Genesis of Limestone Profiles in the Tropics

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Introduction

Tobago is one of the West Indian islands in the equatorial region of the Caribbean archipelago. It is located at 11° 15′ North latitude, 60° 40′ West longitude which places it near the Southern tip of the Antillean arc, 20 miles North East of Trinidad. Its small area, climate, and geology are typical of many of the West Indian islands. The author believes that many similar soils exist throughout the West Indies and hopes that this study may be of some assistance to soil scientists in the Caribbean. It has an area of 116 square miles, average annual rainfall is 79 inches in the section studied. Maxwell (4) describes its geology as volcanic, igneous and coraliferous.

The present paper is a study of shallow and deep profiles found on coral in Tobago. The author has received much assistance from G. C. Witt, the Soil Chemist of Tobago, and his staff, and Professor Joe L. White of Purdue University. The author is particularly grateful to the National Science Foundation for the use of the X-ray diffractometer at Purdue University.

Morphological Descriptions

These soils have never been mapped. They have been given names, by convention, of the locations where they were first described, and legends according to the Soil Survey Manual of the U. S. D. A. (5). Thus symbol C_1 would represent the first soil described on coral in the mapping unit, and the missing C_2 is a peat which has been omitted in this paper.

Mechanically Decomposed Coral

Pigeon Point Sand

$$\frac{5 \cos C_1}{\text{A:1}} = \frac{\text{deep, coarse sand on coral}}{0 - 3\% \text{ slope: no erosion hazard.}}$$

0–5″ —Greyish brown coarse sand
5–60″ —Greyish brown coarse sand, no horizon differentiation.

Shallow Soils on Coral

Crown Point Clay

$$\frac{2cC_3}{\text{A:1}} = \frac{\text{Shallow clay on coral}}{0 - 3\% \text{ slope: no erosion hazard.}}$$

0–5″ —Friable brownish red clay.
5–6″ —Friable brownish red clay.
6″ —Coral: large masses of coral come to the surface, and brownish red soil is found in cylindrical pipes and fissures in the limestone.

Milford Clay (shallow).

$$\frac{2cC_4}{\text{A:1}} = \frac{\text{Shallow clay on coral}}{0 - 3\% \text{ slope: no erosion hazard.}}$$

0–5″ —Friable dark olive brown clay.
5–6″ —Moderate yellowish brown and olive clay.
6″ —Coral: large masses of coral come to the surface and olive brown soil is found in cylindrical pipes and fissures in the limestone.

Deep Soils in Coral

Shirvan Clay Loam

$$\frac{\text{5 sclc } C_5}{\text{A:1}} = \frac{\text{deep, sandy clay loam on clay on coral}}{\text{0 — 3\% slope : no erosion hazard}}$$

0–2″ —Brown clay loam.
2–14″ —Yellowish brown speckled gray clay.
14–28″—Yellow olive finely mottled reddish brown and speckled yellowish brown clay.
27–53″—Moderate olive clay with large red mottlings.
53″—Yellow brown speckled black silty clay loam with white calcareous concretions.

Friendship Sandy Clay Loam

$$\frac{\text{5 fscl } C_6}{\text{A:1}} = \frac{\text{deep, fine sandy clay loam on coral}}{\text{0 — 3\% slope : no erosion hazard}}$$

0–6″ —Olive black sandy clay loam.
6–12″ —Olive brown sandy clay loam with small black spherical concretions.
12–30″—Yellow brown clay loam with small black spherical concretions.
30–48″—Olive gray and yellow brown clay loam with small black spherical concretions.

Hydromorphic Soil on Coral

Buccoo Clay

$$\frac{5cC_4}{\text{A:1}} = \frac{\text{deep clay on coral}}{\text{0 — 3\% slope; no erosion hazard}}$$

0–6″ —Friable olive gray and brownish gray clay.
6–18″ —Pale olive and yellowish brown clay.
18–30″—Yellowish brown and pale olive clay with small black spherical concretions.
30–36″—Medium gray, yellow brown, mottled brown clay.
36–50″—Olive gray, bluish gray clay with yellow brown and reddish streaks.

Pigeon Point Sand occurs along the island foreshore—it is a coral beach sand with a fluctuating water table changing with tide, but the soil surface is normally above the high water mark. Immediately landwards of Pigeon Point Sand is Crown Point Clay, then comes the Shallow Milford Clay. This increases in depth reaching a maximum solum of 50 inches as one gets further inland, then changes almost suddenly into Shirvan Clay Loam near the volcanic foothills to the North and East. There is only one site of Friendship Sandy Loam and it is located in an area, where geomorphologically it represents a raised beach. Buccoo is the

depressional soil developed under hydromorphic conditions and is found near the foreshore. It is totally inundated for long periods during the rainy season.

Analytical Methods

All the methods used have been described by Chenery[1] except that for X-ray analysis. $<2\mu$ clay fraction was separated by centrifugation as outlined by Jackson[4]. Clay samples were oriented on glass slides solvated with glycol and patterns were obtained from a General Electric XRD-5D1 X-ray diffractometer using CuKα radiation.

Physical, Chemical and X-ray Diffraction Data.

Depth Inches	pH	Sand %	Silt %	Clay %	K_2O p.p.m.	17.7Å Relative Intensities*	7.25Å Relative Intensities*	3.04Å Relative Intensities*	Nature of 7.2Å peak
Pigeon Point Sand									
0-6	8.6	89	6	6	85	——	——	0.5	——
6-36	8.8	90	4	6	80	——	——	0.5	——
36-48	9.0	88	5	7	85	0.5	——	0.5	——
Crown Point Clay									
0-5	8.2	26	7	65	239	——	2.5	——	Sharp
5-6	8.4	14	9	75	407	——	2.0	——	Sharp
Coral	8.3	79	14	3	129	——	0.8	2.2	——
Milford Clay									
0-5	7.6	26	16	53	407	——	4.2	——	Sharp
5-6	8.1	20	7	72	369	——	2.5	——	Sharp
Coral	8.5	92	1	5	118	——	0.8	2.2	——
Shirvan Clay Loam									
0-2	6.3	34	21	39	117	0.8	1.9	——	Sharp
2-14	4.8	24	7	68	201	1.0	1.4	——	Broad
14-27	4.3	18	9	70	137	1.5	1.8	——	Broad
27-53	4.3	19	13	65	148	3.2	6.0	——	Sharp
53	8.3	21	32	38	64	12.8	3.6	——	Broad
Friendship Sandy Clay Loam									
0-6	7.4	59	6	30	171	1.0	5.0	——	Sharp
6-12	8.0	62	8	26	85	1.0	3.1	——	Broad
12-30	9.1	46	9	44	106	8.8	7.5	——	Sharp
30-48	8.9	47	8	43	80	8.4	7.0	——	Sharp
Buccoo Clay									
0-18	7.4	21	19	52	105	14.8	2.6	——	Broad
18-30	6.5	18	17	63	221	16.0	3.0	——	Broad
30-50	7.2	19	21	55	236	13.6	2.5	——	Broad

* Peak height in inches.

Discussion

The results fit the following postulate.

1. The shallow soils have been formed from volcanic ash deposited on coral. Hardy (2) has stated that on 16th Oct. 1902 nearly 4 tons of volcanic ash per acre, and on 22nd March 1903 nearly 3½ tons of volcanic ash per acre fell on nearby Barbados from eruptions in St. Vincent and Martinique.

2. The deep soils have received, from the nearby hills, volcanic detritus on which volcanic ash was later deposited. These deeper profiles represent soils developed from two different types of volcanic material. The analytical data support this view e.g. the marked difference at 53″ in the Shirvan, and 30 inches in the Friendship soils. This also explains the similarities between the physical and chemical data of the top and bottom horizons of the Shirvan since detritus is still being deposited on the surface.

3. The end product of weathering is kaolinite except in the hydromorphic soil where montmorillonite predominates. All the surface horizons of the well drained soils have sharp well defined 7.25Å peaks, so that the appearance of similar peaks within the profile suggests a previous A horizon. Such peaks occur at 27-53″ in the Shirvan, 12-30″, in the Friendship. Also in support of the postulate is the absence of a 3-04Å peak in any of the sola studied.

Conclusion

None of the soils found on coral are genetically related to the underlying coral. The shallow soils are entirely of volcanic ash origin. The deeper ones have been influenced by volcanic ash and volcanic detritus.

Detritus is even now being deposited on the surface of the deeper soils. The end product of weathering is kaolinite while montmorillonite accumulates in the poorly drained soils. There is present in some horizons a mineral with maximum spread of spacing 7.13Å to 7.62Å which suggests a low hydration variety of halloysite. This mineral is associated with poor internal drainage. Similar conditions should exist throughout the West Indies where the red soils on coral may not be Terra Rossas, nor the dark ones Rendzinas although there are great similarities. An interesting side observation from the study is that the coconut palm will not tolerate high concentrations of montmorillonite.

Literature Cited

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