CLAY MINERALOGY OF FIFTEEN PHILIPPINE SOIL PROFILES

by

JEFREN L. DEMETERIO

B.S.A., University of the Philippines, 1961

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1968

Approved by:

Roscoe Ellis Jr.

Major Professor

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INTRODUCTION

The greatest single factor which may profoundly influence the attributes of a soil is its clay mineralogical make-up. The role of clay minerals in the physico-chemical properties of soils, such as pH, cation and anion exchange capacities, buffering capacity, nutrient fixation, plasticity, swelling and shrinking, permeability, particle density, and tilth, has been established thoroughly by various workers (Grim, 1953; Kelly, 1948; and Bear, 1964).

A knowledge of the clay mineralogy of a given soil is therefore warranted if an effective assessment of its use capabilities is to be made.

With the advent of such refined analytical techniques as X-ray diffraction, differential thermal analysis, electron diffraction, electron microscopy and neutron diffraction, the study of the clay mineralogy of soils has been boosted greatly. Brindley (1961) stated that among the many methods of studying clay minerals, the X-ray method is the most widely used for identification and is of paramount importance for studying crystalline characteristics. The basic principle underlying the identification of materials by X-ray diffraction is that each crystalline substance has its own characteristic pattern. The recognition of the pattern establishes uniquely the diffracting substance.

In spite of the many techniques developed in identifying the clay make-up of soils, it is regrettable to note that a dearth in this line of research exists in the soil chemistry and mineralogy of Philippine soils. The Philippines being an agricultural country depends much on the fertility and effective management of its soils. To this effect a knowledge of the clay mineral content of the soil could go a long way towards betterment of crop yields.

Among the few works done on the clay mineralogy of Philippine soils are those of Galvez (1957) and Briones (1964). Galvez made a study of the mineral content of four soils representing four Philippine soil types. X-ray diffraction patterns he obtained indicated that Lipa clay loam, Guadalupe clay and Baao clay showed all broad basal spacing in the 18 Å region strongly indicating the presence of minerals dominantly montmorillonite interstratified with illite-vermiculite and intergradational vermiculite-chlorite phosphorus ferro-allophane-like materials. Feldspar and cristobalite were also present. He also found that Guimbalaon clay is dominantly halloysite mixed with some montmorillonite.

Briones found that the clay fraction of some Laguna soils was dominantly montmorillonite.

This present work makes use of soils from the island of Negros which is divided into two provinces--Negros Oriental and Negros Occidental--where sugarcane is extensively grown. Sugar ranks foremost in the export products of the Philippines and it is one of the few agricultural industries having a relatively high degree of mechanization. Sugarcane is grown in two regions of the Philippines: in Central Luzon, where it is grown in a few provinces; and in Western Visayas, where it is extensively cultivated. The province of Negros Occidental is devoted almost entirely to production of sugar cane and is the heart of the sugar industry of the Philippines.

The clay mineralogy of fifteen soil profile samples from the two provinces of Negros was studied using X-ray diffraction techniques.

Work was begun on November, 1964, upon receipt of the soil samples and finished on February, 1966, using the soil chemistry laboratory and dark room of the Department of Agronomy, Kansas State University, at Manhattan, Kansas.

MATERIALS AND METHODS

Materials

Fifteen soil profile samples were provided by the Philippine Sugar Institute at Bacolod City, Philippines. Twelve of the samples were taken from the province of Negros Occidental and three from the adjoining province of Negros Oriental. The soil types obtained from the latter province belong to soil series found in Negros Occidental.

The depths of the soil profiles are shown in Table 1. A general description of the island of Negros and the soil types studied (Alicante _et al_., 1951) are given in the Appendix.

Table 1. Horizon depths of the different soil profile samples.

Soil types	Horizons	Depth (Inches)
1. Soils of the flat lowlands		
(a) Silay clay	A	0-8
	B	8-20
	C	20-29
(b) Silay fine sandy loam	A	0-9
	B	9-33
	C_1	33-48
	C_2	48-60
(c) San Manuel loam	A	0-13
	B	13-29
	C_1	29-43
	C_2	43-62
(d) San Manuel loam*	A	0-11
	B	11-40
	C_1	40-73
	C_2	73-88
(e) Isabela clay*	A	0-14
	B	14-29
	C_1	29-41
	C_2	41-50
2. Soils of the rolling uplands		
(A) Soils derived from sedimentary materials		
(a) Bago loam	A	0-5
	B	5-29
	C_1	29-39
	C_2	39-55
(b) Bolinao clay	A	0-13
	B	13-55
	C	55-63
(c) Faraon clay	A	0-5
	B	5-14
	C_1	14-21
	C_2	21-53
	C_3	53-79

Table 1. (Concluded)

Soil types	Horizons	Depth (Inches)
(B) Soils derived from igneous materials		
(a) Guimbalaon clay	A	0-4
	B	4-13
	C_1	13-49
	C_2	49-79
(b) Guimbalaon loam	A	0-9
	B	9-28
	C_1	28-43
	C_2	43-59
(c) Manapla loam	A	0-12
	B	12-28
	C_1	28-41
	C_2	41-61
(d) Tupi fine sandy loam	A	0-13
	B	13-44
	C_1	44-60
	C_2	60-79
(e) La Castellana clay loam	A	0-5
	B	5-20
	C_1	20-47
	C_2	47-62
(f) La Castellana clay*	A	0-16
	B	16-43
	C_1	43-58
	C_2	58-91
3. Soils of the hills and mountains		
(a) Rough mountainous land	A	0-5
	B	5-43
	C_1	43-91
	C_2	91-98
	C_3	98-118

* Soil profile samples from Negros Oriental province; all the rest from Negros Occidental province.

Methods

The soil samples were air dried, ground in an agate mortar, and passed through a 2 mm. sieve.

Clay fractionation of each horizon was carried out, following procedures outlined by Jackson (1956). Random powder specimens prepared by drying a Ca-saturated glycerol-solvated sample from benzene were mounted and sealed in glass capillaries. A North American Philips X-ray diffraction unit, equipped with Straumanis-type diffraction cameras was used for the diffraction work. The X-ray source was an Fe-filtered cobalt target tube, $\lambda = 1.790$ Å. The resulting X-ray diffraction patterns were microphotometered on a Leeds and Northrup instrument.

RESULTS AND DISCUSSION

Soils of the Flat Lowlands

Silay clay

The d-spacings from the diffraction patterns for the different horizons and clay fractions of Silay clay are shown in Table 2. The data show the clay fractions were a mixture of a 2:1 and 1:1 clay types. The d-spacings ranged from 14.95 to 18.12 Å in all clay fractions and strongly suggested the presence of montmorillonite. The presence of montmorillonite accounted for the stickiness and plasticity of Silay clay when wet.

Table 2. X-ray diffraction powder data for Silay clay.

Horizon	Clay fraction*					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I**	d(Å)	I	d(Å)	I
A	17.99	s	17.68	vs	16.65	vvvw
	7.29	vvw	7.29	w	7.47	vvvw
	4.47	s	4.46	vs	4.46	vs
			3.56	s	3.58	vvvw
	4.04	s	2.58	vw	2.60	vvw
	3.48	w	2.49	vvvw	1.50	vvw
	3.24	w	2.33	vvw		
	2.98	w	1.70	vvvw		
	2.57	vw	1.49	w		
	2.49	vw	1.39	vvvw		
	1.49	vw	1.29	vvvw		
			1.24	vvvw		
			1.16	vvvw		
			1.10	vvvw		
B	17.44	s	15.83	vvw	14.95	s
	7.10	w	7.27	vw	7.52	w
	4.45	s	4.46	vs	4.46	vs
	4.04	s	3.57	w	3.59	vvw
	3.53	w	2.51	vvw	2.57	vw
	3.25	w	2.34	vvw	2.35	vvvw
	2.97	w	1.69	vvw	2.01	vvw
	2.58	w	1.49	s	1.68	vvvw
	2.48	vvw	1.42	vvw	1.48	vvw
	2.35	vvw	1.29	vvw		
	1.69	vvvw	1.24	vvw		
	1.49	w				
	1.29	vvvw				
	1.24	vvvw				
C	17.09	s	17.32	s	18.12	vvw
	7.19	vw	7.30	w	7.44	vvw
	4.46	s	4.45	vs	4.45	s
	4.06	s	3.56	s	3.58	vvw
	3.57	vvw	2.57	w	2.58	vvw
	3.26	vvw	2.50	vvvw	1.70	vvvw
	2.99	vvw	2.35	vvw	1.50	vvw
	2.57	vw	1.69	vvw		
	2.49	vvw	1.49	s		
	2.36	vvvw	1.39	vvvw		
	1.69	vvvw	1.29	vvvw		
	1.66	vvvw	1.24	vvvw		
	1.49	w	1.16	vvvw		
	1.28	vvvw	1.11	vvvw		
	1.25	vvvw				

Table 2. (Concluded)

*Clay fraction size ranges:
coarse clay, .2 - 2 microns
medium clay, .08 - .2 microns
fine clay, less than .08 microns

**Intensities of the diffraction lines relative to the lines in a single film where,

vs	- very strong
ms	- medium strong
s	- strong
w	- weak
vw	- very weak
vvw	- very, very weak
vvvw	- very, very, very weak (a trace of)
vvvvw	- very, very, very, very weak (a faint trace)

The 7 Å peaks, characteristic of 1:1 clays, ranged from 7.10 to 7.52 Å. At first examination one may attribute those peaks to kaolinite and/or metahalloysite. Marel (1950), working with clay separates, gave the first order reflection of kaolinite as a slightly broadened 7.5 Å and that of metahalloysite as a broad 7.3 to 7.6 Å reflection. The value cited for kaolinite (7.5 Å) deviated from the 7.15 Å peak of standard kaolinite powders. This discrepancy may have been due to a loss in crystallinity brought about by weathering. Marel noted that kaolinite from lateritic Sumatra soils gave such values. Kaolinite from soils which have undergone considerable weathering could be expected to have d-spacings as cited by Marel. Thus kaolinite, when occurring together with freshly crystallized metahalloysite may be mistaken for metahalloysite. A criterion which may be useful in distinguishing kaolinite from metahalloysite is that metahalloysite has a characteristic diffuse band around 2.6 to 2.3 Å, while kaolinite gives distinct 2.57 to 2.49 Å and 2.34 to 2.28 Å spacings. Using the preceding characteristics, the 1:1 clay mineral in Silay clay may be identified as kaolinite.

It was noted that the 7 Å spacings for Silay clay increased as clay particle size decreased. This could be attributed to a loss of crystallinity as particle size decreased.

The diffraction patterns for Silay clay did not show differences from horizon to horizon.

The coarse clay fractions also indicated the presence of cristobalite as evidenced by the strong 4.04 Å reflection and also feldspar (3.24 and 2.97 Å). The presence of cristobalite thought to be formed at 1470° C suggested a parent material of high temperature origin.

Silay Fine Sandy Loam

The random powder data for Silay fine sandy loam are shown in Table 3.

A predominance of metahalloysite was observed in all coarse and medium clay fractions.

A very, very weak band was noted in the coarse clay fraction of the C_2 horizon at 7.33 to 11.77 Å units. This suggested the presence of halloysite and metahalloysite. Only a single but very, very weak line was noted in the medium clay fraction at 4.44 Å units and none in the fine clay fraction of the C_2 horizon.

Montmorillonite lines were noted in the fine clay fraction of the A, B, and C_1 horizons.

Feldspar was noted in all coarse clay fractions. It was also observed in the medium clay fractions of the A and C_1 horizons.

Gibbsite and goethite were noted in the coarse clay fraction of the C_1 horizon.

Quartz gave a strong reflection in the coarse clay fraction of the C_2 horizon.

Table 3. X-ray diffraction powder data for Silay fine sandy loam.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	7.49	w	7.37	w	18.92	vvw
	4.54	vs	4.54	vs	4.35	s
	4.13	w	4.21	w	3.57	vvw
	2.62	vw	2.64	vw	3.32	vvw
	1.51	w	1.52	w		
B	7.51	s	7.61	vw	19.95	vw
	4.60	ms	4.49	w	4.44	s
	4.20	s	3.61	vvw	3.52	vvw
	3.31	w	2.62	vvw	2.58	vvw
	1.52	w				
C_1	16.59	vw	15.31	s	18.64	
	7.46	vvw	7.47	w	16.02	vs
	4.81	s	4.22	s	14.78	
	4.18	vw	3.65	w	5.88	s
	3.28	vvw	2.66	vw	3.52	vw
	2.66	vw	2.01	w	2.61	vw
	1.55	vvw	1.54	vw	1.52	w
C_2	11.77	vvw	none		none	
	7.33	vvw				
	4.58	ms				
	4.18	s				
	3.32	s				
	2.63	vw				
	1.53	vw				

*Refer to Table 2 for symbols.

San Manuel Loam

The random powder data for San Manuel loam are given in Table 4.

The data indicated a trend whereby the 1:1 type of clay was predominant in the upper horizons while the 2:1 clays were apparent in the lower horizons. The clay fractions of the A horizon were practically all kaolinite with some cristobalite in the coarse clay fraction. The same pattern was repeated in the B horizon except that a trace of montmorillonite was noted in the medium clay fraction.

The coarse clays of both C_1 and C_2 horizon were practically all kaolinite with a trace of montmorillonite in the C_2 fraction.

The data for the medium clays of the C_1 and C_2 horizon show they were a mixture of montmorillonite, halloysite and kaolinite. The fine clay fractions of these horizons were predominantly montmorillonite but also contained a trace of kaolinite.

Goethite lines of 4.16 and 4.17 Å were observed in the medium clay and coarse clay fractions of the C_1 and C_2 horizons, respectively. Goethite diffraction lines were noted in the upper horizons.

San Manuel Loam (Negros Oriental)

The random powder data for San Manuel loan (Negros Oriental) are shown in Table 5.

Table 4. X-ray diffraction powder data for San Manuel loam.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	7.27	s	7.29	s	7.49	vw
	4.46	s	4.45	vs	4.45	s
	4.07	vs	3.59	s	3.63	vw
	3.59	s	2.57	vvw	2.58	vvw
	3.16	vvvw	2.50	vvw	2.50	vvw
	2.87	vvvw	2.36	vvw	2.35	vvvw
	2.57	vvw	1.67	vvvw	1.67	vvvw
	2.50	vvw	1.49	vvw	1.49	vw
	2.35	vvw				
	1.68	vvw				
	1.50	vw				
B	7.30	vs	17.32	vw	7.34	w
	4.43	vs	7.25	s	4.44	vs
	3.61	s	4.45	s	3.57	w
	2.57	s	4.05	vs	2.56	vw
	2.50	w	3.61	s	2.49	vvw
	2.35	s	3.16	vvvw	2.35	vvw
	1.68	vw	2.88	vvvw	1.67	vvw
	1.49	s	2.57	vw	1.48	vw
	1.40	vvvw	2.50	vw	1.28	vvvw
	1.29	vvw	2.35	vvw	1.24	vvvw
	1.24	vvw	1.68	vvvw		
	1.17	vvw	1.63	vvvw		
	1.14	vvw	1.50	s		
	1.11	vvw	1.29	vvvw		
			1.24	vvvw		
C_1	7.23	w	19.87	vw	17.62	s
	4.46	s	11.40	vvvw	7.10	vvvw
	4.07	w	7.24	s	4.45	s
	3.63	w	4.45	vs	3.57	w
	3.23	w	4.16	vvw	2.56	vvw
	2.58	vvw	3.59	s	2.32	vvvw
	2.52	vvw	2.57	w	1.67	vvvw
	2.35	vvw	2.51	w	1.51	vvw
	1.50	w	2.35	vw	1.49	vvw
			1.99	vvvw	1.16	vvw
			1.69	vvvw	1.11	vvw
			1.49	s		

Table 4. (Concluded)

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
C_2	18.12	vvvw	18.64	w	18.64	s
	7.29	w	12.20	vvw	7.20	vvvw
	4.45	s	7.24	s	4.45	s
	4.17	vvvw	4.44	vs	3.60	vvw
	3.59	vvw	3.60	s	2.56	vvvw
	2.56	vvw	2.57	vvw	2.50	vvvw
	2.49	vvvw	2.40	vvw	2.35	vvvvw
	2.35	vvw	2.35	vvw	1.50	vvvw
	1.68	vvvw	1.68	vvw		
	1.49	vvw	1.49	w		
			1.39	vvvw		
			1.29	vvvw		
			1.24	vvvw		
			1.17	vvvw		

*Refer to Table 2 for symbols.

Table 5. X-ray diffraction powder data for San Manuel loam (Negros Oriental).

Horizon	Clay fractions					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	17.50	vs	17.56	vs	15.04	s
	4.51	w	9.02	vvw	4.47	s
	4.05	s	7.54	vvw	3.56	vvvw
	3.56	vvw	4.46	s	2.57	vvw
	2.59	vvw	3.57	w	1.68	vvvw
	2.49	vvw	2.58	vvw	1.50	vvw
	1.69	vvvw	2.36	vvvw		
	1.50	vvw	1.68	vvvw		
			1.49	vvvw		
			1.29	vvvw		
			1.16	vvvw		
			1.11	vvvw		
B	17.38	vs	17.68	vs	14.53	s
	8.89	vvw	8.93	vvw	4.46	vs
	6.52	vvw	7.55	vvw	3.60	vvvw
	4.47	s	4.45	vs	2.56	vvw
	4.05	s	3.57	w	1.67	vvvw
	3.55	vvw	2.57	w	1.49	vvw
	3.27	vvvw	2.33	vvvw		
	2.58	vvw	1.69	vvvw		
	2.36	vvvw	1.49	vvw		
	1.69	vvvw	1.29	vvvw		
	1.49	vvw	1.23	vvvw		
			1.17	vvvw		
C_1	17.44	vs	17.62	vs	17.50	vs
	8.79	w	8.69	vvw	9.12	vvw
	7.34	w	7.35	vvw	4.49	s
	4.46	s	4.45	s	3.55	vvw
	4.04	s	3.54	w	2.59	vvw
	3.56	w	2.59	vw	2.01	vvvw
	3.56	w	2.59	vw	2.01	vvvw
	3.23	vvvw	2.39	vvvw	1.68	vvvw
	3.00	vvvw	1.68	vvvw	1.50	vvvw
	2.58	vvw	1.52	vvvw	1.17	vvvw
	2.52	vvw	1.49	vvvw		
	2.38	vvvw				
	1.69	vvvw				
	1.50	vvw				

Table 5. (Concluded)

Horizon	Clay fractions					
	Coarse clay		Medium clay		Fine clay	
C_2	16.59	s	17.74	vs	15.08	vs
	8.87	vvw	9.02	w	4.49	s
	7.49	vvw	7.59	vvw	3.58	vvw
	4.47	s	4.49	s	2.61	vw
	4.05	s	3.54	vvw	1.52	vvw
	3.53	w	2.56	w		
	2.58	vw	1.99	vvw		
	2.50	vw	1.68	vvw		
	2.37	vvvw	1.51	vvw		
	1.69	vvvw				
	1.50	vvw				
	1.44	vvw				

*Refer to Table 2 for symbols.

Predominance of montmorillonite was suggested by the presence of strong to very strong reflections in all clay fractions of all horizons. These data drastically deviated from that of San Manuel loam (Negros Occidental) wherein the upper two horizons were practically all kaolinite.

Very weak kaolinite lines were observed in some clay fractions in all horizons. Kaolinite was apparent in the medium clay fractions of the upper two horizons and inexplicably none in the coarse clay. The coarse and medium clay fractions of the two lower horizons showed the presence of kaolinite.

A very, very weak 6.52 Å reflection was noted in the coarse clay fraction of the B horizon. This probably indicated the presence of attapulgite.

The mineral cristobalite was present in all coarse clay fractions as indicated by the 4.04 - 4.05 Å reflection.

It is interesting to note that the same soil type (San Manuel loam) located in two different provinces actually differs in clay mineralogical make-up.

Isabela Clay (Negros Oriental)

The random powder data for Isabela clay are given in Table 6. The dominant clay mineral in this soil appeared to be montmorillonite as indicated by strong montmorillonite line in all clay fractions of all horizons. Ordinarily montmorillonite lines were observed only in the fine and medium clay fraction. The presence of montmorillonite in

Table 6. X-ray diffraction powder data for Isabela clay.

Horizon	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	16.98	vs	17.03	vs	16.38	s
	8.87	vvw	8.73	w	4.47	w
	7.27	vvw	7.35	w	3.52	vvvw
	4.49	s	4.47	s	2.55	vvw
	4.06	w	3.55	vw	1.49	vvw
	3.61	vvw	2.59	w		
	3.24	vvw	2.37	vvvw		
	2.57	w	1.70	vvvw		
	2.50	vvw	1.50	vvw		
	1.95	w	1.29	vvvw		
	1.70	vvvw	1.13	vvvw		
	1.51	vvw				
B	17.21	vs	16.33	vs	13.94	vs
	8.96	vvw	8.91	w	4.47	s
	7.40	vvw	7.43	w	3.56	vw
	4.48	s	4.48	s	2.57	vw
	4.04	vvw	3.57	vvvvw	1.70	vvvw
	3.51	vvw	2.57	vw	1.50	vvw
	2.57	vw	2.52	vw		
	1.96	vvw	2.37	vvw		
	1.50	vvw	1.69	vvvw		
			1.40	vvvw		
			1.30	vvvw		
			1.17	vvw		
			1.15	vvw		
			1.11	vvvw		
C_1	16.12	vs	16.76	vs	13.75	vs
	7.31	vw	8.94	w	4.49	s
	4.46	s	7.43	w	3.53	vvvw
	4.03	w	4.46	vs	2.57	vvw
	3.55	vvw	2.56	w	1.70	vvvw
	3.25	vvw	2.36	vvvw	1.50	vvw
	2.58	vvw	2.35	vw	1.29	vvvw
	1.96	vvvw	1.50	vw	1.16	vvvw
	1.70	vvvw			1.10	vvvw
	1.53	vvw				
	1.29	vvvw				

Table 6. (Concluded)

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
C_2	17.76	vs	16.87	vs	14.25	vs
	7.33	vvw	8.86	w	4.49	s
	4.50	s	7.35	w	3.58	vvw
	4.07	w	4.50	s	2.57	vvw
	3.59	vvvw	3.55	w	1.69	vvvw
	3.28	vvvw	2.59	w	1.51	vvw
	2.57	vvw	2.37	vvw		
	2.27	vw	1.51	vvw		
	1.50	vvw	1.48	vvw		
			1.39	vvvw		

*Refer to Table 2 for symbols.

the coarse clay fraction may have indicated poor fractionation.

Aside from montmorillonite, kaolinite lines were observed in the coarse and medium clay fractions. Only montmorillonite was observed in the fine clay fraction.

The mineral cristobalite was present in all coarse clay fractions of all horizons in the profile.

Soils of the Rolling Uplands

A. Soils Derived from Sedimentary Materials

Bago Loam. The d-spacings for the different horizons and clay fractions of Bago loam are shown in Table 7.

Kaolinite was noted in all coarse and medium clay fractions. Traces of kaolinite were likewise noted in the fine clay fraction of the B and C_1 horizons.

Montmorillonite was first apparent in the fine clay fraction of the A horizon, after which montmorillonite lines were noted in all clay fractions of the lower horizons--B, C_1, and C_2.

A trace of halloysite was noted in the medium clay fraction of the C_1 horizon.

Minerals other than clays were found only in coarse clay fractions. Strong cristobalite reflections were very evident in all horizons. Quartz appeared to be present in the A and B horizons. The presence of very well crystallized goethite and diaspore was revealed by very strong lines at

Table 7. X-ray diffraction powder data for Bago loam.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	7.29	w	7.30	s	14.29	w
	4.45	w	4.43	vs	7.30	vvw
	4.04	s	3.61	w	4.45	vvvw
	3.58	vvw	2.58	vvw	2.57	vvvw
	3.34	vvw	2.01	vvvw	2.02	vvvw
	3.14	vvw	1.49	w	1.49	vvvw
	2.85	vvw	2.37	vvvw		
	2.57	vw				
	2.49	vw				
	1.49	vw				
B	16.77	vvvw	18.44	w diffuse	15.40	vvw
	12.39		7.11	w	7.45	vvvw
	7.23	w	4.36	s	4.47	vw
	4.44	w	3.55	vw	2.59	vvvw
	4.06	s	2.55	vvw		
	3.57	vw	1.48	vw		
	3.35	vvw				
	3.13	vvvw				
	2.84	vvvw				
	2.55	vw				
	2.49	vw				
	1.49	w				
C_1	15.40	vvw	14.49	vvvw	16.02	w diffuse
	7.24	vw	11.55	vvvw	7.29	vvvw
	4.44	s	7.30	w	4.47	s
	4.10	vs	4.44	vs	3.59	vvvw
	4.05	s	3.61	vvw	2.59	vvvw
	4.01	vs	2.57	vvw	1.52	vvvw
	3.59	vvvw	1.49	vw	1.49	vvvw
	3.14	vvvw				
	2.83	vvvw				
	2.57	vw				
	2.49	vw				
	1.49	vvw				

Table 7. (Concluded)

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
C_2	14.86	w	13.90	vw	14.65	vs
	7.31	w	9.52	vvvw	4.49	w
	4.45	s	7.35	s	2.60	vvvw
	4.05	vw	4.43	w	1.52	vvvw
	3.64	vw	3.67	vvw		
	2.58	vw	3.57	vvw		
	1.49	vvvw	2.58	vvw		
			2.52	vvvw		
			1.69	vvvw		
			1.49	vvw		
			1.16	vvw		
			1.11	vvvw		

*Refer to Table 2 for symbols.

4.10 Å and 4.01 Å units, respectively, in the C_1 horizon.

Two peculiar reflections, in the sense that both were shown sharply on only one side of the diffractogram, were noted at 2.01 Å and 2.02 Å for both medium and fine clay fractions. Such reflections were noted only in the A horizon.

Bolinao Clay. The d-spacings for the different horizons and clay fractions of Bolinao clay are shown in Table 8. The soil profile of this soil type consisted of only three horizons.

The X-ray pattern of this sample showed chlorite was the dominant clay in all clay fractions of all horizons.

A trace of montmorillonite was suspected to be present in the fine clay fraction of the C horizon.

Quartz appeared to be present in all coarse clay fractions including the medium clay fraction of the C horizon. The 4.26 Å peak of quartz was noted in all horizons, gradually decreasing in intensity from top to the lower horizon. The amount of quartz present then could be more than 10 per cent since generally the 4.26 Å peak is not noticeable until this value is reached (Jackson, 1964).

A very strong and sharp line was also exhibited in the medium clay fraction of the C horizon at 4.09 Å units. That could indicate the presence of an alkali feldspar.

It was noted that very, very, very weak but sharp lines at 2.02 Å units were shown on only one side of the diffractogram of the medium and fine clay fractions of the A horizon.

Table 8. X-ray diffraction powder data for Bolinao clay.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	14.25	s	13.75	vs	13.82	vs
	7.19	vvvw	6.94	vvvw	4.48	s
	4.47	w	4.47	s	2.57	vvvw
	4.27	vw	3.55	vvvw	2.02	vvvw
	3.53	vvw	2.57	vvw	1.50	vw
	3.36	s	2.37	vvvw	1.17	vvvw
	2.57	vvvw	2.02	vvvw	1.11	vvvw
	1.82	vvvw	1.71	vvvw		
	1.50	vvvw	1.50	w		
	1.38	vvvw				
B	13.82	vs	13.90	vs	14.25	vs
	4.48	s	4.47	s	4.49	s
	4.25	vvvw	2.57	vvw	2.57	vvvw
	3.53	vvvw	1.50	vw	1.50	vvw
	3.35	s				
	2.58	vw				
	1.82	vvvw				
	1.50	vw				
	1.38	vvvw				
	1.30	vvvw				
C	14.09	vs	13.71	vs	14.29	vs
	4.49	w	4.24	s	9.18	vvvw
	4.30	vvvw	4.24	s	4.47	s
	3.36	s	4.09	vs	2.58	vvw
	2.59	vvvw	3.81	vw	1.71	vvvw
	1.50	vvw	3.69	w	1.50	vvw
	1.54	vvvw	2.57	vvvw		
			1.50	vvw		
			1.30	vvvw		
			1.24	vvvw		
			1.16	vvvw		
			1.11	vvvw.		

*Refer to Table 2 for symbols.

Faraon Clay. The d-spacings for the different clay fractions of all the horizons are shown in Table 9.

The first three horizons, A, B, and C_1, were practically dominated by montmorillonite as evidenced by strong to very strong lines in all clay fractions. The predominating presence of montmorillonite accounted for the sticky consistency of this soil type when wet.

Kaolinite lines were apparent in the coarse clay fractions of the A and B horizons and in the medium clay fraction of the B horizon, with metahalloysite showing up in the medium clay fraction of the A horizon.

The last two horizons, C_2 and C_3, appeared to be all chlorite with montmorillonite-chlorite random interstratification in some clay fractions. Chlorite was evident in both coarse clay fractions, the medium clay fraction of the C_2 horizon and the fine clay fraction of the C_3 horizon. Very strong 13.18 to 17.15 Å and 14.05 to 17.68 Å bands were noted in the fine clay fraction of the C_2 horizon and the medium clay fraction of the C_3 horizon, respectively. This possibly revealed the presence of randomly interstratified montmorillonite and chlorite.

The clay mineral hydrobiotite was also noted in the fine clay fraction of the C_2 horizon.

The mineral quartz was present in all coarse clay fractions of the A, B, and C_1 horizons.

A strong reflection at 4.93 Å units in the coarse clay

Table 9. X-ray diffraction powder data for Faraon clay.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	17.20	vs	17.38	vs	14.86	vs
	9.04	vvw	8.93	vw	4.49	s
	7.31	vvvw	7.63	vvvw	2.56	w
	4.49	s	4.47	vs	1.50	w
	3.54	w	3.56	w		
	3.35	vw	2.56	w		
	2.58	vw	2.53	vvvw		
	1.51	vvvw	2.37	vvvw		
	1.49		1.51	vvvw		
			1.49			
B	17.38	vs	16.38	vs	14.09	s
	9.04	vw	9.17	vvw	4.48	s
	7.29	vw	7.21		2.57	vw
	6.09	vvvvw	4.47	vs	1.50	w
	4.93	s	3.55	w		
	3.54	w	2.57	w		
	3.36	vw	2.49	vvvw		
	2.58	vw	2.39	vvw		
	2.52	vvvw	2.27	vw		
	2.36	vvvw	1.51	w		
	1.50	vvw	1.50			
	1.49		1.39	vvvw		
			1.17	vvvw		
			1.11	vvvw		
C_1	14.95	s	15.73	s	17.50	s
	4.47	s	7.20	evls**	4.47	s
	3.55	vw	4.49	vs	2.57	vvw
	3.35	vw	3.57	vw	1.50	vvvw
	2.57	vvw	2.58	vvw		
	2.52	vvvw	2.34	vvvw		
	1.50	vvw	2.01	vvvw		
	1.49		1.70	vvvw		
			1.49			
			1.16	vvw		
			1.11	vvvw		

Table 9. (Concluded)

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
C_2	14.25	s	14.21	vs	17.15, 13.68	vs
	7.19	vvvw	7.08	evls**	11.85	vvw
	4.47	vw	4.45	s	4.47	s
	3.57	vvw	3.56	vvw	3.34	vvvw
	2.58, 1.50	vvvw	2.57	vvw	2.57	vvw
			1.50, 1.49	vvw	1.51, 1.49	vvvw
C_3	14.45	vs	17.68, 14.05	vs	13.79	s
	4.49	s	8.85	vvw	4.50	s
	3.57	vw	7.16	vvw	4.15	w
	2.57	vw	4.46	vs	2.57	vvvw
	1.50	vw	3.57	w	1.51	vvvw
			2.59, 2.52	vw		
			1.50, 1.49	w		

* Refer to Table 2 for symbols.

**edge of very light shadow.

fraction of the B horizon revealed the presence of gibbsite.

The medium clay fraction of the B and C_1 horizons exhibited reflections at 2.27 and 2.01 Å units, respectively, on only one side of the diffraction pattern.

B. Soils Derived from Igneous Materials

Guimbalaon Clay. The d-spacings for the different clay fractions of all horizons of Guimbalaon clay are shown in Table 10.

The mineral kaolinite dominated all clay fractions in all horizons except the coarse clay fraction of the A horizon which appeared to be clino-chrysotile or serpentine. Clino-chrysotile emitted a strong 020 reflection at 4.58 Å unit which was noted in the diffractogram. Montmorillonite was detected in the fine clay fraction of the C_2 horizon. The data gathered appeared to deviate from the Guimbalaon clay data of Galvez (1957), which showed the dominant clay mineral to be halloysite.

The mineral goethite showed a very strong reflection at 4.17 Å units in the coarse clay fraction of the A horizon.

Very strong reflections at 4.06 Å to 4.07 Å units, revealing the presence of cristobalite were noted in the diffractogram of the coarse clays of the horizons B and C_1.

Guimbalaon Loam. The d-spacings for the different clay fractions of all horizons of Guimbalaon loam are shown in Table 11.

Table 10. X-ray diffraction powder data for Guimbalaon clay.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	7.55	s	7.36	s	7.36	s
	4.58	s	4.51	s	4.45	vs
	4.17	vs	3.63	w	3.57	s
	3.71	w	2.58	vvw	2.55	w
	3.21	vw	2.38	vvw	2.33	vw
	2.94	vvvw	1.52	vw	1.97	vvvvw
	2.66	vvvw	1.50	vw	1.68	vvvw
	2.56	vvw			1.49	w
	2.56	vvw			1.28	vvvw
	1.52	vw			1.24	vvvw
B	7.28	s	7.35	w	7.29	w
	4.46	vs	4.47	s	4.46	s
	4.07	vs	4.14	vvw	3.57	w
	3.60	w	3.62	vvw	2.54	vw
	2.56	vw	3.26	w	1.68	vvw
	2.50	vw	2.56	vvvw	1.49	vw
	2.34	vw	2.40	vvw		
	1.68	vvw	1.49	vvvw		
	1.49	w	1.15	vvvw		
			1.11	vvvw		
C_1	7.36	s	7.36	w	7.45	w
	4.46	vs	4.46	s	4.45	s
	4.06	s	3.58	w	3.59	w
	3.62	w	2.58	vvw	2.57	w
	2.58	vw	2.53	vvw	2.35	vvvw
	2.52	vw	2.36	vvvw	1.68	vvvw
	2.36	vvw	1.49	vvw	1.50	vvw
	2.28	vvvw				
	1.49	vvw				
C_2	7.31	s	7.37	w	17.38	vw
	4.47	vs	4.44	s	7.26	w
	3.61	s	3.59	vvw	4.46	vs
	2.58	w	2.54	vvw	2.57	w
	2.51	vvw	2.37	vvw	2.34	vw
	2.35	vvw			1.98	vvvvw
	1.68	vvw			1.69	vvw
	1.49	w			1.49	w
	1.43	vvvw				
	1.24	vvvw				
	1.16	vw				

*Refer to Table 2 for symbols.

Table 11. X-ray diffraction powder data for Guimbalaon loam.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	14.74	****	15.92		12.21	***
	11.08		13.43	**	4.08	vs
	7.26	vw	10.65		3.69	s
	4.44	w	7.22	vvw	2.48	vvvw
	4.07	w	4.43	s		
	3.76	vvvw	3.67	vvvw		
	3.63	vvvw	2.59	vvvw		
	3.22	s	1.68	vvvw		
	2.58	vvvw	1.48	vvw		
	2.53	vvvw				
	1.49	vvvw				
B	16.49	****	16.54		18.78	
	11.06		13.32	**	10.85	**
	7.23	vvvvw	10.69		13.50	
	4.41	vvw	7.11	vvvw	4.42	vvw
	4.07	vvw	4.46	w	3.78	vvvw
	3.24	w	2.59	vvvw	3.35	vvvvw
			1.49	vvvw	1.16	vvvw
					1.11	vvvw
C_1	16.70	**	17.15	**	no pattern	
	10.87		10.45			
	4.47	vvw	7.08	vvvw		
	2.01	vvw	4.44	vvw		
	1.40	w	4.07	vvvw		
			3.78	vvvw		
			3.24	vvw		
C_2	11.20	***	no pattern		no pattern	
	7.13	vvvw				
	4.46	vw				
	4.11	w				
	3.77	vw				
	3.22	w				
	3.01	vvvw				
	2.56	vvvw				
	2.53					
	1.50	vvvw				

* Refer to Table 2 for symbols.
** Approximate--broad hazy band.
*** Approximate--immeasurable hazy ring.
****Approximate--very hazy.

Hazy bands occurred in all diffractograms. This probably indicated random interstratification or very poor crystallinity of the clays present. The absence of diffractogram patterns in both of the fine clay fractions of the C_1 and C_2 horizons preceded by the same occurrence in the medium clay fraction of the C_2 horizon suggested a trend wherein the presence of clay minerals diminished as the profile horizon deepened. This was relevant to the soil profile sample of the soil types where pebbles occurred in the B horizon, stones in the C_1 horizon, and sand in the C_2 horizon.

Illite-montmorillonite interstratification was evident in the coarse clay fractions of the A, B, and C_1 horizons and in the medium clay fraction of the C_1 horizon. The coarse clay fraction of the C_2 horizon emitted a very hazy shadow at about 11.20 Å units which could be illite.

Illite-chlorite-montmorillonite interstratification was observed in the medium clay fractions of the A and B horizons and in the fine clay fraction of the B horizon.

An immeasurable hazy shadow at approximately 12.21 Å units was noted in the fine clay fraction of the A horizon. Three other lines at 4.08 Å, 3.69 Å, and 2.48 Å units were observed in this clay fraction. Due to the scarcity of lines in the diffractogram, identity of the clay mineral content in this fraction could not be effectively made.

A very hazy band at about 11.20 Å units which could be halloysite was noted in the coarse clay fraction of the C_2 horizon.

Kaolinite appeared to be present in the coarse fraction of the two upper horizons, A and B.

Feldspar was present in all coarse clay fractions except that of the C_1 horizon.

Cristobalite was noted in the coarse clay fractions of the A and B horizons.

A sharp reflection at 2.01 Å units occurring in only one side of the diffractogram was noted in the coarse fraction of the C_1 horizon.

Manapla Loam. The d-spacings for the different clay fractions of all horizons of Manapla loam are shown in Table 12.

Montmorillonite and kaolinite were noted in all clay fractions of all horizons. Halloysite, which was the only other clay mineral noted, was present in the medium clay fraction of the A horizon.

The mineral cristobalite gave very strong reflections in the coarse clay fraction of the A, C_1 and C_2 horizons.

A very strong reflection at 3.91 Å units was noted in the coarse clay fraction of the B horizon. This could be diaspore which gives a very strong reflection at 3.98 Å units.

The mineral feldspar was noted in the coarse fraction of the C_2 horizon.

Table 12. X-ray diffraction powder data for Manapla loam.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	18.44	w	15.63	vvw	15.88	s
	7.29	vvw	11.40	vvw	7.47	vw
	4.45	w	7.24	w	4.45	vs
	4.04	s	4.47	vs	3.58	vvw
	3.55	vvw	2.57	w	2.57	vvw
	3.33	vvvw	3.58	w	1.51	vvvw
	2.82	vvvw	2.50	vvw	1.49	vvvw
	2.56	vvw	2.37	vvw		
	2.35	vvw	1.69	vvvw		
	1.49	vvw	1.51	vvvw		
			1.49	vw		
B	16.28	vvw	17.44	vvw	15.40	vvvw
	7.36	w	7.40	w	7.41	vvvw
	4.47	s	4.47	vs	4.47	s
	3.91	vs	3.57	w	3.56	vvw
	3.55	vvw	2.58	w	2.57	vvw
	2.85	vvvw	2.52	vvw	2.37	vvvw
	2.57	vw	2.36	vvvw	1.49	vvw
	2.49	vvw	1.68	vvvw		
	1.98	vvvw	1.49	w		
	1.68	vvvw	1.39	vvvw		
	1.62	vvvw	1.29	vvvw		
	1.50	vvw	1.23	vvvw		
			1.16	vvvw		
			1.11	vvvw		
C_1	15.49	w	16.02	vvw	15.17	vs
	7.38	vvw	7.31	vw	7.53	vvvw
	4.46	s	4.45	vs	4.47	vs
	4.06	w	3.58	w	3.54	vvvw
	3.57	vw	2.57	vvw	2.59	vvw
	2.57	vw	2.51		1.51	vvvw
	2.50	vvvw	2.36	vvvw	1.50	vvvw
	2.36	vvvw	1.68	vvvw	1.40	vvvw
	1.50	vvvw	1.49	vw	1.09	vvvw

Table 12. (Concluded)

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
C_2	16.81	w	16.38	s	15.54	s
	7.39	w	7.47	s	7.52	vw
	4.45	vs	4.45	vs	4.47	vw
	4.05	w	3.55	s	3.55	vvw
	3.59	vw	2.57	w	2.57	vvw
	3.20	w	2.51	vvvw	1.49	vvw
	2.58	vvw	2.35	vvw		
	2.51	vvvw	1.68	vvw		
	2.37	vvvw	1.49	w		
	1.69	vvvw	1.29	vvvw		
	1.50	w	1.24	vvvw		
	1.29	vvvw	1.16	vvvw		
	1.24	vvvw				

*Refer to Table 2 for symbols.

A trace of quartz was shown in the coarse clay of the A horizon.

Tupi Fine Sandy Loam. The d-spacings for the different clay fractions of all horizons of Tupi fine sandy loam are shown in Table 13.

The clay mineral kaolinite dominated all clay fractions except the medium clay fraction of the A horizon which was noted to be clino-chrysotile.

Halloysite was noted in the fine clay fraction of the B, C_1, and C_2 horizons and in the medium clay fraction of the C_2 horizon.

The presence of montmorillonite was indicated in the fine clay fraction of the C_2 horizon.

The minéral cristobalite was detected in all coarse clay fractions. Feldspar, too, was present in all coarse clay fractions except that of the B horizon.

A trace of quartz was shown in the coarse clay of the A horizon.

La Castellana Clay Loam. The d-spacings for all clay fractions of all horizons are shown in Table 14.

The dominant clay mineral of this soil type appeared to be kaolinite. Strong to very strong lines were reflected in all clay fractions of the A and C_1 horizons, the fine clay fraction of the B horizon, and the coarse and fine clay fractions of the C_2 horizon.

Clino-chrysotile was noted in the coarse and medium

Table 13. X-ray diffraction powder data for Tupi fine sandy loam.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	7.33	vs	7.51	s	7.33	s
	4.45	vs	4.59	vs	4.44	vs
	4.05	s	3.72	w	3.64	s
	3.62	w	2.65	vvw	2.58	w
	3.33	vvvw	1.51	vvw	1.67	vvw
	3.24	vw			1.49	vw
	2.57	w			1.28	vvw
	2.49	w			1.24	vvw
	2.36	vvw			1.16	vvw
	1.68	vvvw				
	1.62	vvvvw				
	1.49	vw				
	1.44	vw				
B	7.38	s	7.47	w	11.85	vw
	4.44	vs	4.44	s	7.47	vw
	4.06	w	3.63	vw	4.44	s
	3.65	w	1.48	vvw	3.68	w
	2.58	vw			2.57	vvw
	1.49	vvw			1.66	vvvw
					1.49	vvw
C_1	7.36	s	7.35	s	11.38	vvw
	4.45	vs	4.45	vs	7.35	vw
	4.06	s	3.64	s	4.43	vs
	3.65	w	2.56	vvw	3.69	vw
	3.21	w	1.68	vvvw	2.57	vvw
	2.59	vw	1.49	vvw	1.67	vvvw
	1.67	vvw			1.48	vvw
	1.49	vvw				
C_2	7.35	vs	11.33	vvw	17.44	vvvw
	4.45	vs	7.34	w	11.77	vvw
	4.08	w	4.43	vs	7.49	vw
	3.65	w	3.66	w	4.43	vs
	3.23	w	2.57	vvw	3.67	vw
	2.58	w	1.69	vvvw	2.58	vvw
	1.69	vvvw	1.49	vvw	1.68	vvvw
	1.50	vvw			1.48	vvw

*Refer to Table 2 for symbols.

Table 14. X-ray diffraction powder data for La Castellana clay loam.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	7.34	vs	7.34	s	7.28	s
	4.47	s	4.44	vs	4.46	vs
	4.08	vw	3.61	w	3.62	s
	3.63	w	2.56	vvw	2.59	w
	2.53	vw	2.34	vvw	2.33	vvw
	2.37	vvw	1.50	vvw	1.68	vvw
	1.50	vvw			1.49	w
					1.39	vvvw
					1.29	vvvw
					1.24	vvvw
					1.16	vvvw
					1.11	vvvw
B	7.49	s	7.51	vs	7.29	s
	4.56	s	4.60	vs	4.44	vs
	4.17	w	3.74	s	3.63	w
	3.70	w	3.30	w	2.55	vw
	2.63	vvw	2.26	vw	2.33	vvw
	2.57	vvw	1.73	vvw	1.68	vvvw
	2.41	vvw	1.52	s	1.49	vvw
	1.52	vvw				
C_1	7.30	vs	7.39	s	7.25	s
	4.46	s	4.45	s	4.45	vs
	4.10	vvw	3.63	w	3.61	s
	3.63	w	2.54	vw	2.59	vw
	2.56	vw	2.36	vvvw	2.36	vvw
	2.40	vvw	1.49	vvw	1.68	vvvw
	1.50	vvw			1.49	w
C_2	7.33	vs	7.58	w	7.28	s
	4.44	vs	4.59	w	4.46	vs
	4.07	w	3.70	vw	3.62	s
	3.61	s			2.57	w
	2.55	vw			2.34	vw
	2.37	vw			1.70	vvw
	1.68	vvw			1.49	w
	1.50	vw				

*Refer to Table 2 for symbols.

clay fractions of the B horizon and in the medium clay fraction of the C_2 horizon.

The mineral goethite appeared to be present in the coarse clay fractions of the B and C_1 horizons.

Cristobalite lines were noted in the coarse clay fraction of the A and C_2 horizons.

La Castellana Clay. The d-spacings for the different clay fractions of all horizons of La Castellana clay (Negros Oriental) are shown in Table 15.

Strong to very strong lines were observed in all clay fractions of all horizons. This greatly suggested the predominance of montmorillonite in this soil type.

Faint traces of kaolinite were discernible in the coarse and medium clay fractions of the A and B horizons, the fine clay fraction of the B horizon and the medium clay fraction of the C_1 and C_2 horizons.

The mineral cristobalite was also apparent in the coarse clay fractions of the A, B, and C_1 horizons, and in the medium clay fraction of the C_1 horizon.

A trace of goethite was suggested in the coarse clay fraction of the C_2 horizon.

Sharp reflections occurring on only one side of the diffractograms at 2.01 to 2.02 Å units were noted in the fine clay fraction of the B and C_2 horizons.

Table 15. X-ray diffraction powder data for La Castellana clay (Negros Oriental).

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	17.68	vs	17.15	vs	14.45	vs
	7.24	vvvw	9.23	vvvw	4.47	s
	4.47	s	7.30	vvvw	3.58	vvvw
	4.05	w	4.47	s	2.57	vvw
	3.57	w	3.55	w	1.51	vvvw
	2.58	vvvw	2.57	vvvw	1.49	vvvw
	2.50	vvvw	2.53	vvvw		
	1.51	vvvw	2.36	vvvw		
	1.49	vvvw	2.01	vw		
			1.51	vvvw		
			1.49	vvvw		
B	16.38	vs	16.28	vs	14.05	vs
	7.16	vvvw**	7.36	vvvw**	7.36	vvvw**
	4.47	s	4.47	vs	4.47	vs
	4.06	w	3.58	w	3.55	vvvw
	3.51	w	2.59	w	2.59	vvw
	2.58	vvw	2.52	vvvw	2.01	vvw***
	2.49	vvw	1.70	vvvw	1.51	vvw
	2.35	vvvw	1.52	vvvw	1.49	
	1.52	vvw	1.49	vvvw		
	1.49		1.40			
			1.30	vvvw		
			1.17	vvw		
			1.11	vvvw		
C_1	16.12	vs	14.69	vs	14.15	vs
	4.46	s	7.38	vvvw**	4.48	s
	4.07	vvvw	4.48	s	2.56	vvw
	3.57	vvw	4.07	vvw	1.50	vvvw
	2.58	vvw	3.55	vvw	1.49	
	1.51	vvvw	2.58	vvw		
	1.50		2.36	vvvw		
			1.97	vvvw		
			1.52	vvvw		
			1.49			
			1.40	vvvw		

Table 15. (Concluded)

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
C_2	16.33	s	17.15	vs	14.15	vs
	4.46	s	8.91	w	4.47	s
	4.09	vvvw	7.40	vvvw	3.57	vvvw
	3.55	vvw	4.54	vs	2.57	vvw
	3.25	vvw	3.56	w	2.02	vvw***
	2.60	vvvw	2.58	w	1.51, 1.49	vvvw
	2.53	vvvw	2.35	vvvw		
	1.52, 1.49	vvvw	1.52, 1.49	vvvw		
			1.30	vvvw		

* Refer to Table 2 for symbols.

** Edge of shadow.

***Sharp on one side only.

Soils of the Hills and Mountains

Rough Mountainous Land

The d-spacings of all clay fractions of all horizons for the rough mountainous land are shown in Table 16.

A profusion of sharp lines was noted in all diffractograms of all clay fractions. This may have indicated a highly crystallized clay throughout the profile sample. Of all soil types studied, this sample exhibited the deepest soil profile.

Kaolinite practically dominated all horizons as evidenced by strong to very strong lines in all clay fractions.

Goethite lines were noted in all medium clay fractions, in the fine clay fraction of the A and C_3 horizons, and in the coarse clay fraction of the last three horizons, C_1, C_2, and C_3.

SUMMARY

The clay mineralogy of fifteen representative soil profiles from the Island of Negros, the Philippines, was studied using X-ray diffraction techniques.

The clays and other minerals of five soil types of recent alluvial deposits in the flat lowlands are shown in Table 17. Montmorillonite dominated those soils and was noted to be present in all such soil types studied. Kaolinite was found in all soil types except the Silay fine sandy loam wherein metahallosysite was observed. Halloysite

Table 16. X-ray diffraction powder data for rough mountainous land.

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
	d(Å)	I*	d(Å)	I	d(Å)	I
A	7.20	vs	7.21	vs	7.29	vs
	4.45	vs	4.44	vs	4.45	vs
	3.63	vs	4.17	vvw	4.20	vvvw
	2.57	w	3.61	vs	3.60	s
	2.51	w	2.58	w sharp	2.57	w sharp
	2.35	w	2.51	w sharp	2.50	w sharp
	1.69, 1.65	vvw	2.35	w	2.36	vvw
	1.49	s	2.30	vvvw	2.32	vvw
	1.29	vvvw	1.99	vvvw	1.99	vvw
	1.24	vvw	1.69, 1.66	vvvw	1.68, 1.65	vvvw
			1.49	s	1.49	s
			1.29	vvvw	1.29	vvw
			1.24	vvvw	1.24	vvw
B	7.23	s	7.19	vs	7.38	s
	4.45	vs	4.44	vs	4.43	s
	3.62	s	4.19	vvvw	3.61	w
	2.58	vvw	3.60	s	3.25	w
	2.51	vvw	2.58	w	2.56	vw
	2.36	vvw	2.50	w	2.50	vw
	2.31	vvw	2.35	w	2.36, 2.33	vvvw
	1.49	s	2.21	vvvw	1.69	w
	1.28	vvvw	2.00	vvvw	1.62	vvvw
	1.24	vvvw	1.69, 1.65	vvw	1.49	vw
			1.49	s		
			1.29	vvvw		
			1.24	vvvw		
C_1	7.25	s	7.21	vs	7.30	vs
	4.47	vs	4.43	vs	4.45	vs
	4.20	vvvw	4.21	vvw	3.61	w
	3.36	s	3.60	s	3.36	vw
	2.57	w	2.57	w	2.58	vw
	2.51	vw	2.50	w	2.52	vw
	2.35	vw	2.36	w	2.35	vw
	1.69, 1.66	vvw	1.69, 1.66	vvw	1.98	vvvw
	1.49	w	1.49	s	1.68, 1.64	vvvw
	1.29	vvvw	1.28	vvvw	1.49	s
	1.24	vvvw	1.24	vvvw	1.29	vvvw
			1.16	vvvw	1.24	vvvw
					1.16	vvvw

Table 16. (Concluded)

Horizon	Clay fraction					
	Coarse clay		Medium clay		Fine clay	
C_2	7.31	s	7.21	vs	7.28	s
	4.49	vs	4.44	vs	4.43	s
	4.17	w	4.17	w	3.62	vw
	3.63	vs	3.62	vs	2.57	vw
	2.57	w	2.56	w	2.50	vvvw
	2.51	w	2.51	w	2.35	vvw
	2.34	vw	2.34	w	1.47	w
	1.70, 1.66	vvw	2.00	vvvw		
	1.49	s	1.69, 1.66	vvvw		
	1.29	vvvw	1.49	s		
	1.24	vvvw	1.39	vvvw		
			1.29	vvw		
			1.24	vvw		
			1.17	vvw		
			1.11	vvvw		
C_3	7.30	vs	7.25	vs	7.30	s
	4.46	vs	4.45	vs	4.44	vs
	4.21	vvvw	4.20	vvw	4.20	vvvw
	3.63	vs	3.61	vs	3.63	s
	2.58	w	2.56	w	2.58	vw
	2.51	vw	2.51	vw	2.51	vvw
	2.35	vw	2.35	w	2.35	vw
	1.70	vvvw	2.00	vvvw	1.49	s
	1.65	vvvw	1.69	vvvw		
	1.49	s	1.65	vvvw		
	1.29	vvvw	1.49	s		
	1.24	vvvw	1.28	vvvw		
			1.24	vvvw		

*Refer to Table 2 for symbols.

Table 17. Clays and other minerals present in all clay fractions of the soils of the flat lowlands.

Soil types	Horizon	Clay fraction		
		Coarse clay	Medium clay	Fine clay
(a) Silay clay	A	Montmorillonite s* Kaolinite vvw Cristobalite s Feldspar vw	Montmorillonite vs Kaolinite w	Montmorillonite vvvw Kaolinite vvvw
	B	Montmorillonite s Kaolinite w Cristobalite s Feldspar w	Montmorillonite vvw Kaolinite vw	Montmorillonite s Kaolinite w
	C	Montmorillonite s Kaolinite vw Cristobalite s Feldspar vvw	Montmorillonite s Kaolinite w	Montmorillonite vvw Kaolinite vvw
(b) Silay fine sandy loam	A	Metahalloysite w Feldspar w	Metahalloysite w Feldspar w	Montmorillonite vvw
	B	Metahalloysite s Feldspar s	Metahalloysite w	Montmorillonite vw
	C_1	Montmorillonite vw Metahalloysite vvw Gibbsite s Goethite vw Feldspar vvw	Montmorillonite s Metahalloysite w Feldspar s	Montmorillonite vs
	C_2	Halloysite vvw Metahalloysite vvw Feldspar s Quartz s	None	None

Table 17. (Continued)

Soil types	Horizon	Clay fraction		
		Coarse clay	Medium clay	Fine clay
(c) San Miguel loam	A	Kaolinite s Cristobalite s	Kaolinite s	Kaolinite vw
	B	Kaolinite s	Montmorillonite vw Kaolinite s Cristobalite s	Kaolinite w
	C_1	Kaolinite w Cristobalite w	Montmorillonite vw Halloysite vvvw Kaolinite vs Goethite vvw	Montmorillonite s Kaolinite vvvw
	C_2	Montmorillonite vvvw Kaolinite w Goethite vvvw	Montmorillonite w Halloysite vvw Kaolinite s	Montmorillonite s Kaolinite w
(d) San Miguel loam (Negros Oriental)	A	Montmorillonite vs Cristobalite s	Montmorillonite vs Kaolinite vvw	Montmorillonite s
	B	Montmorillonite vs Attapulgite vvw Cristobalite s Feldspar vvvw	Montmorillonite vs Kaolinite vvw	Montmorillonite s
	C_1	Montmorillonite vs Kaolinite w Cristobalite s Feldspar vvvw	Montmorillonite vs Kaolinite vvw	Montmorillonite vs
	C_2	Montmorillonite s Kaolinite vvw Cristobalite s	Montmorillonite vs Kaolinite vvw	Montmorillonite vs

Table 17. (Concluded)

Soil types	Horizon	Clay fraction		
		Coarse clay	Medium clay	Fine clay
(e) Isabela clay (Negros Oriental)	A	Montmorillonite vs Kaolinite vvw Cristobalite w Feldspar vvw	Montmorillonite vs Kaolinite w	Montmorillonite s
	B	Montmorillonite vs Kaolinite vvw Cristobalite vvw	Montmorillonite vs Kaolinite w	Montmorillonite vs
	C_1	Montmorillonite vs Kaolinite vw Cristobalite w Feldspar vvw	Montmorillonite vs Kaolinite w	Montmorillonite vs
	C_2	Montmorillonite vs Kaolinite vvw Cristobalite w Feldspar vvvw	Montmorillonite vs Kaolinite w	Montmorillonite vs

*Refer to Table 2 for symbols.

was noted in the C_2 horizons of San Manuel loam and in the Silay fine sandy loam. The mineral cristoballite was noted in almost all soil types except the Silay fine sandy loam, possibly revealing high temperature effects on the parent material. Feldspar was noted in all soil types except San Manuel loam where goethite was noted. Gibbsite, goethite, and quartz were noted in the lower horizons of Silay fine sandy loam.

The clays and other minerals of the soils of the rolling upland are shown in Table 18. Three soil types derived from sedimentary materials showed the presence of montmorillonite, kaolinite, and chlorite. Chlorite was predominant in one soil type (Bolinao clay). Quartz was noted in all soil types. Cristoballite, goethite, and diaspore were abundant in the Bago loam soil type. Six soil types derived from igneous rocks exhibited varied clay make-ups. Montmorillonite and kaolinite were noted in all soil types. Clinochrysotile was apparent in the Guimbalaon clay, Tupi fine sandy loam and La Castellana clay loam. Clay mineral interstratifications of illite-montmorillonite and illite-chlorite-montmorillonite were found in the Guimbalaon loam. Goethite, feldspar, quartz and diaspore were noted in some soil types.

The clays and other minerals of the rough mountainous land are shown in Table 19. Kaolinite and goethite, which exhibited very well defined diffraction lines in all patterns, were noted to be the sole clay and mineral present, respectively.

Table 18. Clays and other minerals present in all clay fractions of the soils of rolling uplands.

Soil types	Horizon	Clay fraction		
		Coarse clay	Medium clay	Fine clay
A. Soils Derived from Sedimentary Materials				
(a) Bago loam	A	Kaolinite w* Cristobalite s Quartz vvw	Kaolinite s	Montmorillonite w
	B	Montmorillonite vvw Kaolinite w Cristobalite s Quartz vvw	Montmorillonite w Kaolinite w	Montmorillonite vvw Kaolinite vvvw
	C_1	Montmorillonite vvw Kaolinite vw Goethite vs Cristobalite s Diaspore vs Quartz vvvw	Montmorillonite vvvw Kaolinite vvvw Kaolinite w	Montmorillonite w Kaolinite vvvw
	C_2	Montmorillonite w Kaolinite w Cristobalite vw	Montmorillonite vw Kaolinite s	Montmorillonite vs
(b) Bolinao clay	A	Chlorite s Quartz s	Chlorite vs	Chlorite vs
	B	Chlorite vs Quartz s	Chlorite vs	Chlorite vs
	C_1	Chlorite vs Quartz	Chlorite vs Quartz s Alkali Feldspar vs	Montmorillonite

Table 18. (Continued)

Soil types	Horizon	Clay fraction		
		Coarse clay	Medium clay	Fine clay
(c) Faraon clay	A	Montmorillonite vs Kaolinite vvvw Quartz vw	Montmorillonite vs Metahalloysite vvvw	Montmorillonite vs
	B	Montmorillonite vs Kaolinite vw Gibbsite s Quartz vw	Montmorillonite vs Kaolinite vvw	Montmorillonite s
	C_1	Montmorillonite s Quartz vw	Montmorillonite s	Montmorillonite s
	C_2	Chlorite s	Chlorite s	Montmorillonite vs Chlorite vs Hydrobrotite vvs
	C_3	Chlorite vs	Montmorillonite vs Chlorite vs	Chlorite s
B. Soils Derived from Igneous Materials				
(a) Guimbalaon clay	A	Clino-chrysotile s Goethite vs	Kaolinite s	Kaolinite s
	B	Kaolinite s Cristobalite s	Kaolinite w	Kaolinite w
	C_1	Kaolinite s Cristobalite s	Kaolinite w	Kaolinite w
	C_2	Kaolinite s	Kaolinite w	Montmorillonite vw Kaolinite w

Table 18. (Continued)

Soil types	Horizon	Clay fraction		
		Coarse clay	Medium clay	Fine clay
(b) Guimbalaon loam	A	Illite-Montmorillonite-Interstratification Kaolinite vw Feldspar s	Illite-Chlorite-Montmorillonite Interstratification	Illite-Chlorite-Montmorillonite Interstratification
	B	Illite-Montmorillonite Interstratification Kaolinite vvvvw Cristobalite vvw Feldspar w	Illite-Chlorite-Montmorillonite Interstratification	Illite-Chlorite-Montmorillonite Interstratification
	C_1	Illite-Montmorillonite Interstratification	Illite-Montmorillonite Interstratification	No pattern
	C_2	Halloysite vw Feldspar w	No pattern	No pattern
(c) Manapla loam	A	Montmorillonite w Kaolinite vvw Cristobalite s	Montmorillonite vvw Halloysite vvw Kaolinite w	Montmorillonite s Kaolinite vvw
	B	Montmorillonite vvw Kaolinite w Diaspore vs	Montmorillonite vvw Kaolinite w	Montmorillonite vvvw
	C_1	Montmorillonite w Kaolinite vvw Cristobalite w	Montmorillonite vvw Kaolinite vw	Montmorillonite vs Kaolinite vvvw

Table 18. (Continued)

Soil types	Horizon	Clay fraction		
		Coarse clay	Medium clay	Fine clay
	C_2	Montmorillonite w Kaolinite w Cristobalite w Feldspar w	Montmorillonite s Kaolinite s	Montmorillonite s Kaolinite w
(d) Tupi fine sandy loam	A	Kaolinite vs Cristobalite s Feldspar vw Quartz vvvw	Clino-Chrysotile s	Kaolinite s
	B	Kaolinite s Cristobalite w	Kaolinite w	Halloysite vw
	C_1	Kaolinite s Cristobalite s Feldspar w	Kaolinite s	Halloysite vvw Kaolinite vw
	C_2	Kaolinite vs Cristobalite w Feldspar w	Halloysite vvw Kaolinite w	Montmorillonite vvvw Halloysite vvw Kaolinite vw
(e) La Castellana clay loam	A	Kaolinite vs Cristobalite vw	Kaolinite s	Kaolinite s
	B	Clino-Chrysotile s Goethite w	Clino-Chrysotile vs	Kaolinite s
	C_1	Kaolinite vs Goethite vvw	Kaolinite s	Kaolinite s
	C_2	Kaolinite vs Cristobalite w	Clino-Chrysotile w	Kaolinite s

Table 18. (Concluded)

Soil types	Horizon	Clay fraction		
		Coarse clay	Medium clay	Fine clay
(f) La Castellana clay	A	Montmorillonite vs Kaolinite vvvw Cristobalite w	Montmorillonite vs Kaolinite vvvw	Montmorillonite vs
	B	Montmorillonite vs Kaolinite vvvw Cristobalite w	Montmorillonite vs Kaolinite vvvw	Montmorillonite vs Kaolinite vvvw
	C_1	Montmorillonite vs Cristobalite vvvw	Montmorillonite vs Kaolinite vvvw Cristobalite vvw	Montmorillonite s
	C_2	Montmorillonite s Cristobalite vvvw	Montmorillonite vs Kaolinite vvvw	Montmorillonite vs

*Refer to Table 2 for symbols.

Table 19. Clays and other minerals present in all clay fractions of the rough mountainous land.

Horizon	Clay fraction		
	Coarse clay	Medium clay	Fine clay
A	Kaolinite vs*	Kaolinite vs Goethite vvw	Kaolinite vs Goethite vvvw
B	Kaolinite s	Kaolinite vs Goethite vvw	Kaolinite s
C_1	Kaolinite s Goethite vvvw	Kaolinite vs Goethite vvw	Kaolinite vs
C_2	Kaolinite s Goethite vvvw	Kaolinite vs Goethite w	Kaolinite s
C_3	Kaolinite vs Goethite vvw	Kaolinite vs Goethite vvw	Kaolinite s Goethite vvvw

*Refer to Table 2 for symbols.

No discernible effect of parent material and environment singly affecting the distribution of clay minerals was observed.

For an effective assessment of the use capabilities of the soil types studied, other data such as organic matter and total cations and anions present should be correlated with the clay minerological make-up of the soil types studied.

Detailed clay mineralogical data using refined techniques should be used more in classifying soils rather than relying on feel and color in determining the clay minerals present.

ACKNOWLEDGMENT

The author thanks his major professor, Dr. Roscoe Ellis, Jr., whose guidance and personal concern enabled the author to work on soils from the Philippines.

Thanks are extended to Dr. R. V. Olson, Dr. H. C. Fryer, Dr. O. W. Bidwell, and Dr. G. M. Paulsen, who reviewed the manuscript; to Kansas State University for affording the author a chance to further graduate studies with an assistantship; and to Letty Hombrebueno, Jindra L., and Jylmir L. for typing the bulk of the preliminary draft of this paper.

It has been said that gratitude is the memory of the heart and the author wishes to take this opportunity to express his debt of gratitude to his family, lovingly called the Jays of Batan, Aklan the Philippines--to father Jose K.; mother Josefa L.; brothers Jylmir, Jayner, and Jexter; sisters Jindra, Jannet, Jercyl, and Junice; and sister-in-law Luz--whose letters and love boosted the author's sagging spirit and spurred him to finish the work started.

Dearest appreciation is expressed to the author's wife, Emelita V., who was the epitome of all things nice and beautiful, whose love the author will cherish forever, and for whom in fond and loving memory the author endeavored to finish this paper. A passage in the marriage vows of a Christian wedding ceremony goes, "... to love, honor, and obey ... 'till death do us part." Emelita gave a love that transcends death and it is that love that keeps the author going and makes him feel like living again.

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APPENDIX

General Description of the Province of Negros Occidental

Negros Occidental province is located between 9° and 11° north latitudes and 122°-30' east longitude. On the eastern side of Negros Island is the province of Negros Oriental. Negros Occidental province measures approximately 200 kilometers long and is 69 kilometers at its widest and 23 kilometers in its narrowest width.

The geology and topography of Negros Occidental are characterized by volcanic activity and changes in the elevation of the land. The volcanic regions are found in the northwestern part, and the alluvial fans in the western central plain of the province. A portion of the western and southern part of the province has decidedly been filled with mudflow as a result of erosion of sediments from the higher lands and violent eruptions which occurred during periods of volcanic activity. Marine shells in the subsoil of the south central part of the province indicate the raising of this region from sea level.

Three distinct types of rainfall have been described for the province. The first is characterized by distinct dry and wet seasons. The dry season commences in December and ends in April, while the wet season starts in May and ends in November. Western and southern Negros Occidental fall under this type. The second type, which is predominant in eastern Negros Occidental, is characterized by no very pronounced maximum rain period and with a short dry season lasting from one to three months (February to April). The third type covers the smaller portion of northern Negros Occidental whose climate is characterized by no dry season and very pronounced maximum rain period.

Description of the Soil Profile Samples

The soil profile samples collected are grouped on the basis of relief and formation as follows:

1. Soils of the flat lowlands

   Soils of recent alluvial deposits are classified under this group. All plain lands are only a few meters above sea level, especially if near the coast, but may reach up to 100 feet for areas bordering the uplands. In general they are flat, especially those near the coast, but become gently undulating in the upper regions as a result of the various creeks and rivers that bisect them.

   (a) Silay clay

   The soils of the Silay series are water-laid. The surface soil of Silay clay is of heavy clay that is dark gray when dry and black when wet. It varies in depth from 10 to 20 centimeters. It is strongly hard to almost compact when dry and becomes very sticky and strongly plastic when wet. It shrinks and cracks well when dried after puddling. If pulverized when moist, it becomes friable when dried. If plowed for upland crops when the soil is wet, it hardens in big lumps and becomes very difficult to pulverize. It should be worked only when it contains just the optimum amount of moisture. When dry, the soil is hard to work because it becomes strongly compact. No stones or rock outcrops are found in this soil. A hard, compact cemented layer which highly impedes internal drainage is found in the subsoil. This particular characteristic differentiates the soils of Silay series from other alluvial soils.

(b) Silay fine sandy loam

This sandy loam type is easy to work and cultivate when dry or wet, without any adverse effect on the structure. Color changes dependent on moisture content as exhibited by the Silay clay were also obsérved in this soil and have been postulated to be partly due to high volcanic ash content.

(c) San Manuel loam

The San Manuel series represents alluvial soils which are mostly found along courses of rivers. It has better drainage than the soils of the Silay series. San Manuel loam is a fine granular soil that is mellow and very friable. The surface soil, to a depth of from 30 to 40 centimeters, is dark yellowish brown. Internal drainage is fair to poor so that this soil is often used more for lowland rice than for corn or sugar cane.

(d) Isabela clay

The surface soil of Isabela clay is distinctly black and has an appearance of being powdery. Although clay in texture, it does not crack or shrink like silty clay. The surface soil in some cases reaches a depth of 50 centimeters. The soil is very sticky and difficult to work when wet. When worked wet, it will puddle and become hard and difficult to pulverize. The subsoil is grayish black and at times bluish black, which partly shows its lack of aeration. It is also sticky and slightly hard to compact when wet.

2. Soils of the rolling uplands

The flat lowlands in Negros Occidental are those along the coastal area. The rolling uplands are intermediary and are found between the coastal plains and the central mountainous areas. The rolling lands are more prominently found in the northwestern part of the province. These land-forms are widely cultivated to crops, although some grasslands are not planted either because the land is very stony or the soil is so highly eroded that it cannot support a good crop. Excessive external drainage partly accounts for the accelerated erosion.

Soils of the rolling upland can be divided into two groups based on parent material as follows:

A. Soils derived from sedimentary materials

Limestone and shale compose the only sedimentary materials found in the province. Limestone distinctly of coralline origin make up the parent material of soils in the southwestern and northeastern parts of the province. Shale is the parent material of soils in the Tablas Valley.

(a) Bago loam

Bago loam is a product of the development of older alluvial deposits. The surface soil, which is coarser than the subsoil, has a depth of from 15 to 20 centimeters. It is dark grayish brown when wet; when dry it is gray and in some places brown. Concretions are present but stones and boulders are not found. The soil is fairly friable when moist but when wet is a little sticky. It becomes hard and compact when dry. The subsoil is gray to grayish brown clay. This clay is very soft, plastic and sticky when wet.

(b) Bolinao clay

The Bolinao series is made up of soils developed from limestone. The surface soil of Bolinao clay ranges in depth from 10 to 24 centimeters.

The soil is heavy clay and has a distinct red or reddish brown color. When wet this soil is very sticky and plastic, but is friable and mellow when moist. In some areas the soils are so severely eroded that the bedrocks are exposed.

(c) Faraon clay

The soils of the Faraon series are derived from decomposition of coralline limestone. The surface soil of Faraon clay is black clay and ranges in depth from 15 to 30 centimeters. When moist it is friable, but becomes sticky and plastic when wet. The subsoil is grayish black to dark gray and is also clayey. The substratum is gray to yellowish gray, porous, soft and highly weathered limestone. In some instances the surface soil rests over a substratum that is made up of hard gray coralline limestone.

B. Soils derived from igneous materials

Basalt, andesite and volcanic tuff make up the parent material of these soils. Lava ejected from volcanic craters has been deposited layer by layer at different intervals covering mostly the western and northern portions of Negros Occidental. The following soil profiles were collected:

(a) Guimbalaon clay

The surface soil of Guimbalaon clay varies in depth from 20 to 35 centimeters. In the grassland or forest area, the surface soil is dark to grayish brown, while that of lands under cultivation for a long time is dark brown to almost reddish brown. The color becomes darker when wet. This soil is friable when moist. It is hard when dry and slightly sticky when wet. The subsoil is brown, dark brown to reddish brown clay to heavy clay loam. The dark color of the soil indicates maturity. Sometimes in very deep soils a lower subsoil exists before reaching the parent material. This is of heavy clay which is slightly plastic when wet and possesses no definite structure. The parent material, which is made up of partly weathered rocks, varies in depth from 70 to 200 centimeters. The parent material is dark brown to reddish brown, coarse granular and brittle.

(b) Guimbalaon loam

Guimbalaon loam is a medium brown soil, varying from light brown to dark brown or dark grayish brown when moist. Fields long under cultivation show a darker color of brown to almost reddish brown. This may be due to the exhaustion of organic matter and partly to good drainage. The surface soil, to a depth of from 20 to 30 centimeters, is friable or loose with a fine granular structure. Stones or boulders are comparatively few in this type, except those on the portion east of Isabela. The subsoil is brown to light brown or grayish brown loam to clay loam and at times gravelly loam. The substratum has plenty of boulder rocks placed close to one another. The rocks are angular showing that they were not water transported.

(c) Manapla loam

The surface soil of Manapla loam ranges from 15 to 25 centimeters deep and is friable when moist. The clay loam type which is present in some areas is a bit sticky when wet. The color varies from dark gray to brown and dark brown. Some iron concretions are present. The subsoil is from 20 to 50 centimeters thick and is grayish brown, dark brown to bluish gray, medium gray or light gray. It is mottled red to brown on the lower valleys, signifying poor drainage. The substratum is a thick layer of brown yellowish brown, bluish gray to light gray clay loam to clay.

(d) Tupi fine sandy loam

This soil has a surface soil with a depth from 15 to 30 centimeters and ranges in texture from sandy to silty. The soil is dark gray to grayish black when dry but becomes black when wet. It is very loose and friable and this consistency persists either when dry or wet. It is easy to plow or perform any tillage operation in this soil type. The subsoil is yellowish brown to light yellowish brown fine sand. It is friable but slightly compact with no definite form in structure. The substratum is gravelly sand, gray, friable to very slightly compact. Stones or even boulders are present on this layer.

Drainage condition as a whole is satisfactory. The grades of slopes range from 3 to 10 per cent. In spite of such slope runoff is excessive, causing both sheet and gully erosion. For this reason, the thickness of the surface soil varies to a wide degree. There are even cases when soil erosion is so severe, especially on tops of ridges, that plantings are made on the gray gravelly sand, which is already the substratum.

(e) La Castellana clay and clay loam

The development of the La Castellana series was influenced by the effects of volcanic ejecta, like the occurrence of numerous boulder outcrops, which is its distinguishing characteristic. The soils of this series were developed from andesites and basalts, and partly from volcanic tuff, breccia and other igneous rocks. La Castellana clay loam is typically dark gray or grayish brown, clay loam to silt loam. In some places, it is brown to dark brown especially when wet. The surface soil ranges from 15 to 30 centimeters deep. Due to the presence of stones and boulders on the surface, it is very difficult to till this soil.

3. Soils of the hills and mountains

The areas in this classification are too rough for farming purposes. They are covered by thick forest, stony, or steep slopes. The only soil profile sample belonging to this classification is as follows:

(a) Rough mountainous land

The areas classified under rough mountainous land are soils of non-agricultural value and are mostly derived from basalt and andesites. The humid condition and the comparatively high temperature prevailing in this locality promote intense rock weathering with the resulting formation of deep soils. In some sections outcrops of boulders are abundant. The topography is irregularly hilly and mountainous, roughly broken by very deep gullies, canyons and cliffs. The soil is well drained by many creeks and rivers. The soils found in this area are dark brown to reddish brown loam to clay loam, ranging in thickness from 20 to 35 centimeters. These soils contain high amounts of organic matter and are mellow and friable.

CLAY MINERALOGY OF FIFTEEN PHILIPPINE SOIL PROFILES

by

JEFREN L. DEMETERIO

B.S.A., University of the Philippines, 1961

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1968

The clay mineralogy of fifteen representative soil profiles from the island of Negros, the Philippines, was studied using X-ray diffraction techniques.

The soils in the flat lowlands of recent alluvial deposits showed the presence of montmorillonite in all soil types studied. Kaolinite was noted in all such soil types except the Silay fine sandy loam wherein metahalloysite was observed. Halloysite was noted in the C_2 horizons of San Manuel loam and in the Silay fine sandy loam. The mineral cristobalite was noted in almost all soil types except that of the Silay fine sandy loam, possibly revealing high temperature effects on the parent material. Feldspar was noted in all soil types except San Manuel loam which showed traces of goethite. Gibbsite, goethite and quartz were noted in the lower horizons of Silay fine sandy loam.

Three soil types derived from sedimentary materials showed the presence of montmorillonite, kaolinite and chlorite. Chlorite was predominant in one soil type (Bolinao clay). Quartz was noted in all soil types. Cristobalite, goethite, and diaspore were abundant in the Bago loam soil type.

Six soil types derived from igneous rocks exhibited varied clay make-up. Montmorillonite and kaolinite were noted in all soil types. Clino-chrysotile was apparent in the Guimbalaon clay, Tupi fine sandy loam and La Castellana clay loam. Clay mineral interstratifications of illite-montmorillonite and illite-chlorite-montmorillonite were found in the Guimbalaon loam. Goethite, feldspar, quartz, and diaspore were noted in some soil types.

Kaolinite and goethite exhibited very well defined diffraction lines in all patterns and were noted to be the only minerals present in the soils from the rough mountainous land.

No discernible effect of parent material and environment singly affecting distribution of clay minerals was noted.