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CLAY MINERALS OF SOME ARABLE SOILS IN MIYAZAKI PREFECTURE[1]

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Through the efforts and discoveries of soil scientists since two decades ago, it has established that the mineralogical nature of the clay fraction of the soil is of considerable value for interpreting the properties of the soil. We, however, have little knowledge of clay minerals of the soils in Miyazaki Prefecture.

The purpose of this work is to present data of clay minerals in some representative soils of Miyazaki Prefecture in Kyushu.

MATERIALS AND METHODS

Soil samples were taken from two rice fields on the alluvial plain of the Oyodo River and one upland field, not an irrigated one, at Saitogahara which is a common tableland being distributed in the middle eastern part of this prefecture along the sea shore. The surface soils of the tableland, Ando soils, cover the gravelly diluvial formation lying on Tertiary strata. The profile characteristics of these soils are briefly shown in Table 1, and the mechanical composition and some chemical properties of fine earths of the samples are given in Table 2.

The soil sample kept in a moist condition was repeatedly treated with 10 per cent H_2O_2 in a tall beaker, placing on a steam bath to remove organic matter. The sample thus treated was washed twice or thrice with water in a centrifugal tube, then dispersed with a little NaOH or HCl by a rotatory shaker, and allowed to stand overnight. As far as the dispersing reagents are concerned, the kind and the amounts were decided by a pre-

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Table 1. Soil samples used.

Laboratory number	Horizon	Depth (cm.)	Characteristics
Locality: Kamikomatsu, Ikime-mura, Miyazaki County, Miyazaki Pref. Alluvial soils (Flooded plain of the Oyodo River)			
I -1	A	0- 26	Grey loam.
I -2	B	26- 36	Grey loam, with numerous iron stains and concretions.
I -3	G_1	36-130	Dark grey silty clay, plastic and sticky, with many iron stains and concretions.
I -4	G_2	130-	Whitish grey sandy loam containing small pumice particles.
Locality: Hasugaike, Sumiyoshi-mura, Miyazaki County, Miyazaki Pref. Alluvial soils (Flooded plain of the Oyodo River)			
S -1	A	0- 16	Grey sandy clay loam, somewhat sticky.
S -2	BG	16- 55	Plastic clay loam. The horizon has large prismatie structure, pale grey to grey with few stains and thready concretions.
S -2	G_1	55- 90	Pale grey to grey sandy loam, with few tubular iron concretions.
S -4	G_2	90-	Pale grey sandy loam.
Locality: Kamimiya, Tusma-machi, Koyu County, Miyazaki Pref. Diluvial soils covered with volcanic ash layers. Ando soils, brown.			
T -1	1	0- 72	Blackish brown sandy loam, rich in humus.
T -2	2	72-120	Light brown sandy clay, sticky and hard.
T -3	3	120-150	Light yellowish brown sandy clay, sticky.
T -4	4	150-160	Reddish brown pumice layer.
T -5	5	160-200	Yellowish brown sandy clay containing few small angular rock fragments.
T -6	6	200-	Very stony sandy loam.

liminary dispersion test. The clay particles ($<2\mu$) were separated by siphoning off the top suspension. This fractionation was repeated for several times, and the suspensions collected were flocculated with NaCl. The precipitate was washed several times with water in a centrifugal tube, then twice with n-Ca-acetate solution at pH 5.5, several times with neutral n-Ca-acetate solution, and at last, repeatedly with 80 per cent methanol until free from Ca ions. After air-drying, the clay separates were ground by an agate pestle and stored in a desiccator containing 50 per cent H_2SO_4.

The analytical methods applied herein were the same as those in a previous paper (4).

Table 2. Some physical and chemical properties of soil samples.

	I-1	I-3	I-4	S-1	S-2
Coarse sand (2-0.2 mm.) (%)	9.20	0.24	9.43	18.79	3.29
Fine sand (0.2-0.02 mm.) (%)	32.86	8.93	56.10	28.49	30.08
Silt (0.02-0.002 mm.) (%)	31.94	41.95	24.80	26.16	37.64
Clay (below 0.002 mm.) (%)	22.80	45.48	9.33	23.29	27.27
pH(H_2O) of fresh soil	7.1	6.4	7.1	5.7	6.4
Total nitrogen (%)	0.15	0.12	0.05	0.29	0.09
Total organic carbon (%)	2.14	2.41	0.24	2.19	1.14
C/N	14.3	20.1	4.8	7.6	12.7
C.E.C. (m.e./100 gm.)	19.0	23.3	6.6	16.6	18.6
Exch. base (m.e./100 gm.)	12.6	13.8	3.3	8.0	9.8
Base saturation (%)	66.6	59.3	50.0	48.4	52.7

	S-3	S-4	T-1	T-2	T-6
Coarse sand (2-0.2 mm.) (%)	13.35	22.02	7.53	17.74	23.25
Fine sand (0.2-0.02 mm.) (%)	43.48	44.35	23.48	24.70	39.82
Silt (0.02-0.002 mm.) (%)	27.27	21.07	34.59	16.19	14.44
Clay (below 0.002 mm.) (%)	14.22	10.12	10.30	37.42	19.59
pH(H_2O) of fresh soil	5.2	4.3	5.0	5.3	5.4
Total nitrogen (%)	0.09	0.08	0.50	0.13	0.07
Total organic carbon (%)	1.12	1.63	13.60	2.64	1.97
C/N	12.5	20.4	27.2	20.3	28.1
C.E.C. (m.e./100 gm.)	12.7	9.4	42.7	20.6	10.0
Exch. base (m.e./100 gm.)	5.0	tr.	1.3	0.7	0.4
Base saturation (%)	39.6	0	3.0	3.3	4.0

Oven dry basis.

X-RAY ANALYSIS

X-ray powder diffraction patterns were obtained from the clay separates saturated with ethylene glycol (Table 3). As seen in the table, some clay separates have spacings of approximately 14 Å which may be attributed to vermiculite or chlorite. In such cases, the analysis was performed on the clays heated to 700°C. for 3 hours to distinguish one from another.

All the clays from the alluvial soils excepting I-4 (see Table 1) show somewhat similar patterns having about 10.2 Å and about 14 to 16 Å lines. As the latter line was replaced by a line at about 10Å by heating to 700°C. and 10.2Å by the treatment with KCl, it is suggested that these clays have some vermiculite, montmorin, or some interstratified minerals of both layers. It is

Table 3-1. X-ray diffraction data of Ca-clays ($<2\mu$) saturated with ethylene glycol.

I-1		I-3		I-4		S-1		S-2		S-3		S-4	
d(Å)	i*	d(Å)	i*	d(Å)	i*	d(Å)	i*	d(Å)	i*	d(Å)	i*	d(Å)	i*
13.7	V	14.2	IV			15.7	IV	15.6	IV	15.9	III	14.3	V
10.2	III	10.1	IV	10.8	I	10.0	V	10.4	II	10.2	III	10.2	II
7.3	IV	7.3	IV	7.2	V	7.2	V	7.2	V	7.3	V	7.2	IV
		4.83	VI	4.86	VI	4.91	VI	4.93	V	4.94	V	5.60	VI
												5.13	V
(4.49	II	(4.45	III	(4.44	II	(4.47	I	(4.45	I	(4.44	I	(4.45	I
3.95)	III	3.95)	IV	3.96)	III	3.95)	III	3.95)	III	3.95)	III	3.95)	III
				3.63	II			3.70	V			3.63	VI
		3.54	VI			3.51	V	3.51	V				
3.35	III	3.33	II	3.34	III	3.34	II	3.34	II	3.36	II	3.34	II
		3.20	V	3.19	V	3.18	V	3.18	IV	3.21	V		
								3.01	V			3.09	IV
								2.82	V	2.82	VI	2.82	V
2.58	III	2.58	III	(2.57	II	2.57	II	2.57	II	2.58	II	2.57	II
2.46	VI			2.46)	IV	2.46	IV	2.48	IV	2.46	IV	2.46	IV
2.37	V	2.36	V	2.36	IV	2.36	IV	2.37	IV	2.37	IV	2.37	IV
2.26	V							2.26	IV	2.26	IV	2.28	IV
		2.21	VI	2.21	V	2.23	V						
2.13	V	2.11	VI			2.12	V	2.13	IV	2.12	IV	2.12	IV
2.02	V	1.99	V	2.00	V	2.00	V	2.00	IV	1.99	IV	1.98	IV
						1.88	V	1.90	V			1.89	VI
1.84	V	1.81	IV	1.82	V	1.82	IV	1.82	IV	1.82	IV	1.82	IV
(1.68	IV	(1.70	IV	(1.70	IV	(1.71	IV	(1.71	IV	(1.71	IV	(1.71	IV
1.65)	IV	1.63)	IV	1.64)	IV	1.68)	IV	1.68)	IV	1.64)	IV	1.63)	IV
1.55	V	1.54	V	1.54	VI	1.54	IV	1.54	IV	1.54	IV	1.54	IV
1.50	III	1.50	III	1.50	III	1.50	III	1.50	III	1.50	III	1.50	III
						1.45	VI	1.45	VI	1.43	VI	1.43	VI
1.38	V	1.38	IV	1.38	VI	1.38	IV	1.42	VI				
								1.38	IV	1.38	IV	1.38	IV
								1.35	V			1.34	V

1.31 IV	1.30 IV	1.30 IV	1.30 IV	1.30 IV	1.30 IV	1.30 IV
1.25 V	1.25 VI	1.24 IV	1.25 V	1.25 V	1.25 V	1.25 V
1.20 VI	1.20 VI		1.20 V	1.23 V	1.20 V	1.20 VI
				1.20 V		
1.19 V	1.18 VI	1.18 VI	1.18 V	1.18 V		1.18 V
1.16 VI	1.15 VI	1.14 VI	1.16 V	1.15 V		
1.12 VI	1.11 VI	1.12 VI	1.13 VI	1.11 VI		1.13 V
			1.11 VI			

* i : Intensity, I : Very strong, II: Strong, III: Medium, IV : Weak, V: Very weak, VI : Barely visible, (: Reflection broadened.

obvious from strong or medium lines at 10.2, 3.34, 2.58, and 1.50 Å in the patterns of these clay separates that all these have illite as the most prominent mineral. Besides these, weaks lines of hydrated halloysite and halloysite are observed and some samples have a barely visible line at 4.86 Å, which indicates the presence of gibbsite.

The Diffraction pattern of I-4 does not indicate any vermiculite or montmorin, but hydrated halloysite with some amount of illite and little gibbsite.

Table 3-2. X-ray diffraction data of Ca-clays ($<2\mu$).

T-1 d(Å)	i*	T-2 d(Å)	i*	T-6 d(Å)	i*
		10.1	III	10.4	III
		7.3	IV	7.2	V
5.97	V				
4.87	VI	4.92	III	4.86	IV
4.46	V	(4.45	III	(4.45	II
4.09	V	4.16	IV	3.95	III
3.70	V	(3.84	VI		
		3.51	VI	3.58	VI
3.34	IV	3.38	III	3.34	III
2.93	V			2.96	VI
				2.82	VI
(2.60	V	2.60	III	2.57	III
2.45	V	2.49	V	(2.50	IV
2.36	VI	2.39	V	2.34	IV

(2.30	V			(2.27	V
(2.13	V	(2.09	VI	(2.12	V
		(2.03	VI		
1.99	VI	2.01	VI	1.98	V
1.89	VI				
1.82	VI	1.82	VI	1.81	V
		(1.72	VI	(1.71	V
		(1.64	VI	(1.63	V
		(1.52	VI	1.54	V
		(1.47	V	1.49	IV
		1.36	VI	1.38	V
				1.29	V
				1.25	V
				1.19	VI

* i: Intensity, II: Strong, III: Medium, IV: Weak, V: Very weak, VI: Barely visible, (: Reflection broadened.

The x-ray diffraction data of T-1 is quite different from the others. It has only a few barely visible lines from minerals barely known. There is no doubt that the principal mineral of T-1 is the amorphous material called allophane, which is found in general Ando soils (4), (5).

T-2 has diffraction patterns of hydrated halloysite and halloysite, but as their intensity is not so strong, these minerals seem to be contained in rather small quantities, while considerable allophane is present.

The diffraction pattern of T-6 generally resembles that of the alluvial soils except it has no lines of vermiculite or montmorin. T-6 has predominant illite with hydrated halloysite, halloysite, and gibbsite.

Differential Thermal Analysis

Differential thermograms obtained on the clay separates, being regulated by hygroscopicity of 50 per cent H_2SO_4 prior to the analysis, are shown in Figure 1.

The curves of the clays from the alluvial soils with one exception (I-4) substantially bear a resemblance in shape. They have two noticeable endothermic peaks at about 150°C. and 550°C.

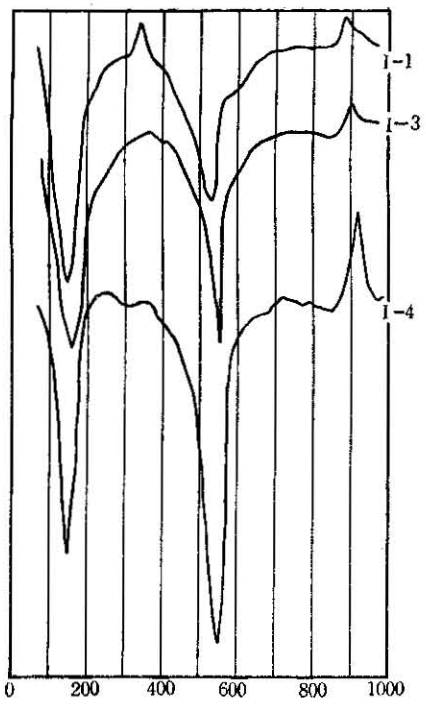

Fig. 1-1. Differential thermal curves of clay separates (<2μ) from Ikime profile.

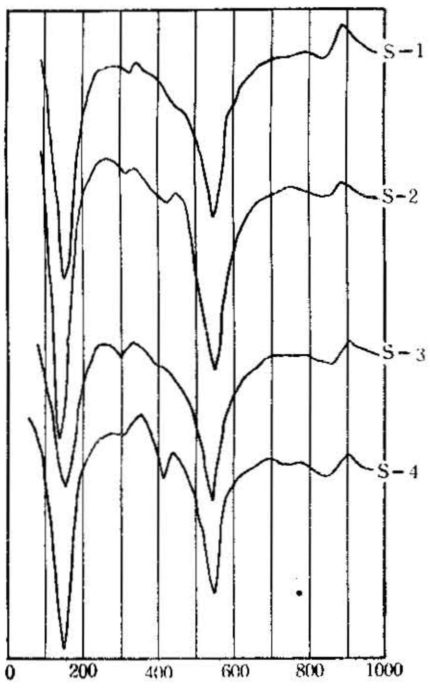

Fig. 1-2. Differential thermal curves of clay separates (<2μ) from Sumiyoshi profile.

and a distinct exothermic peak near 900°C. Besides these peaks, the curves show a small endothermic reaction at approximately 850°C. just before the exothermic peak. Amplitude of the first endothermic peak generally is greater than that of the second one, and initiation and termination of the principal reactions are rather vague. Moreover, the curves have some minor peaks between the principal peaks, as if some reactions, endothermic or exothermic, minor or major, were in succession till 1,000°C. These characteristics of the curves, in general, appear in a clay separate having predominant minerals of the illite-montmorin series. Meanwhile, the curve of I-4 seems to present a similarity to that of hydrated halloysite. It presumably contains hydrated halloysite as a major mineral, and is different from other horizons of the alluvial soils presented heretofore.

The curve of T–1 shows a gigantic endothermic peak at about 170°C. and a huge exothermic reaction between 300°C. and 500°C. The portions in dotted lines, herein, are on one-fifth of the intensity scale. The exothermic reaction may be due to organic matter remaining in the clay separate, which sometimes has been observed in surface soils having allophane, in spite of repeated treatment with H_2O_2 (4). Omitting that exothermic peak, the shape of the curve is roughly in accordance with that of allophane including other minor minerals (4).

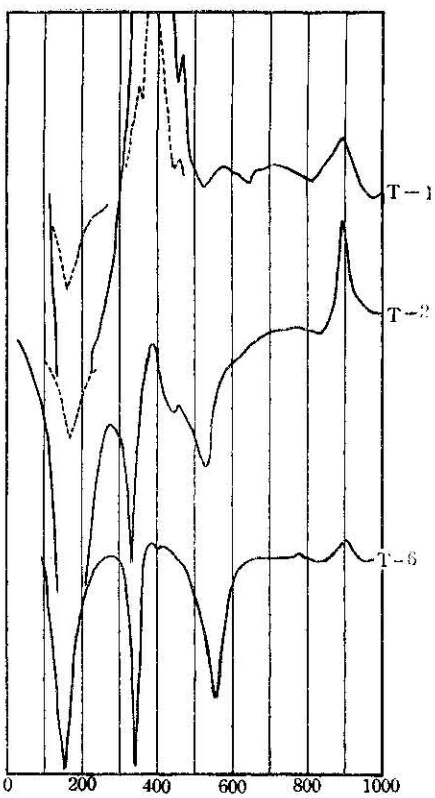

Fig. 1–3. Differential thermal curves of clay separates ($<2\mu$) from Tsuma profile.

Other curves of the Tsuma profile indicate three noticeable endothermic reactions at about 150°C., 330°C. and 550°C., and one exothermic reaction at 900°C. They may be said, hereupon, to be similar, but the relative greatness of each peak is quite different. The shape of T–2 suggests that the clay consists of a large amount of allophane and considerable hydrated halloysite with gibbsite. However, the curve of T–6 appears to be similar to that of alluvial soils with the exception of a noted peak at about 340°C. It means that the clay separate from the diluvial layer at Saitogahara contains predominant hydrous mica with considerable hydrated halloysite and gibbsite.

Dehydration Analysis

Dehydration curves of the clay separates are shown in Figure

2. As seen in the figure, the curves from the Sumiyoshi profile resemble each other. The curves indicate two comparatively great losses of water at about 50°C. to 100°C. and about 400°C. to 600°C. The latter reaction occurs in a comparatively wide range of temperature and is not as sharp as in kaolin minerals. Furthermore, a considerable loss (about 4 per cent) is noticed between 100°C. and 400°C. without any noted reaction at a special temperature. The shape of the curves may be similar to that of the three-layer minerals between illite and montmorin.

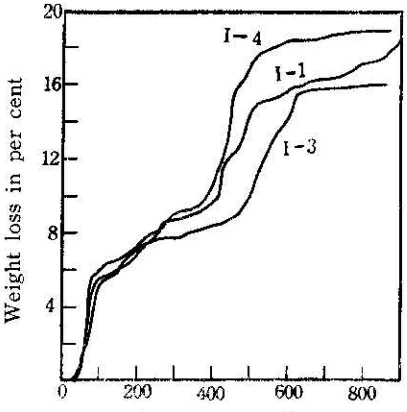

Fig. 2-1. Dehydration curves of clay separates ($<2\mu$) from Ikime profile.

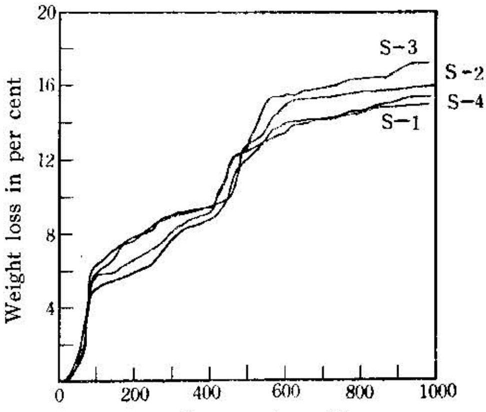

Fig. 2-2. Dehydration curves of clay separates ($<2\mu$) from Sumiyoshi profile.

Among the clay separates of Ikime soil, I-1 and I-3 have fairly similar curves with those of the Sumiyoshi soil, but I-4 differs from these in that it has a sharp and marked loss (about 8 per cent) between approximately 400°C. and 500°C. This loss can be ascribed to dehydration of kaolin mineral.

On the clay separate of T-1, a very marked loss occurs practically continuously until 500°C., and its total loss amounts to about 35 per cent; this is not known in any clay minerals exclusive of allophane. There is some resemblance between the curves of T-1 and T-2, but the latter differs from the former in that it has two appreciable dehydration reactions at about 250°C. and 420°C., and also has far less total loss (about 25 per cent). The two reactions may be due to R_2O_3 hydrate, probably gibbsite, and halloysite, presumably hydrated halloysite. The curve of T-6 is similar to those of the Sumiyoshi soil with the exception of marked dehydration at about 250°C.

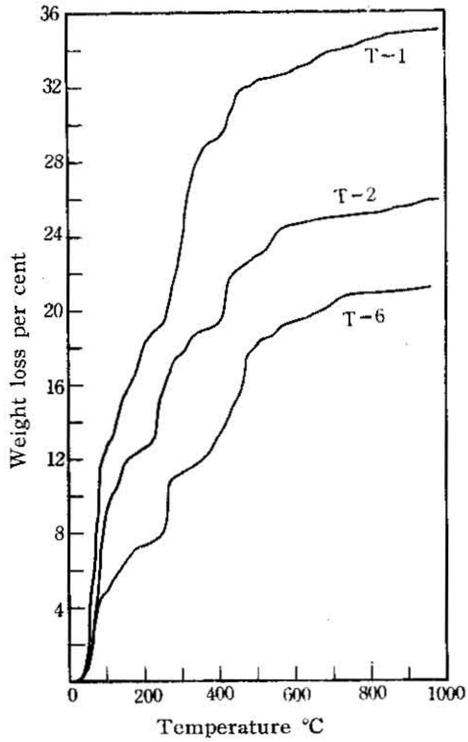

Fig. 2-3. Dehydration curves of clay separates ($<2\mu$) from Tsuma profile.

Chemical Analysis

Chemical composition, cation-exchange capacity, and phosphate retention of the Ca-clays or Na-clays ($<2\mu$) are shown in Table 3.

The Ca-clay separates from the two alluvial profiles, except I-4, are noted to have rather high molecular ratios of silica to alumina (2.97 to 3.45 per cent), and considerable quantities of MgO (1.19 to 1.90 per cent) and K_2O (1.43 to 3.45 per cent). These results suggest that the separates have some three-layer type minerals as a main component, which is of illite or an interstratifying illitic mineral.

The clay of I-4, meanwhile, shows a decidedly lower content of K_2O (0.53 per cent) and MgO (0.53 per cent) and a lower ratio

Table 4. Chemical analyses of Ca-clays (< 2μ).

		I-1	I-3	I-4	S-1	S-2
SiO_2	(%)	44.75	49.79	45.46	48.77	50.99
Al_2O_3	(%)	25.63	27.68	32.43	25.92	25.12
Fe_2O_3	(%)	10.01	5.53	6.10	9.33	8.83
MnO	(%)	0.10	tr.	tr.	tr.	0.02
MgO	(%)	1.57	1.19	0.53	1.90	1.72
CaO	(%)	1.19	0.79	1.15	0.69	0.76
Na_2O	(%)	0.35	0.63	0.49	0.43	0.38
K_2O	(%)	1.49	1.43	0.53	1.51	2.10
P_2O_5	(%)	0.39	0.19	0.28	0.43	0.32
TiO_2	(%)	0.87	0.60	0.12	0.82	0.65
$H_2O(+)$	(%)	12.51	11.22	13.10	9.86	9.09
Total	(%)	98.86	99.05	100.19	99.66	99.98
Free Fe_2O_3*	(%)	5.62	1.69	2.25	3.21	2.49
Molecular ratio	SiO_2/Al_2O_3	2.97	3.05	2.38	3.20	3.45
	SiO_2/R_2O_3	2.37	2.70	2.13	2.37	2.82
C.E.C.	(m.e./100 gm.)	46.7	41.9	39.6	48.0	44.2
P.R.	(m. mol./100 gm.)	17.5	12.4	36.8	25.5	7.3
C.E.C./P.R.§		2.67	3.38	1.08	1.88	6.05

		S-3	S-4	T-1	T-2	T-6
SiO_2	(%)	49.73	46.64	24.76	32.00	37.35
Al_2O_3	(%)	27.16	25.89	30.09	32.93	32.86
Fe_2O_3	(%)	6.66	8.65	11.13	10.48	11.90
MnO	(%)	0.10	0.02	0.25	0.29	0.27
MgO	(%)	1.58	1.60	0.50	1.43	1.40
CaO	(%)	0.79	0.69	4.24	1.49	0.56
Na_2O	(%)	0.43	0.40	0.37	0.02	tr.
K_2O	(%)	2.18	2.24	0.45	0.48	1.46
P_2O_5	(%)	0.52	0.63	0.88	0.64	0.66
TiO_2	(%)	0.95	0.63	1.18	0.77	0.73
$H_2O(+)$	(%)	8.92	10.86	25.98	20.37	13.25
Total	(%)	99.02	98.25	99.83	100.90	100.44
Free Fe_2O_3*	(%)	4.81	3.05	10.63	9.31	9.63
Molecular ratio	SiO_2/Al_2O_3	3.11	3.06	1.40	1.65	1.93
	SiO_2/R_2O_3	2.69	2.52	1.13	1.37	1.57
C.E.C.	(m.e./100 gm.)	39.8	37.3	40.6	36.2	34.4
P.R.	(m. mol./100 gm.)	13.3	33.9	296.2	103.7	21.0
C.E.C./P.R.§		2.99	1.10	0.14	0.35	1.64

Expressed on oven-dry basis.

* Determined by Truog's method (10).

§ Cation-exchange capacity (C.E.C.), Phosphate retention (P.R.).

of silica to alumina (2.38) than those of the clay separates from the other horizons of the alluvial soils. This fact indicates that the clay is rather kaolinic, and granting some three-layer type mineral is contained, its content must not be much.

Chemical composition of the T-2 clay separate bears some resemblance to that of T-1. It is also suggested that the separate contains much allophane with some other minerals having a high ratio of silica to alumina. The clay separate of T-6 has a considerably high content of MgO and K_2O, but its ratio of silica to alumina is rather low (1.93). This clay presumably has some illitic minerals and certain minerals having a low ratio of silica alumina.

Furthermore, the clay fractions of the upland soil, in general, contain more MnO and free iron than those of the alluvial soils. Indeed, free iron content of the upland clays comes to approximately 90 per cent of total iron.

Among the cation-exchange capacity of the clay separates, any great difference is not observed, but the phosphate retention is shown to be very variable from sample to sample. The greatest figure of the phosphate retention is about 300 millimols per 100 gm. of S-2. A very low figure in the ratio of cation-exchange capacity to phosphate retention and a large figure of phosphate retention may be useful in distinguishing allophane from other minerals.

ELECTRON MICROSCOPY

Electron microgrphs of the representatives of the clay separates ($< 2\mu$) are shown in Figure 3.

The clays from the alluvial soils except I-4 have similarly shaped particles. Most particles are thin plates with somewhat distinct edges and small holes on the surface, and they often appear to occur in irregular stacks as in figure 3-1. Besides these particles, the clays have a few tubular particles.

The electron micrograph of I-4 shows small, well-defined, and somewhat short rod-like particles with thin plates. The former bear much resemblance in shape to hydrated halloysite derived from volcanic ash (3), (9).

The electron micrograph of T-I shows hair-like particles in addition to irregular, indefinitely shaped aggregates. The clay separate of T-6 has both thin plates as seen in the alluvial soils and short rods as observed in I-4.

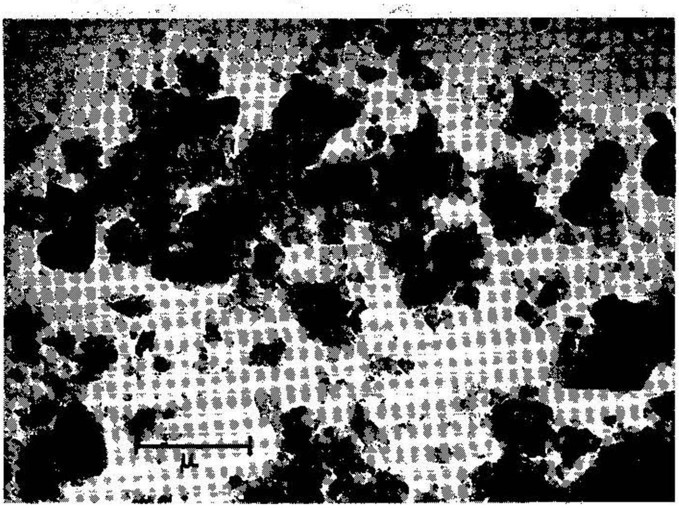

Fig. 3-1. Electron micrograph of Ca-clay ($<2\mu$) from G_1 horizon at Ikime (I-3).

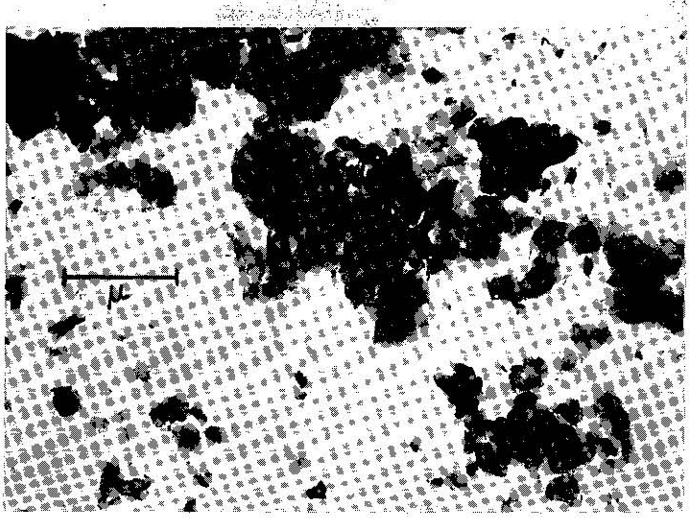

Fig. 3-2. Electron micrograph of Ca-clay ($<2\mu$) from G_2 horizon at Ikime (I-4).

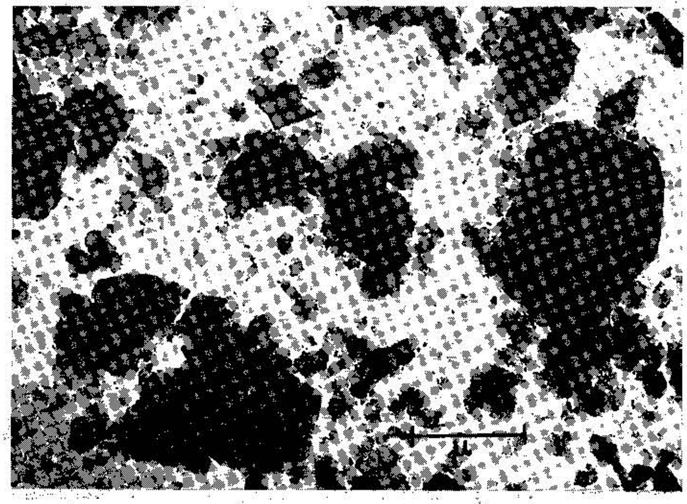

Fig. 3-3. Electron micrograph of Ca-clay ($<2\mu$) from A horizon at Sumiyoshi (S-1).

Fig. 3-4. Electron micrograph of Ca-clay ($<2\mu$) from the first horizon at Tsuma (T-1).

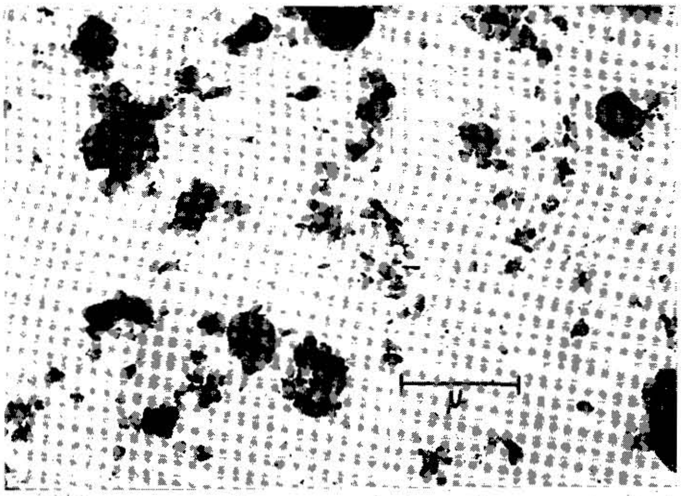
Fig. 3-5. Electron micrograph of Ca-clay ($<2\mu$) from the sixth horizon at Tsuma (T-6).

DECOMPOSITION OF ORGANIC MATERIALS IN THE SOILS

Dissolved albumin or pulverized cellulose (filter paper) was added to 1 gm. of air-dried Ca-soils in a 10 c.c. porcelain dish. For this experiment, the soils used were prepared as follows: fine earths of S-1, T-1, and Ariake clay (2) were washed in order with H_2O, n-$Ca(CH_3COO)_2$, H_2O, and 80 per cent methanol, after removing organic matter by treatment with H_2O_2, as in the preparation of the clay separates. A mixture of KH_2PO_4 (4 mgm.) and $MgSO_4$ (0.25 mgm.) was, in general, added to a dish, and 10 mgm. of NH_4NO_3 were also supplied to the dish in which cellulose was added. In another experiment, varied amount of KH_2PO_4 were supplied to the dish with $MgSO_4$ (0.25 mgm.), as shown in Table 5. Furthermore, the soils in the dishes were inoculated with soil infusion from fertile garden soil, and brought to water-logged condition by adding water. The dishes were covered with a watch glass and allowed to incubate at 30°C. for a desired period, water being added from time to time. Remaining organic carbon in the soils was determined by the chromic acid method. All treatments were run in pairs and data was obtained by the average of duplicate analyses of a single sample.

Table 5. Organic carbon retention in soils treated with H_2O_2 following addition of albumin.

Soil	Treatment KH_2PO_4	After 5 days Total	After 5 days Added C	After 10 days Total	After 10 days Added C	After 30 days Total	After 30 days Added C
	mgm.	mgm.	%	mgm.	%	mgm.	%
	0	17.1	74	15.5	67	7.0	30
Ariake	4	15.8	69	11.1	48	5.8	25
	10	16.1	70	11.8	51	6.2	27
	0	15.8	69	12.0	52	5.6	24
S-1	4	15.0	65	8.6	37	5.0	22
	10	14.1	61	8.1	35	4.8	21
	0	17.9	78	17.5	76	17.1	74
T-1	4	16.7	73	16.2	70	14.4	63
	10	16.4	71	15.2	66	13.5	59

50 mgm. of albumin was added to 1 gm. of air-dried soils.

According to the results obtained, decomposition of the organic materials was slower in the T-1 soil than in the others, albumin was more rapidly decomposed in every soil than cellulose, and the rate of the decomposition increased with the amount of organic matter in the limits of the experiment.

The Table 5 shows that mineralization of albumin is more or less promoted by the addition of phosphate, and mineralization in the T-1 sample is distinctly slower than in the other soils in each level of the phosphate.

General Consideration

The x-ray analysis furnished following results: a) all samples of the alluvial soils, except one from the G_2 horizon of Ikime, have dominant hydrous mica, b) the clay fractions of G_2 at Ikime and the diluvial layer of the Saitogahara profile consist of hydrated halloysite and a considerable amount of hydrous mica, c) the clay separate of the subsoil at Saitogahara contains some hydrated halloysite, but its surface soil has a little amount of crystalline minerals in the clay fraction. Other experiments, chemical, thermal, and electron microscopical methods applied hereupon, substantiated these results by the presentation of characteristics in each aspect.

The hydrous mica coexists with some expanding lattice layer minerals, as the x-ray analysis indicates. The minerals are thin plates in shape having many small holes on the surface, and have considerable potash and iron. Their thermal curves show somewhat intermediate features of illite and montmorin. These results suggest that the clay fractions of the alluvial soils of the Oyodo River come from illite in shales and sandstones of Neogene formations, and the mineral has been turning into vermiculite, and further into montmorin in the soil, disintegrating and replacing K ions with H ions. Therefore, the clay fractions contain various minerals from illite to montmorin and interstratified specimens of these, namely, minerals of the illite-montmorin series.

The G_2 horizon of the Ikime profile is quite different, not only in general characteristics but also in mineralogical make-up of the clay fraction from other profiles of the alluvial soils. There is no doubt that the horizon has been mainly derived from ejecta, because it contains abundant grey pumices and glass shards, which are not found in other horizons. According to the x-ray analysis, the clay fraction of this horizon contains much hydrated halloysite and considerable hydrous mica; on the other hand, the chemical analysis shows that the fraction has a definitely higher molecular ratio of silica to alumina than hydrated halloysite, and a considerable amount of MgO and K_2O. These facts in the results of the chemical analysis may be taken as an illustration of the results obtained in the x-ray analysis. Furthermore, the electron micrograph shows some thin plate-like particles which look like hydrous mica particles seen in other horizons. As the hydrated halloysite bears resembleance in shape to that derived from volcanic ash and pumice in Japan (3), (9), it may be a weathering product of ejecta. Meanwhile, hydrous mica has presumably come from its upper horizons by the downward flow of water.

The upland soil at Saitogahara consists of various horizons differing from the alluvial soils. The uppermost horizon (T-1) has a predominance of allophane in the clay fraction. That fraction gives no diffraction lines in the x-ray analysis except for a few very weak or barely visible ones. It has unique characteristics of chemical composition, differential thermograms, dehydration curve, phosphate retention, and shape. It contains a considerable amount of iron (11.13 per cent) in addition to three principal constituents, i. e. SiO_2, Al_2O_3, and H_2O, but over 95 per cent of this iron is made soluble by the Truog's treatment (10). The hair-like particles were already reported by several workers in Japan (4), (6) in volcanic ash soils, and a bauxitic clay derived from the ashes (7). Kinoshita and Muchi (7) stated that the particles were hydrated halloysite, but we could not find any evidences of hydrated halloysite in the hair-like particles in our sample.

The subsoil has hydrated halloysite, allophane, and gibbsite as main clay minerals, and the content of hydrated halloysite increases on going down the profile; the reverse is true for allophane. In this sense, the clay fraction of the volcanic ash soils may be said to be a series of allophane-hydrated halloysite. The clay fraction of the diluvial layer is quite different from overlying volcanic ash layers, and has hydrous mica, presumably illite, with hydrated halloysite and gibbsite which are recognized by the x-ray, differential and dehydration analyses.

Some workers have found that clays inhibit the mineralization of organic materials, and capacity of the inhibition depends upon the kind of clay minerals and the clay content in soils (1), (8). The order of clay minerals in the inhibition was found to be as follows: Montmorillonite > Illite > Kaolinite.

Since the clay content of T-1 is not higher than the S-1 and Ariake soils, the slowness in the former soil must be chiefly due to quality of the fraction. It also cannot be explained merely by the cation-exchange capacity of clays as Mortland and Gieseking have done (8), because the orders of both the capacity of cation-exchange and the rapidity of the decomposition of organic materials do not coincide with each other in our experiments. Marked retardation of the mineralization in T-1 may be partly due to the deficiency of phosphate for microbial activity; because allophane fixes phosphate very much, as seen in table 4, even heavy applications of phosphate did not improve the character appreciably.

SUMMARY AND CONCLUSIONS

Clay separates from the alluvial soils of the Oyodo River and

diluvial upland soil at Tsuma-machi in Miyazaki Prefecture were examined by the techniques of x-ray diffraction, electron microscopy, phosphate retention, cation-exchange capacity, and thermal and chemical analyses with decomposition tests for organic materials.

The clay separates of the alluvial soils consist mainly of hydrous mica and vermiculite with some montmorin and intermediates between illite and montmorin. It is suggested that hydrous mica has come from illitic shales and sandstones of Neogene formations, and vermiculite and montmorin layers have originated from hydrous mica. That is, the alluvial soils of the Oyodo River in the Miyazaki Plain contain predominant minerals of the illite-montmorin series in the clay fraction.

One of these soils at Ikime has an underlying layer derived from ejecta, of which the clay fraction consists mainly of hydrated halloysite with subsidiary hydrous mica.

The diluvial tableland of Saitogahara is covered with volcanic ash soils, brown Ando soils, for several feet in thickness. The horizons of this soil profile disagree in clay minerals with each other. The clay fraction of the uppermost horizon consists mainly of allophane, but the horizons of the subsoil have hydrated halloysite, allophane, and gibbsite, and, in fact, the content of hydrated halloysite has a tendency to increase with depth, while the diluvial layer has hydrous mica with hydrated halloysite and gibbsite.

This seems to suggest that the clay mineral of the soil is definitely related to the parent material of the soil.

It is worthy of notice that the decomposition of organic matter is markedly slower in the soil having allophane as a dominant clay mineral than in the soils of illite or illite-montmorin.

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