(7) The soils of the Caribbean Region have been classified mainly according to the kind of parent material, although topography has also been considered as equally or even more important in some instances.

For example, in the classification schemes suggested by Hardy and Croucher for Jamaica and by Charter for British Honduras, the soils of hilly lands are differentiated from those of flat lands. Furthermore, in the schemes suggested by Charter and by Chenery for Trinidad, and by Charter for British Honduras, parent material and topography are combined, in-as-much as they may determine the *degree of drainage*, thus facilitating subdivision into soils developed under free, partially impeded and fully impeded drainage.

(8) An attempt has been made to co-ordinate some of the soil suites differentiated by the British investigators with World soil groups, distinguished by American workers,as represented in Puerto Rico. Most of these World groups seem to occur within the areas surveyed, though their sub-division into Zonal, Intrazonal and Azonal categories does not perhaps sufficiently stress the importance of parent rock and topography which appear to be the predominant factors in soil formation within the Caribbean Region.

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II.—SOIL CLASSIFICATION

SOIL CLASSIFICATION IN THE CARIBBEAN REGION (A REVIEW)

by

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Introductory

Several soil investigations that have specifically involved attempts to classify tropical soils have been carried out in the Caribbean Region by American and British investigators during the past twenty years. The more important publications describing these investigations are listed at the end of this article, but only those articles in which soil classification receives special consideration are mentioned.

Summary of Literature

(A) American Soil Surveys

(1) Soils of Cuba : 1928 (H. H. Bennett and R. V. Allison)

The greater part (four-fifths) of Cuba (area, 43,000 square miles) consists of rolling plains, mainly below 600 feet elevation, having annual rainfall around 50 inches, with marked wet and dry seasons. The underlying rocks are chiefly limestones and marls (Miocene to Pliocene) through which igneous intrusions have been thrust.

Altogether, 106 soil series were identified by Bennett and Allison, according to the features of the soil profile as a whole, except texture which is used for subdividing series into soil types. Colour is stressed "as an indicator of what has taken place in the process of soil development" and is given prominent position in the key for combining the soil series into ten easily recognizable groups, each of which is subdivided according to the nature of the parent rock and then according to the consistency of the parent material (weathered rock), whether "friable" or "stiff". Soil series are arranged into thirteen families "based on a few of the most outstanding properties of the types", chiefly "structure or consistence of the component material", but not necessarily on colour.

It is evident from Bennett and Allison's profile descriptions that the particular soil-forming factor which they chiefly stress as being mainly responsible for the differentiation of the soils of Cuba is parent material, whose features are decided not only by the nature of the parent rock, but by the conditions under which the rock has altered. In many cases, the parent rock consists largely of sediments comprising weathering products that have been transported, as calcareous and siliceous alluvium or detritus,

considerable distances from their original sources. It differs but little from the parent material of the soil proper. Bennett and Allison's series descriptions include detailed lithological notes whereby these materials may be identified. No attempt was made to relate the soils of Cuba to World Groups, but the preponderance of soils derived from limestones, marls and calcareous concretions, called "coco", is stressed. A special chapter describing the Marbut system of soil classification in vogue in the United States at this period (1928) is contributed by its author, although not systematically applied to the soils of Cuba.

(2) Soils of St. Croix : 1932 (J. Thorp)

Nearly one-half of this small island (area, 82 square miles) is hilly and comprises steeply dipping stratified tuffs, shales and volcanic intrusions of Cretaceous age, against which have been deposited thin beds of Oligocene limestones and marls. The rainfall ranges from 20 to 50 inches and is fairly uniformly distributed throughout the year. Nineteen soil series were identified and mapped by Thorp. They include 20 soil types and 5 phases, and are associated into four soil groups, namely, (i) rendzina (7 soil types, 3 phases), (ii) lithosol of the hills, (2 soil types, 2 phases), (iii) mature soils overlying alluvial deposits (9 soil types), most of which resemble solonets, and (iv) undifferentiated sea-coast soils (2 soil types). It is evident that the kinds of parent materials have mainly decided the types of soil that have developed in St. Croix under a relatively dry climate, although topography has been involved in the main sub-division of the soils into flat-land and hilly-land representatives.

(3) Soils of Puerto Rico : 1942 (R. C. Roberts)

The soil survey carried out in Puerto Rico during 1929-1936 yielded 123 soil series and 352 soil types which were classified according to the latest American system, due to M. Baldwin, C. E. Kellogg and J. Thorp*, based on an earlier system devised by C. F. Marbut, outlined in *Soils and Men* (1938 Yearbook of Agriculture, published by U.S. Department of Agriculture).

Puerto Rico (area, 3,400 square miles) is about one-thirteenth of the size of Cuba, though geologically the two are somewhat similar, except that calcareous rocks are much less abundant in Puerto Rico. Their topography is different, however, in that most of Puerto Rico consists of a dissected plateau, 3,000 feet elevation, within which basement tuffs, shales and igneous rocks are exposed, the lower-lying limestone country being confined to a wide coastal plain in the north and a narrow one in the south.

The mean annual rainfall ranges from over 160 to 80 inches in the mountains, and from 80 to 60 in the interior valleys. It lies between 75 and 50 inches in the north coastal area, and is less than 50 inches only in the south coastal plain where the annual rainfall often lies below 35 inches. The rainy period extends from May to November, but the remaining five months are definitely dry only in the south coastal area, the rest of the island showing no marked dry season.

The Puerto Rico soil classification is shown in the following table, in which the total numbers of soil series representing each soil group are given, as well as the approximate area (expressed both in square miles and in percentages of the total area) occupied by each. The limiting mean annual rainfalls under which the different soil groups have developed, and the kind of natural vegetation associated with each, are also indicated.

* A somewhat broader but essentially similar scheme, designed to cover tropical soils in all parts of the world, was suggested in 1940 by J. Thorp and M. Baldwin (*Ann. Assoc. Amer. Geog.*, 1940, 30, pp. 165-194).

logical system which has the same suites and series as the scheme set out above, though differently grouped. As far as the writer is aware, a description of this morphological system has not yet been published by Charter.

Relationships : Charter does not attempt to correlate any of his sub-groups or fascs with World soil groups. His soil series are about equally divided between those developed over calcareous rocks and those developed over non-calcareous rocks. The former appear mostly to belong to the Rendzina group (26 series), although a few (6 series) would be classed as Terra Rossa, being red in colour. The non-calcareous soil series are mostly developed over river alluvium (13 series) or over swamp deposits (7 series) ; these would probably be classed on the Puerto Rico system mainly as Groundwater Laterite and some perhaps as true living Alluvial Soils. Upland residual soils, developed over igneous and sedimentary rocks (11 series), would be classed as Yellow and Red Podzolic. These comprise the Zonal soils of British Honduras.

Summary and Conclusions

(1) This review brings together the various systems of tropical soil classification that have been elaborated and applied by different soil investigators, both American and British, in the Caribbean Region during the past twenty years.

(2) The islands for which relevant data are available are Cuba, Jamaica, Puerto Rico, Trinidad, Antigua (with Barbuda), and St. Croix. Mainland areas are represented by British Honduras.

(3) The *climate* of most of the areas surveyed has been regarded as constant thus comprising an invariable factor in soil formation.

Exceptions to this rule are Puerto Rico for which climatic subdivision has been made into arid, semi-arid, sub-humid, humid and wet climates, and Jamaica, subdivided into regions of low rainfall (under 40 inches) and regions of medium and high rainfall (over 40 inches). The climate of Cuba, in spite of the large size of the island, is uniform and relatively dry*.

(4) The *parent rocks* of the areas surveyed mainly comprise sediments ranging in age in the islands from Cretaceous (or earlier) to Recent. Rocks of Devonian age are exposed in British Honduras. The older sediments have been variably metamorphosed into gneisses, schists, quartzites and slates. Intrusions of igneous rocks, mainly acid types, are associated with them. The later sediments (Oligocene, Miocene) are mostly calcareous, and include a wide range of foraminiferal and shelly limestones, marls and shales. Coastal and estuarine alluvial deposits and terrestral detrital accumulations are widespread. Pleistocene swamp and lagoon deposits are prevalent over the plains.

(5) The *topography* varies from mountainous or hilly to rolling, undulating and flat ; from steep to level ; from rough to smooth, and from elevated to depressed. The most productive lands mainly occupy the coastal plains.

(6) The original *vegetation* ranged from Montane Rain Forest and Evergreen Seasonal Forest in the wettest areas to Deciduous and Dry Evergreen Forests in the plains. Swamp and Marsh communities, including halophytes, occupied the low-lying flats. Most of the original vegetation has been destroyed during the agricultural exploitation. Abandoned cultivations are occupied by second growths.

* Hispaniola (comprising the Republics of Haiti and Dominica) has not here been considered ; its climate is perhaps the most varied of all the Caribbean islands.

A soil survey of the area north of the central mountains was carried out in British Honduras by C. F. Charter in 1940. The system of soil classification used was a further elaboration of that which he used for classifying the soils of the sugar-cane lands of Trinidad. Its main features are summarized in the following table.

SOILS OF BRITISH HONDURAS (C. F. Charter)

DIVISION I: SOILS OF THE FLATLANDS

GROUP I: PERMEABLE PARENT MATERIALS (maximum downward leaching)

SUB-GROUP I A:	LOW LIME STATUS	
FASC 1:	Drainage free	(4 suites)
FASC 2:	Drainage seasonally impeded	(2 suites)
FASC 3:	Drainage perennially impeded	(2 suites)
SUB-GROUP I B:	HIGH LIME STATUS	
FASC 1:	Drainage free	(2 suites)
FASC 2:	Drainage seasonally impeded	(2 suites)
FASC 3:	Drainage perennially impeded	(1 suite)

GROUP II: IMPERMEABLE PARENT MATERIALS (minimum leaching)

SUB-GROUP II A:	LOW LIME STATUS	
FASC 1:	Drainage (external) poor or absent	(3 suites)
FASC 2:	Drainage (external) fair or good	(2 suites)
SUB-GROUP II B:	HIGH LIME STATUS	
FASC 1:	Drainage (external) poor or absent	(3 suites)
FASC 2:	Drainage (external) fair or good	(2 suites)

DIVISION II: SOILS OF THE UPLANDS

GROUP I: PERMEABLE PARENT MATERIALS

SUB-GROUP I A:	LOW LIME STATUS	
FASC 1:	Drainage free	(1 suite)
SUB-GROUP I B:	HIGH LIME STATUS	
FASC 1:	Drainage free	(4 suites)

GROUP II: IMPERMEABLE PARENT MATERIALS

SUB-GROUP II A:	HIGH LIME STATUS	
FASC 1:	Drainage (external) good	(2 suites)
SUB-GROUP II B:	HIGH LIME STATUS	
FASC 1:	Drainage (external) good	(?)

Note: Each suite is further subdivided into soil series, varying in number from one to eight. Altogether some 66 soil series were identified.

Charter's system of soil classification "is constructed so that the soils of British Honduras fit into a comprehensive scheme designed to accommodate all the soils of the Caribbean region". Chief consideration is given in this scheme to topography and permeability of the soil parent material, in-so-far as these determine drainage. The drainage suites are finally subdivided into soil series bearing place names and differentiated according to the features of the soil profile which here is taken to include "not only the solum but the upper part of the crust of weathering."

Amendment: It should especially be noted that Charter had intended to style this system an *agricultural* classification*. He has stated that he had worked out a morpho-

* Private communication to the writer, dated 24th November, 1941.

SOILS OF PUERTO RICO: (R. C. Roberts)

Soil Group	No. of soil series	Area occupied by soil series (sq. mi.)	Percent of total area (%)	Mean annual rainfall (in.)	Associated vegetation
(I) ZONAL SOILS					
(A) Arid to semi-arid to sub-humid (rainfall 20 to 35 to 60 in.)					
1. Red Desert	2	11	0.3	20	Scrub
2. Reddish-brown	1	45	1 3	25	Grasses and shrubs
3 Reddish-chestnut ...	4	35	1.0	35	Grasses and shrubs
4 Chernozem	5	61	1.8	45	Grasses and shrubs
5. Reddish Prairie	11	104	3.1	60	Tall grass
	23	256	7.5		
(B) Humid to wet (rainfall 60 to 110 to 160 in.)					
6. Gray-brown Podzolic ...	12	261	7.7	65	Coniferous to broad-leaved forest
7. Red and yellow Podzolic	8	233	6.9	75	Coniferous to broad-leaved forest
8. Reddish-brown Lateritic	11	624	18.4	90	Tropical rain forest
9. Yellowish-brown Lateritic	3	57	1.7	80	Tropical rain forest
10. Laterite soils	1	5	1.0	110	Tropical rain forest
	35	1180	35.7		
(II) INTRAZONAL SOILS					
(A) Halomorphic (rainfall below 40 in.)					
11. Solonchak	2	23	0.6	25-35	Halophytes
12. Solonets	1	6	0.2		Halophytes
	3	29	0.8		
(B) Hydromorphic (rainfall 60 to 70 in.)					
13. Wiesenboden (meadow) ...	4	43	1.4		Grasses, sedge
14. Bog	3	35	1.1	60-70	Grasses, sedge
15. Half Bog	4	10	0 3		Swamp forest
16 Planosol	4	65	2.0		Grass savanna
17 Ground-water Podzol ...	2	14	0.5	—	Swamp forest
18. ,, ,, Laterite	2	36	0.4		Swamp forest
	19	203	5.7		
(C) Calomorphic (rainfall 30 to 85 in.)					
19. Rendzina	6	308	9.1	75-95	Grass or forest

Soil Group	No. of soil series	Area occupied by soil series (sq. mi.)	Percent of total area (%)	Mean annual rainfall (in.)	Associated vegetation
(III) Azonal Soils					
20. Lithosol	11	1113	32.7	25-100	—
21. Alluvial	17	266	7.8	30-80	—
22. Dry sands	9	47	1.4		—
	37	1426	41.9		
Grand total	123	3402			

Soil correlations : A marked correlation occurs in Puerto Rico between soil series and rainfall. Soils that have developed under rainfalls less than 35 inches are reddish-brown in colour, and those that have formed under rainfalls between 35 to 60 inches are black. Under higher rainfalls, the colour is greyish-brown with a bleached layer below (podzolic), though it is mainly red (lateritic) where dry periods recur. Under the highest rainfalls (over 110 inches), however, the colour is usually grey.

A correlation also exists between reaction and rainfall. Where the rainfall is below 40 inches, the soils are strongly alkaline (pH 8.0) and contain free sodium carbonate. Where it lies between 40 and 50 inches, they are alkaline to neutral, and free lime occurs in the subsoil. Where it lies between 50 and 60 inches, the surface soil is neutral to slightly acid, but the subsoil is still alkaline. Where the rainfall is above 60 inches, both topsoil and subsoil are acid.

Distribution of chief soil groups in Puerto Rico : The most widely distributed soil group is Lithosol, which occupies nearly one-third of the whole island. This indicates the extent to which soil erosion has gone on, for the Lithosol mainly occupies sloping ground that has been cleared of its original vegetation. The next widely-distributed soil group is Reddish-brown Lateritic Soil which covers nearly one-fifth of the area, and the next, Rendzina (derived from soft calcareous rocks) which occupies one-tenth of the land surface.

(B) British Soil Surveys

(1) Soils of Jamaica : 1932 (F. Hardy and H. H. Croucher)

A brief visit was made by the writer to Jamaica in August, 1932, for the purpose of collecting profile soil samples at sites which had been selected by H. H. Croucher within typical areas growing banana and sugar cane. Some 466 soil samples, taken from 53 pits, were subsequently examined in the laboratory by selected methods which have been regularly used at the College in investigations of agricultural soils in the British Caribbean islands.*

Geologically, Jamaica (area, 4,450 square miles) resembles Puerto Rico. It is one-and-a-third times as large. A basement of igneous and metamorphic rocks, associated

* Studies in West Indian Soils : (I) Montserrat ; (II) Dominica ; (III) Tobago ; (IV) Grenada ; (V) Antigua; (VI) Jamaica ; (VII) Trinidad (Montserrat District) ; (VIII) St. Vincent ; (IX) British Honduras ; (X) Trinidad ; (South-Central District). *In the Press* : (XI) Montserrat ; (XII) St. Lucia ; (XIII) St. Kitts-Nevis. *In preparation* : (XIV) Dominica. F. Hardy, G. Rodrigues, *et al.* I.C.T.A., Trinidad, 1922-1948.

(II) Drainage Partially Impeded :

(a) Temporary water table high in wet season ; permanent water table at about 10 feet.
(b) Permanent water table at about 4 feet, due to low relief and permeable topsoil.
(c) Temporary water table on surface in wet season ; no permanent water table, but easy lateral flow of water.
(d) No temporary water table, but probably permanent water table at about 18 feet.
(e) Slowly permeable parent material.

(III) Drainage Impeded :

(a) Impervious topsoil on slopes ; no water table.
(b) Impervious topsoil ; temporary water table due to slow runoff.
(c) Perennial water table near surface.

The importance of *external* (in contrast to internal) drainage is also stressed as a factor in soil classification. This depends solely on the degree of surface slope and the absence of obstruction to the surface flow of water.

In this report on the Northern Basin soils, Chenery first differentiates between (1) soils developed on young alluvial flats having (a) low flood plains, (b) high flood plains, (c) higher flood plains ; (2) soils developed on old alluvial flats (terraces, fans, aprons) and (3) soils developed on older alluvial flats. In each class the soil types developed under free, partially impeded and impeded drainage are separately described and named.

In a later report (December, 1945) on the soils of Caroni Sugar Estate, Chenery employed this method of specifying soil drainage for classifying soil types developed over alluvial deposits which originally comprised swamps and lagoons in the western part of the Northern Basin of Trinidad. It was similarly used in still later reports (December, 1946, and December, 1947) describing the soils of the mid-western part of the Northern Basin and of Woodford Lodge Sugar Estate contiguous on the south with Caroni Estate.

(4) Soils of British Honduras : 1940 (C. F. Charter)

British Honduras (area, 8,870 square miles) forms part of the south-eastern peninsular of Mexico and is situated on the western coast-line of the Caribbean Sea. The rocks of the central mountains consist of Upper Carboniferous slates, schists, quartzites and sandstones with intruded igneous rocks, mainly granodiorite. The rocks of the south-eastern hills (Toledo District) comprise clays, sandstones and limestones, and those of the northern plain, extending far into Yucatan, solely comprise Oligocene to Pliocene limestones and marls. Extensive areas of river and coastal alluvia, derived from the non-calcareous rocks, cover the northern plain and the coastal belt.

The annual rainfall ranges from over 100 inches in the mountains to 50 inches or less in the west and north parts of the plains. A well-marked dry season of three to five months' duration occurs over most of the country. The natural vegetation is mainly Evergreen Seasonal Forest with Deciduous Forest in the drier limestone country in the north. Montane Rain Forest occupies the high lands and Swamp and Marsh communities occur over the lowland flats.

(II) DRAINAGE PARTIALLY IMPEDED : Loams, marly clays and sandy clays. Medium permeability through compaction, restricted perviousness of parent material or depressed topography. Intermittently high water table.

(A) *Calcareous parent materials* (3 soil types)
(B) *Non-calcareous parent materials* (5 soil types)

(III) DRAINAGE IMPEDED : Stiff clays. Low permeability through compaction, restricted perviousness of top-soil or depressed topography.

(1) *No true water-table*
(A) *Calcareous parent materials* (2 soil types)
(B) *Non-calcareous parent materials* (3 soil types)
(2) *Perennially high water table,* due to low relief (2 soil types)

Soil type here coincides with soil series, since all the series so far identified contain only one textural type. Twenty-three soil types were differentiated and provisionally named in this report.

Relationships : The free-draining soils (Division (I)) should include the Zonal soils of the area. They occur mainly in the mountainous and hilly country of the Northern, Central and Southern Ranges of Trinidad. The first mountain mass chiefly comprises Jurassic to Cretaceous quartz-mica schists together with slightly metamorphosed sandstones and limestones giving red and yellow soils which would be classed as Red and Yellow Podzolic in the Puerto Rico system. The second consists chiefly of clay-stones, limestones and glauconitic sandstones which give rise to free-draining soils resembling Terra Rossa (Red Podzolic). The third is made up of soft sandstones which produce low-grade soils which would be classed as Yellow Podzolic or Lithosols.

The partially impeded- and fully impeded-draining soils (Divisions (II) and (III)) include Rendzina as well as acid clays having impervious clayey parent materials. These occupy the whole of the dissected peneplains that form the northern and southern basins of Trinidad. They comprise reticulately mottled red or yellow-brown soils that would be classed on the Puerto Rico system as Red or Yellow Podzolic. Also included in these drainage groups are certain alluvial clays, loams and sands. According to age and degree of flatness, Grey-brown and Yellow Podzolic or true Hydromorphic soils (*Wiesenböden*) have developed. These three kinds of soil are widely distributed and make up the greater part of the agricultural lands. Ground-water Podzols and Planosols occur in the older parts of the Northern Range detrital foothill plain and Half Bog and Bog Soils occur in low-lying swamps.

Recent soil surveys in Trinidad : 1941-1947 (E. M. Chenery)

Apart from the general description of the major soil types and their tentative classification summarized above, various unpublished detailed reports have recently been issued by E. M. Chenery in which his scheme of classification is further elaborated. Thus, in a report (dated December, 1941) dealing specifically with the soils of the eastern part of the Northern Basin of Trinidad (area, 120 square miles) that overlie alluvial and detrital materials of differing geological age, Chenery states categorically that "the most significant factor in the development of soils and vegetation appears to be drainage". He further elaborates the various kinds of internal drainage thus :—

(1) DRAINAGE FREE :
(a) Water table above 10 feet.
(b) Deep water table, below 10 feet.

with younger (Eocene) rocks (tuffs, conglomerates and limestones), forms the interior mountain core which rises to 7,000 feet. This is surrounded by a plateau, 3,000 feet elevation, composed of Oligocene limestones, covering three-quarters of the total surface. The limestone apron has subsided in various places, through solution, forming large interior basins and valleys whose floors are covered with residual deposits over which have developed impeded-draining soils resembling the Ground-water Podzols of Puerto Rico. Around the coastline, detrital terraces and marine alluvial flats abound, and the banks of the larger rivers and estuaries are occupied by alluvia and peat swamps.

The climate of Jamaica resembles that of Puerto Rico. The annual rainfall ranges from over 100 inches in the mountains to 30 inches or less in the southern coastal plain. Over most of the limestone plateau, it varies from 95 to 55 inches. There are two fairly distinct rainy periods, namely, May to June and September to November, and a relatively dry season in December to April, except in the rainiest mountainous regions where it is continuously wet.

In the Jamaica report, an attempt was made to classify the soils by a scheme involving (1) kind of parent rock, (2) magnitude of the prevailing rainfall, (3) topography and (4) texture, thus :—

SOILS OF JAMAICA (F. Hardy and H. H. Croucher).

(A) SOILS DERIVED FROM CALCAREOUS ROCKS
(I) *Regions of Low Rainfall* (less than 40 inches per annum)
(a) *Flat Land*
(i) Sand type (Reddish-brown soils)
(ii) Clayey type (Black soils)
(b) *Hilly Land*
(i) Sandy type None
(ii) Clayey type (Brownish-black soils)
(iii) Loamy type (Bright red soils)
(II) *Regions of Medium and High Rainfall* (more than 40 inches per annum)
(a) *Flat Land*
(i) Sandy type (Greenish-brown soils)
(ii) Clayey type (Brownish-black soils)
(b) *Hilly Land*
(i) Sandy type (Greenish or brownish-black soils)
(ii) Clayey type Brownish-black or black soils)

(B) SOILS DERIVED FROM NON-CALCAREOUS ROCKS
(I) *Regions of Low Rainfall* (less than 40 inches per annum)
(a) *Flat Land*
(i) Sandy type (Purplish-brown soils)
(ii) Clayey type (Dark brownish-grey soils, crimson below)
(b) *Hilly Land* None
(II) *Regions of Medium and High Rainfall* (more than 40 inches per annum)
(a) *Flat Land*
(i) Sandy type (Brownish-black soils, tawny below)
(ii) Clayey type (Yellowish-black soils, white below)
(b) *Hilly Land*
(i) Sandy type (Brownish-red soils)

This scheme was designed tentatively to accommodate the soils actually examined. It may require modification when a greater range of soils has been investigated. Certain of the soils were identified with World groups, for example, Chestnut Earth, Chernozem, Solonchak and Solonets, occurring mainly among the low- and medium-rainfall flat-land soils, and Terra Rossa occurring among the high-rainfall hilly-land soils developed over hard limestones. Also, Rendzina was identified in soils derived from soft limestones and marls both in regions of high and of low rainfall.

(2) Soils of Antigua and Barbuda: 1936 (C. F. Charter)

Antigua is a small island (area, 108 square miles) lying 270 miles east of Puerto Rico. Geologically it resembles Puerto Rico, Jamaica and St. Croix in that there is an exposed Cretaceous basement series of tuffs, shales and igneous rocks (the last forming hilly country) flanked by low hills composed of Oligocene limestones and marls. The main parent rocks from which the soils are derived are Pleistocene superficial deposits, mostly comprising calcareous swamp and lagoon clays that overlie the tuffs of the Central Plain.

Barbuda is situated 25 miles north of Antigua. It is entirely composed of Pleistocene coral limestone.

The climate of Antigua and Barbuda is distinctly dry; the average rainfall is 44 inches, fairly evenly distributed, though two-thirds of the total amount falls during the second half of the year. It is highest (50 inches) in the volcanic hills and lowest (35 inches) in the east.

The soil survey was carried out by C. F. Charter in 1936 who based his classification on the American system, as modified by G. W. Robinson. Altogether, 24 soil series were identified and roughly mapped in Antigua and 4 in Barbuda. They are grouped into 5 suites (having similar parent materials) in Antigua and one suite in Barbuda. *Relationships*: Variations in climate over the area were thought not to be sufficient to account for the observed soil differences. The main factor on which the soil series are differentiated is soil parent material. The soils developed over lagoon clays show impeded drainage; the name "Vlei" has been suggested by Robinson for such soils. The soils developed over marls are classed as Rendzina. Those developed over volcanic tuffs and agglomerates under a rainfall of 35 inches are classed as Chestnut Earth, and those developed over hard limestone in Barbuda as Terra Rossa, being red in colour.

(3) Soils of Trinidad: 1939-1947 (C. F. Charter; E. M. Chenery)

(i) *System of C. F. Charter*: 1939

The sugar-cane lands of Trinidad were surveyed by C. F. Charter in 1938. These lands occupy the flat low-lying western part of the Northern Plain and the reclaimed part of the Caroni Swamp comprising marine, lagoon and swamp alluvia lying to the west of it (100 square miles), together with the area farmed by the Ste. Madeleine Sugar Company which occupies the western part of the undulating Naparima District south of the Central Range (80 square miles) made up of Miocene sediments. The climate is wet to humid, the annual rainfall ranging from 80 inches in the east to 50 inches in the west. There is a well-defined dry season, having one or two dry months in the east and up to 4 or 5 in the west. Generally about three times as much rain falls in a wet-season month as in a dry.

The system of classification employed by Charter in his soil survey of the sugar-cane lands of Trinidad is similar to that which he used in Antigua. Altogether, 25 soil series were identified and grouped into 6 suites and these into three fascs having similar drainage features, though not necessarily derived from the same or similar parent materials. The classification scheme may be summarized thus :—

Soils of Trinidad Sugar Estates (C. F. Charter)

Fasc I: Soils Having Free Drainage

Suite (1) :—	Red and Reddish-brown loams and sandy-loams developed over sandy sediments	(3 soil series)

Fasc II: Soils Having Seasonally Impeded Drainage With Seasonally High Water Table

Suite (1) :—	Dark grey soils over swamp clays	(3 soil series)
Suite (2) :—	Brown or brownish-grey soils over recent river alluvium	(5 soil series)
Suite (3) :—	Brown or brownish-grey soils over red or brown-mottled alluvial clays	(4 soil series)
Suite (4) :—	Greyish-brown soils over leached terrace sands over mottled alluvial clays	(4 soil series)
Suite (5) :—	Red to blackish-brown clays over sedimentary clay shales containing gypsum	(4 soil series)
Suite (6) :—	Black clays over marls	(2 soil series)

Fasc III: Undrained Soils With Perennially High Water Table

(No suites nor soil series have been differentiated for these swamp soils which are not yet in general cane production).

(*Note*: Suites (5) and (6) of Fasc (II) occur in the Naparima District only).

Relationships: Variations in climate over the area where these soils occur are considered to be insufficient to account for the differences between them.

The low-lying topography of the northern area and the imperviousness of the parent materials in the southern (Naparima) area are responsible for impeded drainage; consequently, drainage conditions are given chief prominence in this system of soil classification.

The majority of the soil series would be classed in the Puerto Rico system as Intrazonal-Hydromorphic (Bog, Half-Bog, Planosol (?), Ground-Water Podzol), although artificial drainage may be slowly changing them into the Zonal soils of the area, which should be Red and Yellow Podzolic or Reddish and Yellowish-brown Lateritic. Suite (6) of Fasc (II) is Rendzina (Intrazonal-Calcimorphic), and Suite (I) of Fasc (I) approximates to the Zonal soil for the area.

(ii) *System of E. M. Chenery*: 1939

A provisional classification of the soils of Trinidad, not including sugar-cane soils, was formulated in 1939 by E. M. Chenery as a result of preliminary reconnaissance surveys carried out in cacao and forest lands occupying the east, central, south and south-west of the Island. Here the climate is wetter and more continuously rainy than that of the sugar-cane areas surveyed by Charter. The annual rainfall ranges from 110 to 60 inches, although there may be a weak or marked dry season of one to three months' duration in the more westerly parts of the area. Chief prominence is given in Chenery's system, as in Charter's, to drainage. The scheme is :—

Soils of Trinidad (E. M. Chenery)

(I)	Drainage Free: Sands, loams, friable silts and some clays. High permeability. Very low water table.	
(A)	*Calcareous parent materials*	(3 soil types)
(B)	*Non-calcareous parent materials*	(5 soil types)