the dominant clay mineral in these soils and approachs 50 percent of the clay fraction. The physical problem of land slippage is the most serious of the area.

Installation of subterranean drainage to remove spring water has been used to reduce land slippage. Maintenance of vegetation cover would seem to be essential to prevent erosion on these steep surfaces. Some land reforming is being used to prevent further slippage and erosion, also. Since the population density on Barbados is among the highest in the world, reclamation even though expensive, may be necessary.

Cropping appeared to be confined to food crops on small holdings. Some of the land was grazed and overgrazing contributed to some of the erosion problems. On some of the better soils of the Scotland region sugar-cane was

TABLE 19: Routine chemical and physical analysis of soil: Scotland Sandstones Soil

Depth (ins)	pH	% Free $CaCO_3$	Elec. cond. mho x 10^{-6}	m.e. per 100gm. Oven dry soil							% Base Sat.	% Oven dry soil		C/N Ratio	p.p.m. P_2O_5
				C.E.C.	T.E.B.	Ca	Mg	K	Na	H		C	N		
0-5	7.3	0.0	166	14.7	32.9	32.9	1.5	0.32	0.44		100	1.3	0.14	9.3	-
8-13	7.4	0.0	193	10.9	36.0	15.6	3.5	0.16	0.35		"	1.0	0.21	4.8	-
20-25	7.5	0.0	263	12.1	16.3	36.6	2.5	0.30	0.30		"	0.3	0.11	2.7	-

grown. Yields were high and the crop was as well managed in this region as in other parts of the island.

Soils of Grenada and St. Vincent

Both the Islands of Grenada and St. Vincent are of volcanic origin. Most of the materials from which the soils are derived are ash deposits of varying ages from fairly old to the most recent major erruption of the Soufriere in 1902 and a minor erruption in 1972. Rainfall also varies so that on the leeward side of the islands marked dry seasons occur reducing the rate of weathering of the materials. As a consequence of the different ages of materials and climatic variations a wide range of soils that have developed on volcanic ash are found.

Soils of Grenada: The Belmont clay is derived from basic andesitic agglomerate It is found on long gentle slopes and the soil is moderately to well drained. Notable is the extremely high content of exchangeable Mg found in the soil. This soil is likely an Inceptisol. Some of its properties are given in Table 20 and the profile description follows:

Depth (cm)	Description
6 - 40	Dark grayish-brown (10YR 3/2); sandy clay loam; fine moderate sub-angular blocky structure; friable consistency; roots plentiful, evidence of earthworms.
40 - 90	Dark brown (7.5YR 3/2) sandy clay loam; fine weak sub-angular blocky structure; friable consistency; fewer roots.
90 - 170	Reddish brown loam; very fine weak angular blocky structure; very friable.
170 - 180	Same as last horizon but with dark stains and nodules.

The Capital Clay derived from andesite is a deep highly weathered residual soil which has been developed on the oldest rocks and wettest areas in Grenada. The topography is generally steep or hilly and the drainage is good. The soil had excellent physical condition. It is likely an Oxisol.

TABLE 20: Particle size distribution and chemical properties - Belmont Clay

Idn. No.	Depth (cm)	pH	Mechanical Analysis % Oven dry soil				m.e. per 100gm Oven dry soil					% Base	% Oven dry soil		C/N	p.p.m.
			Crse. Sand	Fine Sand	Silt	Clay	C.E.C.	Ca	Mg	K	Na	Sat.	C	N	Ratio	P
97	0-40	6.7	15	16	15	52	39.14	14.04	25.56	1.56	0.51		1.64	0.16		8
99	40-90	6.7	16	17	13	51	31.43	11.39	22.80	2.56	0.60		1.28	0.14		6
98	90-170	6.9	17	16	15	50	35.43	14.47	24.84	2.94	0.58		0.44	0.07		4
100	170-180	6.5	20	21	13	44	24.86	12.12	19.83	1.86	0.99		0.30	0.05		3

Some of the properties of the Capital Clay are given in Table 21. The profile description follows:

Depth (cm)		Description
10	10 - 30	Reddish-brown (5YR 4/3) clay; very friable; strong large crumb structure; many living and rotting roots; gradual smooth boundary.
11	30 - 45	Reddish-brown (5YR 4/4) clay; very friable; weak large crumb structure; many roots; gradual smooth boundary.
12	45 - 90	Yellowish red (5YR 4/6) clay; very friable; weak medium sub-angular blocky; structure; fewer roots than above; gradual smooth boundary.
13	90 - 120	Yellowish red (5YR 4/6) clay; friable moderate medium sub-angular blocky structure; very few roots; clear smooth boundary.
14	120 - 150	Yellowish red (5YR 4/6) clay with very few very fine white rock fragments; less friable than above; moderate medium sub-angular blocky structure; very few roots; clear smooth boundary.
15	150 - 240	Yellowish red (5YR 4/6) clay with very few very fine white rock fragments; firm; weak medium sub-angular blocky structure. Profile continues below road grade and is perhaps 80 ft. (27 m) deep.

The most extensive soil of Grenada, the Woburn Clay Loam, is formed on cemented predominantly fine-grained ash. It is found on the leeward side of the island under a low rainfall. The soil is found on gentle slopes and has moderate drainage. Although this soil cracks upon drying it is likely an Inceptisol since it appears to be too shallow for a Vertisol. Some of its properties are given in Table 22. The profile description follows:

Depth (cm)	Description
0 - 10	Very dark greyish brown (10YR 3/2) clay; coarse strong sub-angular blocky structure; consistency hard when dry but plastic when wet.
10 - 32	Very dark greyish brown (10YR 3/2) clay; coarse sub-angular blocky structure; consistency of dry soil hard; wet soil firm.

TABLE 21: Particle-size distribution and chemical properties - Capitol Clay

Depth (cm)	pH	Mechanical Analysis % Oven dry soil				m.e. per 100gm. Oven dry soil						% Base	% Oven dry soil		C/N	p.p.m.
		Crse Sand	Fine Sand	Silt	Clay	C.E.C.	T.E.B.	Ca	Mg	K	Na	Sat.	C	N	Ratio	P
0-30	-	4	9	32	54	21.2	21.1	18.3	2.3	0.32	0.17	100	5.3	0.33	16.1	5
30-45	-	2	7	26	68	14.3	6.8	5.8	0.7	0.13	0.15	48	4.2	0.27	15.6	6
45-90	5.7	1	8	16	75	9.5	1.8	1.5	0.2	0.06	0.17	20	1.4	0.11	12.7	8
90-120	5.4	1	7	20	73	8.8	1.8	1.1	0.2	0.03	0.27	18	-	-	-	7
120-150	-	0	7	15	79	18.2	1.0	0.3	0.4	0.09	0.20	5	-	-	-	4
150-240	5.0	1	10	26	65	16.5	1.8	0.8	0.6	0.09	0.35	11	-	-	-	8

TABLE 22: Some Properties of Woburn Clay

Sample Depth cm	Sand			pH	O.M. %	N %	C/N ratio	Available P_2O_5+ p.p.m	Available K_2O* p.p.m	C.E.C. m.e./100gm
	V.C. %	Med. %	Fine %							
0-10	0	12	18	6.7	2.6	0.16	9.5	25	241	33.7
10-32	0	12	15	7.0	1.1	0.09	6.9	19	120	42.9
32-42	1	11	17	6.7	0.8	0.06	7.6	20	-	33.5
42-50	1	10	19	8.3	-	-	-	23	-	27.5
Below 50	6	6	23	8.2	-	-	-	29	-	40.9

+ Truog's method

* Extractable by 0.2N acetic acid

Depth (cm)	Description
32 - 42	Dark brown (10YR 3/3) clay; medium strong angular blocky structure; hard consistency.
42 - 50	Dark brown (10YR 4/3) sandy clay loam; medium moderate angular blocky structure; hard consistency.
50 +	Dark brown (10YR 4/3) fine cemented ash.

The Perseverence Clay is formed on basic andesitic ash on the drier and leeward side of the island. The topography is moderately sloping and the permeability is moderate on the surface and slow at deeper depths. The soil is fairly compact and cracks upon drying. This soil is undoubtedly a Vertisol. Some of its properties are given in Table 23 and the profile description follows:

Depth (cm)	Description
0 - 15	Dark grey (10YR 4/1) clay; coarse moderate sub-angular blocky structure; firm consistency.
15 - 32	Transition.
32 - 50	Greyish brown (10YR 5/2) clay; very coarse weak angular blocky structure; sticky when wet; firm when dry; many rusty and black mottles, some small stones and black shot.
50 - 65	Olive (5Y 5/3) clay; very coarse weak angular blocky structure; plastic when wet but firm when dry.
65 +	Dark greyish brown (10YR 4/2) clay; massive weak angular blocky structure; plastic when wet, firm when dry.

While no data were available on the mineralogy of these soils it is apparent from the physical properties and the cation exchange capacity of the soils from the leeward side of the island, montmorillonite was the dominant clay mineral in these soils. The cation exchange capacity of the Capital clay was obviously much lower than the other three soils and was likely dominated by kaolinite thus qualifying the soil as an Oxisol.

TABLE 23: Some Properties of Perseverance Clay

Sample Depth cm.	Sand V.C. %	Sand Med. %	Sand Fine %	pH	O.M. %	N %	C/N ratio	Available P_2O_5* p.p.m.	Available K_2O+ p.p.m.	C.E.C. m.e./100gm
0-15	0	6	15	6.1	3.5	0.20	10.1	5	145	38.6
15-32	0	3	10	6.6	1.8	0.12	8.3	8	145	39.8
32-50	0	8	8	6.8	0.6	0.06	6.0	6	-	42.3
50-65	0	3	8	6.8	-	-	-	5	-	27.2
Below 65+	2	7	9	7.4	-	-	-	15	-	44.0

* Truog's method

\+ Extractable by 0.2N acetic acid

On both the Woburn and Perseverence soils food crops grown by small holders were the major crops grown. Sugar-cane apparently was being tried in some areas although we did not see any. Excellent crops of bananas were being grown on the Capital and Belmont soils. Nutmeg was also an important crop grown largely on the Capital soil. Food crops were being grown rather generally on the Capital and Belmont soils. The Capital soil, an Oxisol, appeared to be a highly productive soil. It responded to management and was being used fairly intensively to grow bananas and nutmeg. Agriculture on other parts of the Island appeared to be only modestly developed.

Soils of St. Vincent: Soil formation in St. Vincent shows a wide range of desilication and re-silication phenomona as influenced by texture of the materials and the rainfall. The large scale pedogenesis is influenced by two factors; the wide spread occurrence of earth movements, and the frequent eruptions of the volcano Soufriere. Progressing from the coast toward the mountain backbone, the proportion of stable landsurfaces decreases, seasonal drying of the soil decreases, and the clay minerals appear more amorphous and of lower SiO_2/R_2O_3 ratios. Progressing northward on the island toward Soufriere the depth of ash increases from about 3 m on most stable surfaces to more than 30 m which overlies lava deposits of much lower permeability and much greater age (probably Pliocene or Lower Pleistocene).

Two examples of soils from St. Vincent will be given. The first of these is a recent ash covered landsurface. This soil is found on sloping landscape and some land slipping is evident. This area is subject to seasonal drying. There evidently is a buried horizon, "Bsg", that contains montmorillonite as the dominant clay mineral. Slippage appears to occur at the interface between this horizon and those above. This soil appeared to be an

Inceptisol although this is a very tentative decision. Some properties of this soil are given in Table 24, and a profile description follows:

Horizon	Depth	Description
1. A	0- 17 cm	Clay to silty clay with some relatively unaltered sand grains, (10YR 3/2), pH 6.9. V. small red mottles show clear boundaries and vertical alineations: concretions present, black and fairly hard, but crushable between nails. Transition clear to abrupt.
2. A-B	17- 34 cm	Clayey sa. with grit, (10YR 4/3); pH 7.2. Structure v. weak prismatic, breaking easily to small crumbs. Structure interiors show lighter colours, and small, diffused reddish mottles also present. Grit fragments show black streaks (MnO_2) along plane of weakness within interiors - weathering ununiform and immature, as fragments are still fairly hard. Vertical channels fairly common, many infilled - roots very common. Layer of stones in transition (abrupt), 15 cm diameter, fairly rounded.
3. $(B)_{\underline{sg}}$	34- 62 cm	Clay, (2.5Y 5/3) with alineated gleying around the few vertic roots of (Green) 4/1, pH 7.2. Structure unobservable, but horizontal ⟶ slope-inclined large slickensides (15x5 cm) show v. clearly. Uniformly v. moist, but seepage not visible. Some vertical streaks indicating weak structuring of origin other than from slope movements. Transition abrupt.
4. B	62- 84 cm	Comparable horizon to 2. (10Y 4.5/3) with black mottles, pH 7.4. Roots common, but rooting colonisation poor: Notably less moist and more porous than Hor. 3 above. Transition abrupt.
5. $(B)_{\underline{sg}}$	84-130+	Clay with some fairly angular sa. grains. (2.5Y 5/3) with blue-green root-centred mottling as in 3. pH 7.2. Structure similar to Hor. 3, but v. clearly cuneate: 2 mm diam. black concretions present. Roots still present. Stones very common.

The second soil described is one derived from the pyroclast material resulting from the 1902 eruption of the Soufriere Volcano. The flatter coastal lands near the Soufriere Volcano often show the full sequence of the 1902 pyroclast deposits overlying the Pre-1902 soil surface. This is

TABLE 24: Some chemical properties for soil creep system with montmorillonitic clay horizon.

Horizon	Depth (cm)	pH	m.e. per 100g Oven dry soil					% Oven dry soil		p.p.m. P
			C.E.C.	Ca	Mg	K	Na	C	N	
1. A	0 - 17	6.6	15.6	10.0	7.3	0.56	0.32	1.68	0.22	6
2. A - B	17 - 34	6.7	17.1	10.0	7.5	0.12	0.40	0.32	0.07	10
3. (B)sg	34 - 62	6.7	27.7	17.1	18.3	0.08	0.65	0.28	0.09	4
4. B_3	62 - 84	6.6	18.2	10.8	8.1	0.04	0.47	0.18	0.06	14
5. (B_3)sg	84 - 130+	Not available.								

evident where the second horizon shows layers of uniformly-sized fine-textured ash, indurated by pedogenic processes to a very high degree. The higher C and N values for the fourth and fifth horizons reflect the buried pre-1902 horizons. Presumably this soil might be classed as an Entisol. Some properties of this soil are given in Table 25 and the profile description follows:

Horizon	Depth	Description
1.	0- 22 cm	Loamy sand-v. gritty loam; (10YR 3/2). Cinder layer prominent at base of horizon-transition abrupt.
2.	22- 42 cm	Series of stratified, consolidated fine ash deposits: i) half-cemented, fine sand, greyish colour with pronounced orange mottling in the form of streaks. ii) dark grey sand. iii) orange-grey sand-again mottled. iv) light grey sand.
3.	42- 50 cm	Dark grey sand, banding fine, continuous + horizontal-consistency friable.
4.	50- 94 cm	Coarse-silt-showing interstratification-thin lens formation. Notable absense of roots. Charcoaled twigs buried in some layers in middle of horizon-orientation is diagonal. Slightly indurated layers observed at 55cm and (less indurated) at 65cm.
5.	94- 114 cm	Sandy (clay) loam; (10YR 3.5/2.5). Consistency v. friable. Notably moist and containing many roots.
6.	115- 132 cm	Extremely stony layer-stones are angular and of highly vesicular (almost pumice) material.
7.	132- 146 cm	Loamy sand, very stony, including small lenses of fine bedded material showing induration.

The mineralogy of these soils has not been thoroughly studied. Montmorillonite, however, appears to be involved in the land slippage which is fairly general on steep slopes throughout the island. Undoubtedly allophanic materials occur in many of the soils. Halloysite was found to be a con-

TABLE 25: Some chemical properties for the soil derived from 1902 - 3 pyroclast material.

Horizon	Depth	pH	m.e. per 100g Oven dry soil					% Oven dry soil		p.p.m. P
			C.E.C.	Ca	Mg	K	Na	C	N	
1.	0 - 22	6.2	7.4	4.0	1.3	0.18	0.10	2.52	0.21	53
2.	22 - 42	6.8	5.7	5.2	1.5	0.19	0.18	0.12	0.06	120
3.	42 - 50									
4.	50 - 94	6.3	7.0	3.5	0.8	0.04	0.24	2.32	0.21	7
5.	94 - 114	6.3	7.6	5.0	1.5	0.06	0.19	3.40	0.33	17
6.	114 - 132	-	-	-	-	-	-	-	-	-
7.	132 - 146	6.7	3.3	2.5	0.8	0.22	0.15	0.08	0.05	33

stituent of several of the soils found on the island.

A general impression that the soils of St. Vincent were highly productive was gained. The physical problems of variable erosion on steep slopes and land slippage were major problems. Many of these volcanic ash materials were very high in extractable phosphorus. Food crops were quite generally grown. Bananas appeared to be highly productive throughout the Island. Arrowroot was grown in a few areas.

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