A Study of the Soil for Coating the Stems of Mat Rushes

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(Plates 1-3; Text-figs. 1-6; Tables 1-25)

(I) INTRODUCTION

Japanese mats are one of the most important furnishings in the Japanese daily life. The mats are made by placing a matting of rushes on a woven rice straw. The size of mat is ca. 1 m wide, ca. 2 m long and ca. 5 cm thick.

The mat rush (*Juncus effusus* L. var. *decipiens* BUCHEN) is a perennial plant and is almost always transplanted in the paddy field in November. In the latter part of July the plant is harvested in the early morning on days of good weather and soaked in the mud water. After soaking, the stems of the mat rush are spread on the ground for drying. Soaking the stems of the mat rush in the mud water hastens the drying of the stems. Quick drying of the stems of the mat rush is necessary in order to prevent the oxidation of chlorophyll in the stems and thus preserve the brand-new look of the stems. All Japanese are fond of brand-new mats.

Up to date studies on the breeding1)2), cultivation3)4)5) and fertilizing6)7)8)9)10)11)12)13) of mat rushes have been carried out, but not yet on soil colloid which coats the stems. So the nature and properties of this soil colloid were studied by the authors.

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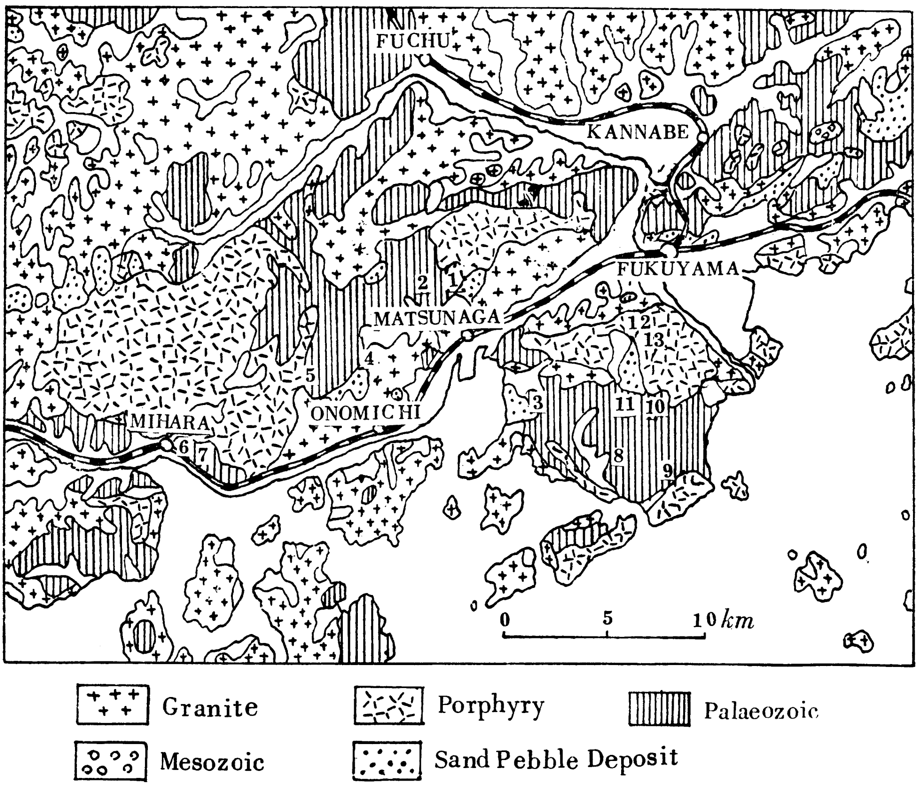
(II) EXPERIMENT

1) Producing districts and geological system of soils

The best known producing districts of soils which coat the stems of mat rushes are Hiroshima Prefecture and Hyôgo Prefecture in the Chûgoku District. In Hiroshima Prefecture, the producing districts are limited to those areas near Mihara, Onomichi and Matsunaga in the southeast part of the Prefecture. In Hyôgo Prefecture the producing district is Akashi, in the south part of the Prefecture. The geological system of these producing districts is shown in Table 1.

Table 1. Geological system of producing districts

No.	Locality	Geological system
	Hiroshima Prefecture	
1	Matsunaga, Kamura	Palaeozoic
2	// Hongô	//
3	// Kanae	//
4	Onomichi, Kajiyamada	Granite
5	// Takasu	Palaeozoic
6, 7	Mihara, Fukamachi	//
8	Numakuma-gun, Shirahama	//
9	// Tomoji	//
10	// Mizuochi	//
11	// Kumano, Uenohara	//
12, 13	Fukuyama, Seto	Granite Porphyry
	Hyôgo Prefecture	
14	Akashi, Ôkura	Diluvium
15	// Ôkubo	//



Text-fig. 1. Geological map of the southeastern part of Hiroshima Prefecture

There are eleven producing districts in Hiroshima Prefecture. The geological system of soil found at Kajiyamada belongs to Granite, at Seto to Granite Porphyry, and in the other areas to Palaeozoic. The nature and properties of the soils differ according to the districts, and since all soil horizons are very thick, it is considered that a supply for many years in the future may be possible.

The producing districts in Hyôgo Prefecture form a table land, and its geological system is Diluvium. The soil class belongs to clay and texture of the soil is very compact.

2) pH and soil color

After drying and sieving, pH of soils was determined by the glass electrode. The color of the dried soils was compared to the Standard Color Chart.

Table 2. pH and soil color

No.	Locality	pH	Soil color
1	Kamura	4.95	whitish grey
2	Hongô	6.70	〃 〃
3	Kanae	6.15	light, brownish grey
4	Kajiyamada	4.85	light, yellowish grey
5	Takasu	4.55	yellowish grey
6	Fukamachi A	5.40	light, yellowish grey
7	〃 B	5.80	whitish grey
8	Shirahama	4.90	light, brownish grey
9	Tomoji	5.75	light, yellowish grey
10	Mizuochi	6.30	yellowish grey
11	Uenohara	6.06	〃 〃
12	Seto A	5.60	light, brownish grey
13	〃 B	5.71	〃 〃 〃
14	Ôkura	6.15	bluish grey
15	Ôkubo	6.21	〃 〃

Soil color was divided into five groups: whitish grey (1. Kamura, 2. Hongô, 7. Fukamachi B); light, yellowish grey (4. Kajiyamada, 6. Fukamachi A, 9. Tomoji); yellowish grey (5. Takasu, 10. Mizuochi, 11. Uenohara); light, brownish grey (3. Kanae, 8. Shirahama, 12, Seto A and B); and bluish grey (14. Ôkura, 15. Ôkubo). There are some differences in soil color to observe in detail. For example, though color of Kamura soil is whitish grey, it looks bluish grey in some parts.

The lowest pH of soil is 4.55 and the highest is 6.70. In fifteen samples, four soils show pH 4.0, five 5.0 and six 6.0. The reaction of all soils is acid.

3) Chemical properties of soils

a) *Moisture content:* Place 1 g of air-dried fine soil in a wide-mouthed weighing bottle and heat at 105°C in an electric oven 5 hours. Report loss in weight as % based upon H_2O-free weight of sample.

b) *Loss on ignition:* Ignite soil to full redness in crucible, stirring occasionally, until organic matter is destroyed. Cool in desiccator, weigh and report % loss in weight as loss on ignition.

c) *Total nitrogen:* Digest 10 g of soil in 500 ml Kjeldahl flask with 30–40 ml of H_2SO_4 and ca. 10 g of salt mixture (9 parts of K_2SO_4 and 1 part of $CuSO_4$). Continue digestion until mixture is colorless or nearly so. After cooling, dilute contents of flask with H_2O, add excess of ca. 45% NaOH solution, connect flask with condenser and distill 150 ml into standard acid. Titrate excess acid with 0.1 N alkali, using methyl red indicator.

d) *Humus:* Humus was determined by the wet combustion method, namely by decomposing the organic matter with chromium sulphate, absorb CO_2 in KOH of kali-bulb. Weigh kali-bulb and multiply 0.5.

e) *HCl soluble matter:* Put 5 g air dried fine soil in 300 ml flask, add 50 ml HCl (sp. gr. 1.10) and heat one hour in water bath. After filtration, separate SiO_2 and other elements were determined by the usual methods.

The contents of several elements determined by the above mentioned methods are shown in Table 3.

As shown above there are some differences in several elements of the soils in both Hiroshima and Hyôgo Prefectures. In the soils of Hiroshima Prefecture, the content of moisture, loss on ignition, humus, total nitrogen, Na_2CO_3 soluble SiO_2, Al_2O_3, Fe_2O_3, TiO_2 and MnO seemed to be more in dark color soils than in light color soils, but no such tendency was found with CaO, MgO, P_2O_5, SO_3, K_2O and Na_2O.

In comparing the average result of soils in Hiroshima Prefecture with those of Hyôgo Prefecture, the content of total nitrogen, Fe_2O_3, CaO and MgO is more in Hyôgo Prefecture soils than in Hiroshima Prefecture ones.

4) Soil colloid and its chemical properties

Soil particles which have a diameter of less than 0.002 mm are regarded as soil colloid, and colloid is separated by the sedimentation method. The International Pipette Method is the sedimentation method and the separated soil particles with diameter of less than 0.002 mm are designated as clay.

The sedimentation method has some defects such as the length of time required for separation, the possible occurrence of convection by variation in temperature and the possible putrefaction of soils rich in organic matter.

As soils used for the coating of mat rushes contained little or no organic matter owing to the composition and soil color as seen in Table 3, there was no fear of putrefaction of organic matter during the separation of soil colloid.

Soil colloid was separated in a room where a constant temperature was maintained, so that there was no convection by the variation of temperature.

The content of clay, that is soil colloid, is 39.65% in maximum, 8.32% in minimum and 23.07% in average, and it seems that the content is more in dark colored soils than

Table 3. Chemical composition (1)

No.	Locality	Soil color	Moisture %	Loss on ignition %	Humus %	Total N %	HCl sol. SiO_2 %	Na_2CO_3 sol. SiO_2 %	Total SiO_2 %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %	MnO %	CaO %	MgO %	P_2O_5 %	SO_3 %	K_2O %	Na_2O %
1	Kamura	whitish grey	1.21	2.87	0.089	0.002	0.114	8.744	8.858	2.712	1.157	0.046	0.010	0.100	0.022	0.055	0.103	0.171	0.180
2	Hongô	〃 〃	1.22	2.78	0.025	0.009	0.120	10.578	10.698	1.779	1.158	0.035	0.008	0.093	0.015	0.048	0.086	0.113	0.188
7	Fukamachi B	〃 〃	2.34	3.91	0.025	0.003	0.098	7.273	7.371	9.992	0.798	0.046	0.017	0.110	0.076	0.123	0.048	0.235	0.188
4	Kajiyamada	light, yellowish grey	1.32	6.94	0.089	0.011	0.118	7.603	7.721	3.743	1.956	0.046	0.012	0.101	0.018	0.045	0.052	0.250	0.236
6	Fukamachi A	〃 〃 〃	2.91	3.44	0.026	0.006	0.061	7.812	7.873	3.769	1.112	0.048	0.014	0.111	0.101	0.101	0.060	0.097	0.215
9	Tomoji	〃 〃 〃	2.11	2.00	0.064	0.014	0.086	11.384	11.470	3.370	1.637	0.093	0.030	0.137	0.033	0.110	0.086	0.277	0.174
5	Takasu	yellowish grey	2.94	4.68	0.095	0.008	0.116	10.593	10.709	5.573	2.196	0.046	0.010	0.080	0.072	0.035	0.062	0.224	0.226
10	Mizuochi	〃 〃 〃	2.12	4.65	0.087	0.014	0.080	28.262	28.342	12.549	6.707	0.543	0.080	0.127	2.513	0.091	0.172	0.259	0.231
11	Kumano	〃 〃 〃	2.89	5.51	0.329	0.011	0.071	22.088	22.159	10.741	5.908	0.514	0.083	0.124	0.862	0.065	0.127	0.263	0.229
3	Kanae	light, brownish grey	4.48	8.94	0.063	0.028	0.108	27.970	28.070	11.587	6.946	0.542	0.048	0.295	1.589	0.076	0.069	0.293	0.236
8	Shirahama	〃 〃 〃	3.11	5.49	0.193	0.016	0.120	14.380	14.500	7.308	5.349	0.210	0.025	0.146	0.056	0.112	0.069	0.214	0.175
12	Seto A	〃 〃 〃	5.39	10.23	0.055	0.014	0.061	21.495	21.556	11.913	3.553	0.243	0.037	0.112	0.109	0.039	0.132	0.236	0.199
13	〃 B	〃 〃 〃	3.06	6.81	0.288	0.040	0.098	12.919	13.017	7.748	3.433	0.204	0.046	0.100	0.211	0.043	0.086	0.230	0.141
14	Ôkura	bluish grey	3.96	3.49	0.144	0.280	0.001	16.525	16.526	7.940	5.751	0.054	0.056	1.400	1.955	0.116	0.084	0.338	0.273
15	Ôkubo	〃 〃	3.07	5.96	0.067	0.275	0.002	12.625	12.627	6.844	5.113	0.041	0.037	0.735	1.548	0.116	0.084	0.338	0.278

Table 4. Chemical composition (2)

	Hiroshima Prefecture			Hyôgo Prefecture
	Maximum %	Minimun %	Average %	Average %
Moisture	5.390	1.210	2.700	3.527
Loss on ignition	10.230	2.000	5.250	4.953
Humus	0.329	0.025	0.109	0.105
Total N	0.040	0.002	0.013	0.377
HCl sol. SiO_2	0.120	0.061	0.096	0.001
Na_2CO_3 sol. SiO_2	28.262	7.273	14.700	14.575
Total SiO_2	28.302	7.371	14.795	14.576
Al_2O_3	12.549	1.779	7.137	7.392
Fe_2O_3	6.946	0.748	3.223	5.432
TiO_2	0.543	0.035	0.201	0.047
MnO	0.083	0.008	0.032	0.046
CaO	0.295	0.080	0.126	1.067
MgO	2.513	0.015	0.436	1.751
P_2O_5	0.123	0.035	0.076	0.081
SO_3	0.172	0.048	0.089	0.070
K_2O	0.282	0.097	0.219	0.346
Na_2O	0.236	0.141	0.185	0.275

Table 5. Mechanical analysis of soils

No.	Locality	Coarse sand (2-0.2mm)	Fine sand (0.2-0.02mm)	Silt (0.02-0.002mm)	Clay (<0.002mm)	Soil color
1	Kamura	34.41	38.97	10.98	15.64	whitish grey
2	Hongô	41.50	36.50	13.68	8.32	//
7	Fukamachi B	45.28	29.95	5.45	19.32	//
4	Kajiyamada	48.76	16.21	19.15	15.88	light, yellowish grey
6	Fukamachi A	33.00	38.59	16.37	12.04	//
9	Tomoji	29.71	26.66	22.31	21.32	//
5	Takasu	43.29	28.82	11.84	16.05	yellowish grey
10	Mizuochi	22.47	28.08	22.07	27.38	//
11	Uenohara	28.20	19.46	26.34	26.00	//
3	Kanae	8.88	24.87	31.67	34.58	light, brownish grey
8	Shirahama	50.52	11.76	16.34	21.38	//
12	Seto A	16.92	18.71	32.67	31.70	//
13	// B	18.65	21.69	30.93	28.73	//
14	Ôkura	0.05	37.32	22.98	39.65	bluish grey
15	Ôkubo	0.10	9.49	62.36	28.05	//

in light colored soils.

Separated colloid was put in a weighing bottle and the content of combined water was calculated by loss on the ignition reduced moisture content.

1 g soil colloid was weighed in a platinous crucible, mixed with anhydrated Na_2CO_3 and

Table 6. Chemical composition of soil colloid

No.	Locality	H_2O^-	H_2O^+	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	P_2O_5	CaO	MgO	MnO	K_2O	Na_2O
1	Kamura	4.035	0.982	48.623	29.501	12.981	0.702	0.300	0.523	0.432	0.121	0.761	0.513
2	Hongô	5.880	0.928	51.035	26.761	11.087	0.525	0.525	0.761	0.512	0.129	0.899	0.768
7	Fukamachi B	3.640	1.120	50.216	29.168	10.638	0.489	0.701	0.896	0.512	0.123	0.986	0.878
4	Kajiyamada	4.119	1.080	49.168	29.629	11.921	0.599	0.426	0.764	0.461	0.213	0.861	0.981
6	Fukamachi A	3.390	0.837	49.221	29.051	11.956	0.399	0.798	0.671	0.629	0.216	1.001	0.861
9	Tomoji	4.770	1.002	50.201	28.729	11.614	0.200	0.600	0.625	0.301	0.211	0.862	0.961
5	Takasu	6.164	1.001	48.916	28.493	11.798	0.199	0.213	0.817	0.600	0.124	0.862	0.961
10	Mizuochi	4.308	0.986	50.628	27.017	12.963	0.412	0.534	0.861	0.512	0.131	0.996	0.862
11	Uenohara	3.774	0.913	48.973	30.952	11.116	0.500	0.410	0.413	0.391	0.120	1.001	0.816
3	Kanae	3.587	1.226	50.523	25.534	14.320	0.300	0.901	0.964	0.623	0.101	1.103	0.986
8	Shirahama	3.432	0.944	46.287	29.952	13.964	0.790	1.198	0.861	0.514	0.206	0.849	0.716
12	Seto A	5.540	1.063	45.249	29.859	13.817	0.701	0.300	0.986	0.627	0.121	0.819	0.769
13	// B	8.396	1.116	44.343	27.792	12.986	0.906	0.402	0.986	0.762	0.291	0.900	0.816
14	Ôkura	5.861	7.882	46.360	24.658	8.309	0.695	0.130	0.900	2.607	1.235	0.795	0.285
15	Ôkubo	3.491	6.090	45.521	27.015	9.588	0.696	0.192	2.000	3.059	1.015	0.826	0.201
	Hiroshima Prefecture												
	Maximum	8.396	1.226	50.628	30.952	14.320	0.906	1.198	0.986	0.762	0.291	1.103	0.986
	Minimum	3.390	0.913	44.343	25.534	10.638	0.199	0.213	0.413	0.301	0.101	0.761	0.513
	Average	4.695	1.015	48.721	28.649	12.397	0.517	0.562	0.779	0.528	0.162	0.913	0.837
	Hyôgo Prefecture												
	Average	4.676	6.986	45.940	25.836	8.948	0.695	0.160	1.450	2.833	1.125	0.810	0.243

Note: H_2O^- shows moisture evaporated at 100°C. H_2O^+ shows moisture evaporated during 100°C to ignition.

fused in electric furnace at 1000°C. After cooling, dissolve in HCl solution, SiO_2 in the solution was separated by the usual method. The filtrate after separation of SiO_2, Al_2O_3, Fe_2O_3, TiO_2, MnO, CaO, MgO and P_2O_5 were determined by the usual method. K_2O and Na_2O were determined by the Lawrence Smith Method[14], namely fused sample with $CaCO_3$ and NH_4Cl. Chemical reaction occurs as follows:

$$2KAlSi_3O_8 + 6CaCO_3 + 2NH_4Cl = 6CaSiO_3 + 6CO_2 + Al_2O_3 + 2NH_3 + H_2O + 2KCl$$

Extract with H_2O, alkali metals and one part of calcium dissolved in H_2O as chloride, other metals remain such as oxide and silicate as Ca-silicate.

After treating Ca-salts in aqueous solution, K_2O was determined by the platinum-chloride method. Content of Na_2O was calculated by the difference between the sum of KCl+NaCl and KCl.

Chemical composition of soil colloid by the above mentioned methods are shown in Table 6.

As compared with the composition of soil colloids produced from both Hiroshima and Hyôgo Prefectures, there is much more H_2O contained in Hyôgo Prefecture soil colloid. SiO_2 and Al_2O_3 show no appreciable difference in either Prefectural colloids. Contents of Fe_2O_3 and P_2O_5 are less in Hyôgo Prefecture soil colloids than in Hiroshima soil colloids, especially P_2O_5 which decreases markedly. On the contrary contents of CaO and MgO are much higher in Hyôgo soil colloids than in Hiroshima soil colloids. MnO, K_2O and Na_2O show no appreciable difference.

ROBINSON & HOLMES[16)17)] separated the soil particle, smaller than 0.003 mm in diameter, from 45 soils in several places in the U. S. A. and showed the following results.

SiO_2	55.44～31.84%
Al_2O_3	38.28～16.42%
Fe_2O_3	16.67～4.66%

Maximum, minimum and average values of elements in colloids separated from soils in several parts of Japan[18)19)20)] are shown in Table 7.

Table 7. Maximum, minimum and average values of elements

	Maximum	Minimum	Average
SiO_2	54.17%	24.62%	37.65%
Al_2O_3	30.44	13.92	21.97
Fe_2O_3	14.29	5.20	9.00
TiO_2	1.21	0.04	0.50
P_2O_5	1.20	trace	0.32
CaO	5.26	0.39	1.08
MgO	3.38	0.12	1.24
MnO	2.01	0.13	0.68
K_2O	2.96	0.14	0.75
Na_2O	3.93	trace	0.64

As shown above, in both the American and Japanese soils, considerable differences in composition of soil colloids are recognized; but the composition of soil colloids separated from adjacent areas is quite similar.

In determining the result of colloids separated from Alluvium, Diluvium and Residual uncultivated soils developed from different mother rocks, of the 18 provinces in the central and western part of Japan, the content of SiO_2 is the highest in colloid separated from Alluvium, and high in Tertiary, Mesozoic and Palaeozoic soils or in colloids separated from Quartzite Sandstone, Shale and Granite. The least is in Diluvium soil. Content of Al_2O_3 is more in Residual soils than in Alluvium. On Residual soils, there is no difference according to geological origin. Fe_2O_3 is relatively high in colloid of Alluvium. Difference of CaO amount is not recognizable by geological origin; on the contrary the amount of MgO is different according to geological origin and high in Mesozoic soil colloid. K_2O and Na_2O have no defined tendency.

The geological system of soils used for the coating of mat rushes is almost all Palaeozoic in Hiroshima Prefecture and Diluvium in Hyôgo Prefecture. The composition of soil colloid originating from Palaeozoic and Diluvium in Japan is shown in Table 8.

Table 8. Composition of soil colloid originated from Palaeozoic and Diluvium

	Palaeozoic		Diluvium	
	Suspension	Emulsion	Suspension	Emulsion
SiO_2	41.45%	39.04%	38.92%	38.45%
Al_2O_3	35.25	36.70	35.58	34.84
Fe_2O_3	8.00	8.42	8.76	9.06
TiO_2	0.43	0.19	0.68	0.63
CaO	1.33	1.27	1.21	1.16
MgO	1.52	1.34	1.33	1.26
K_2O	1.35	0.42	0.99	0.99
Na_2O	0.67	0.55	0.59	0.56

In comparing the composition of soil colloid used for the coating of mat rushes to soil colloid of Palaeozoic and Diluvium in Japan, there is much more SiO_2 and less Al_2O_3 in soil colloid used for the coating of mat rushes than in Palaeozoic and Diluvium soil colloids. There is more Fe_2O_3 in Hiroshima soil colloid than in Palaeozoic ones, and more CaO in Hyôgo soil colloid than Diluvium.

The nucleus of inorganic soil colloid is clay mineral, and soil genetic process is defined by the kind and proportion of clay minerals[21)23)24)25)26)27)32)33)]. Studies on clay minerals were carried out to determine the relationship between clay minerals and the absorption of plant nutrients; hydrogen ion concentration of soil solution or the holding and consumption of soil humus; and plasticity; percolation and permeability which are much influenced by soil physical properties such as swelling and shrinking.

As the soil colloid is the mixture of many kinds of minerals and amorphous materials it is very difficult to determine soil minerals by only using the result of chemical analysis. But it can be clearly recognized that the existence of Mg-Montmorillonite or Mg-Illite by a large quantity of MgO[21], Nontronite or Fe-Illite by Fe_2O_3[21] and Illite by K_2O[21,22,23]. The composition of principal clay minerals by GRIM[23] shown in Table 9.

Table 9. Composition of clay minerals

	Kaolinite	Halloysite	Montmorillonite	Nontronite	Illite
	%	%	%	%	%
SiO_2	44.59~48.80	43.79~44.76	49.91~57.55	40.54~46.06	47.55~52.23
Al_2O_3	35.18~37.82	36.10~38.46	15.96~20.14	3.6~12.22	21.67~32.45
Fe_2O_3	0.72~1.24	0.11~0.36	0.06~6.35	18.54~31.24	0.76~6.20
FeO	~0.11	~0.07	0.26~0.95	~0.39	0.57~1.80
CaO	0.13~1.02	0.48~0.51	0.50~3.28	~1.97	0~0.67
MgO	0.27~0.37	trace~0.18	2.49~6.53	~1.62	1.70~4.48
K_2O	0.40~1.47	0.48~0.51	0.11~0.60	~0.24	6.08~7.47
Na_2O	0.05~0.44	0.01~0.14	0.04~2.75	~0.14	0.13~1.05
H_2O^-	0.61~1.55	2.53~5.92	14.75~15.77	12.10~14.75	~3.22
H_2O^+	12.18~13.63	13.38~14.59	7.46~8.53	6.00~9.25	6.03~7.88

As shown in Table 9 Montmorillonite has the physical characteristics of containing large quantity of MgO, Nontronite in Fe_2O_3 and Illite in K_2O.

Comparing the chemical composition of soil colloid used for the coating of mat rushes with those of clay minerals, the soil colloid used for the coating of mat rushes does not contain as much MgO as Montmorillonite, and even Al_2O_3 as Nontronite, and more K_2O as Illite. All clay minerals contain a little quantity of Fe_2O_3 except Nontronite, and soil colloids used for the coating of mat rushes contain Fe_3O_3 to some extent. Therefore with these results it can be determined to which kind of clay minerals these soil colloids used for the coating of mat rushes belong. But owing to Japanese climatic conditions it may be presumed that the soil colloids used for the coating of mat rushes are mixtures of Kaolinite and Halloysite.

5) Molecular ratio of soil colloid

The result of the total analysis of soil colloids is shown in Table 6, SiO_2/Al_2O_3 and SiO_2/R_2O_3 are calculated as shown in Table 10.

SiO_2/Al_2O_3 and SiO_2/R_2O_3 of soil colloids separated from the soils of 18 provinces in central and western Japan are shown in Table 12.

The molecular ratio of soil colloid separated from Alluvium is the greatest, the value of Tertiary, Mesozoic and Palaeozoic the next and that of Diluvium, Metamorphic rock and Igneous rock soils the least. As mentioned before the ratios of Palaeozoic soil and Di-

Table 10. SiO_2/Al_2O_3 and SiO_2/R_2O_3

No.	Locality	SiO_2/Al_2O_3	SiO_2/R_2O_3
1	Kamura	2.79	2.18
2	Hongô	3.23	2.55
7	Fukamachi B	2.92	2.36
4	Kajiyamada	2.81	2.24
6	Fukamachi A	2.87	2.27
9	Tomoji	2.96	2.35
5	Takasu	2.91	2.30
10	Mizuochi	3.18	2.43
11	Uenohara	2.68	2.18
3	Kanae	3.35	2.47
8	Shirahama	2.62	2.02
12	Seto A	2.57	1.98
13	〃 B	2.70	2.08
15	Ôkura	3.19	2.63
15	Ôkubo	2.86	2.33

Table 11. Maximum, minimum and average of SiO_2/Al_2O_3 and SiO_2/R_2O_3

	Hiroshima Prefecture			Hyôgo Prefecture
	Maximum	Minimum	Average	Average
SiO_2/Al_2O_3	3.35	2.57	2.89	3.03
SiO_2/R_2O_3	2.55	1.98	2.26	2.48

Table 12. SiO_2/Al_2O_3 and SiO_2/R_2O_3 of various soils in Japan

	Alluvium	Tertiary Mesozoic Palaeozoic	Diluvium Metamorphic rock soil Igneous rock soil
SiO_2/Al_2O_3	3.4	1.9～2.1	1.6～1.8
SiO_2/R_2O_3	2.2	1.5～1.7	1.4～1.5

Table 13. SiO_2/Al_2O_3 and SiO_2/R_2O_3 of Palaeozoic and Diluvium soils

	Palaeozoic		Diluvium	
	Suspension	Emulsion	Suspension	Emulsion
SiO_2/Al_2O_3	1.99	1.84	1.60	1.61
SiO_2/R_2O_3	1.74	1.57	1.85	1.87

luvium soil are calculated as shown in Table 13.

Both SiO_2/Al_2O_3 and SiO_2/R_2O_3 of soil colloids used for the coating of mat rushes average 2 to 3. And in comparing the ratios of Palaeozoic and Diluvium soil colloids, the ratios of soil colloids used for the coating of mat rushes show higher value than that of Palaeozoic and Diluvium.

Ratios of clay minerals showed by GRIM are calculated as shown in Table 14.

Table 14. SiO_2/Al_2O_3 and SiO_2/R_2O_3 of clay minerals

	Kaolinite	Halloysite	Montmorillonite	Nontronite	Illite
SiO_2/Al_2O_3	2. 18～2. 15	2. 15～1. 97	5. 30～4. 84	19. 11～6. 39	3. 72～2. 70
SiO_2/R_2O_3	2. 14～2. 0	2. 05～1. 96	5. 29～4. 03	4. 45～2. 43	3. 64～2. 43

As shown above both SiO_2/Al_2O_3 and SiO_2/R_2O_3 of Kaolinite and Halloysite are 2 and another clay minerals show a much higher value. The fundamental composition of Kaolinite and Holloysite is $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ and silica-alumina molecular ratio is 2. In fact SiO_2/Al_2O_3 of Kaolinite has some fluctuation of about 1.6～2.8. It is said that in the case of a ratio lower than 2, aluminium substitutes for silicon in the silicic acid layer and in the case of ratio over 2, an aluminium layer is not contained in a crystal and only 2 silicic acid layers are combined in a crystal. Both ratios of soil colloid coating the stems of mat rushes in Hiroshima and Hyôgo Prefectures are between an average of 2 or 3 and these values are similar to the ratios of Kaolinite and Halloysite.

6) Base exchange capacity of soil colloid

Soil colloid absorbs many kinds of bases such as Ca, Mg, K and Na in its surface area. When these bases decrease in quantity, the hydrogen ion is absorbed in the colloid instead of in the bases. Soil colloid which is saturated by only bases is called the saturated colloid, and a part of these bases is exchanged by hydrogen ion is called the unsaturated colloid. And the total sum of bases which is saturated by only bases, namely the maximum amount of bases which can be absorbed on soil colloid is the base exchange capacity.

Usually base exchange capacity is indicated by milligram equivalent (m eq) per 100 g soil. The result of determination of base exchange capacity by 1 N ammonium acetate solution14)15) is shown in Table 15.

The base exchange capacity of many kinds of clay minerals which have been known23)34) is shown in Table 16.

Base exchange capacity is usually 10 m eq or so per 100 g in the case of inorganic soil colloid composed chiefly of Kaolinite. On the contrary in the case of Montmorillonite, the base exchange capacity is 100 m eq per 100 g and in the case of Mica clay its capacity is intermediary.

Base exchange capacity of soil colloid used for the coating of mat rushes is recognized as showing the value of the base exchange capacity of Kaolinite and Halloysite.

Table 15. Base exchange capacity (m eq/100 g soil)

No.	Locality	Base exchange capacity (m eq)
1	Kamura	7.99
2	Hongô	7.46
7	Fukamachi B	13.78
4	Kajiyamada	10.52
6	Fukamachi A	8.31
9	Tomoji	13.04
5	Takasu	13.46
10	Mizuochi	19.98
11	Uenohara	16.51
3	Kanae	21.61
8	Shirahama	15.04
12	Seto A	13.25
13	〃 B	13.04
14	Ôkura	18.00
15	Ôkubo	13.30
Hiroshima Prefecture		
	Maximum	21.61
	Minimum	7.46
	Average	13.38
Hyôgo Prefecture		
	Average	15.65

Table 16. Base exchange capacity of minerals

Clay mineral	m eq/100g soil
Kaolinite	3〜15
Halloysite	5〜10
Montmorillonite	60〜120
Illite	10〜40
Allophan	20〜40

7) Properties of Fe of soil

When the stems of mat rushes are put in the mud water and dried, the content of humus and iron in soil colloid have much influence upon the color of the stems of mat rushes and also upon the manufactured mat. Because humus and iron in soil colloid are the coloring material in soil, after drying of the stem these elements color the stem by their oxidation. Naturally, though humus should be colorless, humus gives grey, brown and greyish black color on soil, because it contains a greyish black pigment. Besides red, the brown or yellow colors of soil originate from the content of free iron. In the case of the drying of mat rushes, iron is more easily oxidized and has more influence upon the color of the stem than humus by oxidation. So the properties of iron in soil colloid were examined; then the total sums of ferric oxide and ferrous oxide were determined[28)].

a) Total sums of ferric oxide and ferrous oxide were determined by Redox titration method using H_2S.

b) Dissolve ferrous oxide by 1 N H_2SO_4, and produce color by 0.1% α-α' dipyridyl, and transmission % is determined by photometer and by calculating the amount of ferrous oxide.

c) Amount of ferric oxide is calculated by the deduction of ferrous oxide quantity from total sums of ferric and ferrous oxides.

Table 17. Amount of ferric and ferrous oxides in soil

Plot	Locality	100g soil(g)		Ratio (%)		Soil color
		Fe^{++}	Fe^{+++}	Fe^{++}	Fe^{+++}	
I	Kamura	0.133	1.024	11.50	88.50	whitish grey
	Hongô	0.099	1.059	8.55	91.45	〃
	Fukamachi B	0.090	0.708	11.28	88.72	〃
	Average	0.107	0.930	10.44	89.56	
II	Kajiyamada	0.441	1.515	22.55	77.45	light, yellowish grey
	Fukamachi A	0.121	0.991	10.89	89.11	〃
	Tomoji	0.130	1.507	7.95	92.05	〃
	Average	0.231	1.338	13.80	86.20	
III	Takasu	0.216	1.980	9.84	90.16	yellowish grey
	Mizuochi	1.011	5.696	15.08	84.92	〃
	Uenohara	1.062	4.846	17.98	82.02	〃
	Average	0.763	4.174	14.30	85.83	
IV	Kanae	0.216	6.730	3.11	96.89	light, brownish grey
	Shirahama	0.345	5.004	6.45	93.55	〃
	Seto A	0.400	3.153	10.98	89.02	〃
	〃 B	0.390	3.043	11.37	88.63	〃
	Average	0.338	4.485	7.98	92.02	
V	Ôkura	5.494	0.259	95.54	4.46	bluish grey
	Ôkubo	4.370	0.743	85.46	14.56	〃
	Average	4.932	0.502	90.50	9.50	

Plots I through IV are in Hiroshima Prefecture production and plot V is Hyôgo Prefecture production.

In Hiroshima Prefecture soils the amount of ferrous oxide is greater than that of ferric oxide and the ratio is Fe^{++} 10 to Fe^{+++} 90 in plot I, 14 to 86 in plots II and III, and 8 to 92 in plot IV.

In comparing soil colors whitish grey and yellowish grey soils show the ratio of 10∼14 to 86∼90, brown soil decreases the amount of Fe^{++} and increases Fe^{+++}. On the contrary Hyôgo Prefecture soils contain much more Fe^{++} than Fe^{+++} and the ratio of Fe^{++} and Fe^{+++} is 90 to 10 and its color is bluish grey. It is characteristic of Hiroshima Prefecture soil colloids that they contain much more Fe^{+++} than Fe^{++} and that Hyôgo Prefecture soil colloids contain much more Fe^{++} than Fe^{+++}.

Also, for the determination of ferrous oxide, there is another method using $AlCl_3$ instead of 1 N H_2SO_4 solution.

Weight 0.2～0.5 g dried soil in a flask, add 0.2% $AlCl_3$ solusion 50 cc, and after shaking for an hour, set aside and add 0.2% $\alpha \sim \alpha'$ dipyridil to supernatant liquid 5 cc and produce color. Transmission % is determined by photometer and by calculating the amount of ferrous oxide.

By using this method the quantity of soluble Fe^{++} and Fe^{+++} is much less than by using 0.1 N H_2SO_4 solution, but the ratio of Fe^{++} and Fe^{+++} in both Prefecture soils has almost the same tendency as by using the first method.

8) Color reaction of soil colloid

As aromatic diamine characteristically reacts upon clay minerals, it is used to detect qualitatively the clay mineral in soil colloid by the oxidation of a slight amount of diamine incidental to the semiquinone type.

HENDRICKS & ALEXANDER[30)] used benzidine or benzidinehydrochloride to detect Montmorillonite in soil colloid. In this case benzidine or benzidinehydrochloride has nothing to react with Kaolinite or any other inorganic materials in soil. Subsequently HARADA[31)] reported that this benzidine color reaction was applicable to Kaolinite. That result reported by him is shown in Table 18.

Table 18. Color reaction of clay minerals

Clay mineral	Reagent	Color reaction
Montmorillonite	Paraphenylendiamine or Phenylendiamine	violet color;crimson in slightly acid
	Methol	dark deep blue
	Benzidinehydrochloride	deep blue
Halloysite and Kaolinite	Manganese dioxide Benzidine	violet color

Soil colloid has the nature of absorbing many kinds of pigments. Moreover these pigments occasionally change their color tone when absorbed by colloid. Put soil colloid on a slide glass, add one drop of saturated nitrobenzen of safranine T, cover with a cover glass and look at it through a microscope.

Sericite, Montmorillonite, Halloysite and Kaolinite are almost dyed, but are different in color tone[34)].

Kaolinite is dyed to red and other clay minerals are dyed to slightly brownish red. Coloration of clay minerals by the saturated benzidine and safranine T is as Table 19.

As shown in Table 19 the result is the qualitative one of coloration of soil colloid used for the coating of mat rushes, it is sufficiently understood that these soil colloids are mixed with many kinds of clay minerals. According to the violet coloration by benzidine and the crimson red dying by safranine T, soil colloid used for the coating of mat rushes may be considered to be mixed with Kaolinite group.

Table 19. Coloration and dying of soil colloid

No.	Locality	Coloration by benzidine	Dying by safranine	Black particle by safranine T	Grade of crystal
1	Kamura	1) +++	crimson red	2) +	large
2	Hongô	++	red	+	medium
7	Fukamachi B	− ?	crimson red	+	〃
4	Kajiyamada	+	red	+	〃
6	Fukamachi A	− ?	crimson red	+	〃
9	Tomoji	−	red	++	small
5	Takasu	+	〃	++	〃
10	Mizuochi	−	slightly yellowish red	+	〃
11	Uenohara	−	yellowish red	+	〃
3	Kanae	−	red	+++	〃
8	Shirahama	−	〃	+++	〃
12	Setô A	− ?	〃	+	〃
13	〃 B	− ?	〃	+	medium
14	Ôkura	−	〃	−	—
15	Ôkubo	−	〃	−	—

Note: 1) + Grade of coloration. − No coloration. 2) + shows quantity.

9) Specific gravity of soil colloid

For the separation of soil colloid from soil which coats the stems of mat rushes, the International Pipette Method was chosen as mentioned previously. The principle of this method is that the sedimentation velocity of globular particles of the same specific gravity is proportional to the size of particles. So, specific gravity of soil colloid was determined by picnometer.

Table 20. Specific gravity of soil colloid

No.	Locality	Specific gravity
1	Kamura	2.370
2	Hongô	2.286
7	Fukamachi B	2.279
4	Kajiyamada	2.487
6	Fukamachi A	2.280
9	Tomoji	2.268
5	Takasu	2.295
10	Mizuochi	2.475
11	Uenohara	2.438
3	Kanae	2.431
8	Shirahama	2.248
12	Seto A	2.388
13	〃 B	2.295
14	Ôkura	2.710
15	Ôkubo	2.730

Specific gravity of clay minerals which has been known up to date is as follows:

Table 21. Specific gravity of clay minerals

Kaolinite	2.58～2.60
Halloysite	2.0～2.2
Montmorillonite	2.25±0.05
Nontronite	2.50
Allophane	1.80～1.86
Pirohirite	2.8～2.9
Biederite	2.70±0.3

As shown above there is not much difference in specific gravity of soil colloid. In these clay minerals Pirohirite is the heaviest. Kaolinite and Nontronite show the same value and are next to Pirohirite. Biederite, Montmorillonite and Halloysite are somewhat light and Allophane is the lightest. By SUDO[21)] the specific gravity of hydrated Halloysite and another clay minerals in Japan as determined by GOINIRK's Method is 2.16～2.34.

In comparing the result shown above with results which have been known up to date, it reveals that the specific gravity of soil colloid used for the coating of mat rushes is similar to that of Kaolinite.

9) Dehydration curve of soil colloid

Determination of a dehydrated condition can be seen to a certain degree in the properties of soil colloid. We can determine the kind of minerals by representation of the relationship between loss of weight and temperature by heating and making a curve and then comparison of the curve with that of well-known minerals. There are three methods for the determination of dehydration curve.

a) *Intermittent heating:* Heat a sample to a certain temperature and maintain at a constant weight. Again heat at still higher temperature and maintain a constant weight. Carry out such a method gradually. After the sample has cooled, it is weighed.

b) *Continuous heating:* it is a method to determine the variation of weight of a sample by heating at a constant rate. Generally the temperature rise is from 20°C to 1000°C taking 2 to 200 hours. Sample is weighed in heating.

c) *Single heating:* Prepare numerous samples equivalent to the various kinds of temperature for determination, heat each of the samples to the various temperatures at the same time and determine the variation of weight by heating.

In these three methods, the authors selected the first method and determined the dehydration curve. Weigh exactly 1 g soil colloid in a crucible and heat it in a muffle furnace at various temperatures for 30 minutes. After heating, transfer the crucible to a desiccator for cooling and determine the decrease in weight. Moreover, in heating it is believed that there is a decrease in weight of the sample by the decomposition of carbonate, organic matter and other volatile materials, and the oxidation of ferrous oxide or manganese oxide. But in this method, moisture in organic matter, ferric hydroxide and hydrated aluminium are supposed to be lost at less than 400°C; and OH in the grating of crystal of clay mineral at from 400°C to 600°C, especially moisture in Mica group at higher temperature.

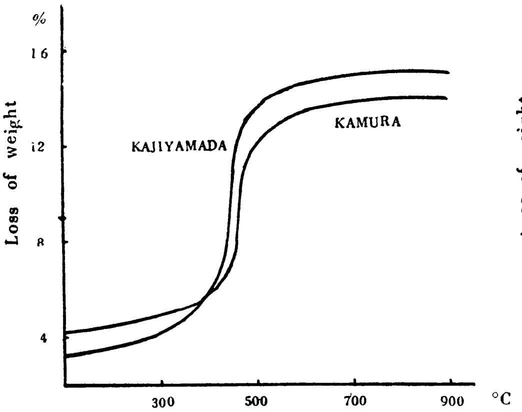
Accordingly in case a great quantity of water is lost at less than 400°C, the existence of Montmorillonite is considered likely, and in the case of loss at 400~600°C Kaolinite and Halloysite groups are likely to exist.

The results are shown in Table 22 and illustrated in Text-figs. 2–5.

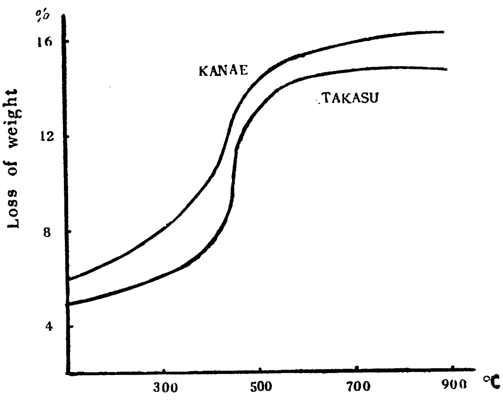
Table 22. Total loss of moisture at various temperatures (%)

No.	Locality	100°C	200°C	300°C	400°C	500°C	600°C	700°C	800°C	900°C
1	Kamura	4.11	4.53	4.82	5.27	12.81	13.62	13.66	14.02	14.09
2	Hongô	6.32	7.56	7.75	9.74	13.94	14.57	14.82	14.72	14.80
7	Fukamachi B	3.78	4.07	4.41	5.36	10.23	11.64	11.85	12.19	12.28
4	Kajiyamada	3.15	3.65	4.90	5.65	14.59	14.74	15.09	15.28	15.38
6	Fukamachi A	4.07	5.05	5.22	6.05	10.67	11.95	12.17	12.32	12.40
9	Tomoji	4.43	5.33	5.49	7.52	11.32	11.88	12.11	12.29	12.39
5	Takasu	4.80	5.30	6.72	7.25	13.74	14.55	14.65	1) 14.52	1) 14.45
10	Mizuochi	3.42	4.31	5.08	5.75	10.70	11.98	12.49	12.90	13.00
11	Uenohara	2.49	3.49	4.23	5.34	11.21	11.93	12.19	12.55	12.58
3	Kanae	5.71	6.53	8.06	9.66	14.65	15.46	15.73	16.02	16.16
8	Shirahama	3.25	4.19	5.28	6.39	10.89	11,57	12.53	12.89	12.93
12	Seto A	7.32	9.19	11.04	12.45	18.58	19.10	20.25	20.25	20.45
13	// B	4.74	6.17	6.46	9.38	15.77	16.34	16.98	17.39	17.44
14	Ôkura	4.96	6.23	9.68	10.62	11.40	14.77	14.86	15.34	15.57
15	Ôkubo	4.44	5.91	7.00	7.49	9.29	12.95	13.44	13.74	13.89

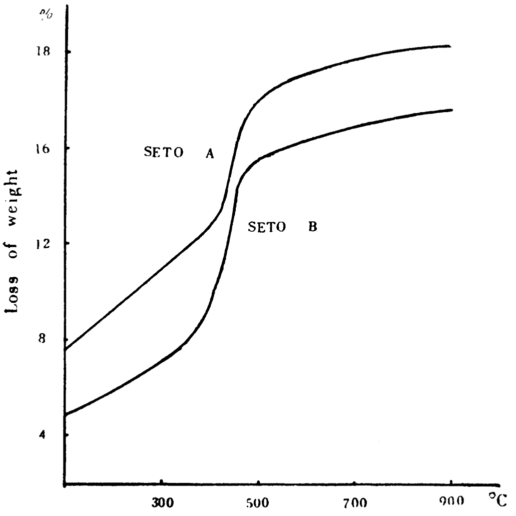
Note: 1) shows increase of weight.



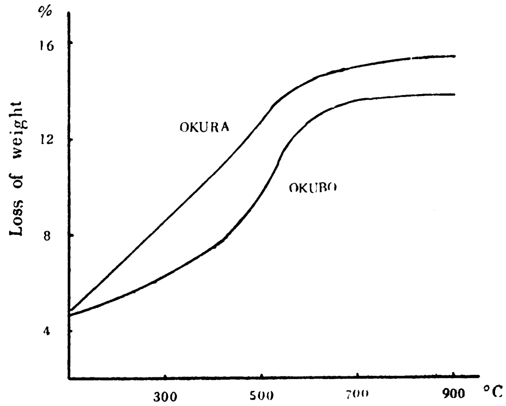
Text-fig 2. Dehydration curve of soil colloid of the soils from Kajiyamada and Kamura.



Text-fig. 3. Dehydration curve of soil colloid of the soils from Kanae and Takasu.

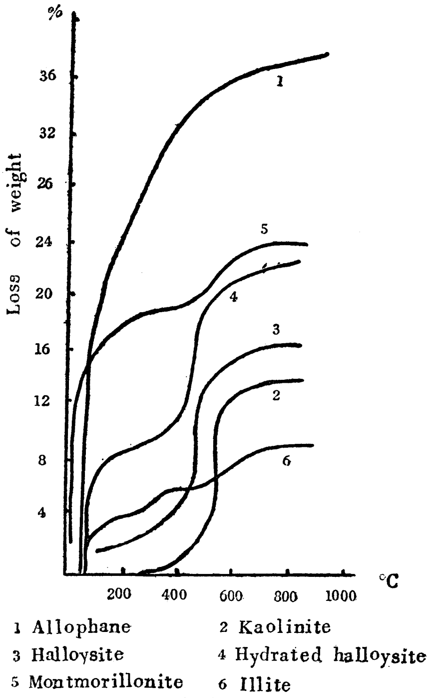


Text-fig. 4. Dehydration curve of soil colloid of the soils from Seto.



Text-fig. 5. Dehydration curve of soil colloid of the soils from Ôkura and Ôkubo.

Typical dehydration curves of Kaolinite, Halloysite and Montmorillonite[15][32] are shown in Text-fig. 6.



Text-fig. 6. Typical dehydration curves.

As shown in the above table and diagrams, in soil colloid which coats the stems of mat rushes, the existence of many kinds of clay minerals such as Kaolinite and Halloysite group is considered.

10) Absorptive power of soil colloid

On the contrary, loss of moisture by increasing temperature, determination of absorptive power of soil colloid is very important in coating the stem of mat rushes and its influence on the quality of the manufactured mat. So, absorptive power of soil colloid was determined.

Place 2 g soil sieved by a 0.5 mm sieve in a weighing bottle and dry in an oven at 105°C. After drying to a constant weight, the opened weighing bottle was put in a desiccator of 82.5% relative humidity at 25°C, and after a fixed hour weighing the closed bottle and calculating the absorptive power by the increase of weight.

To keep constant humidity in the desiccator, sulfuric acid of appointed concentration was added in the bottom of the desiccator and put in an incubator at 25°C.

These values in 1955 and 1956 by Japanese Statistical Year-Book are as follows:

Hiroshima Prefecture	1955	1956
Average Temperature	26.1°C	25.9°C
Average Relative Humidity	80.0%	83.0%

By the method as above mentioned, the result is shown in Table 23.

Table 23. Total moisture absorption at various hours (mg)

No.	Locality	After 1 hour	2 hours	3 hours	4 hours	5 hours	6 hours	7 hours	9 hours	12 hours	24 hours
1	Kamura	11.8	15.4	17.4	19.7	21.7	22.7	24.2	25.2	25.7	26.9
2	Hongô	13.9	18.9	25.5	28.5	31.0	32.3	33.5	36.1	38.5	39.5
7	Fukamachi B	14.2	24.2	30.6	34.0	37.7	41.1	44.2	47.2	49.2	50.7
4	Kajiyamada	11.5	14.6	17.2	19.5	21.0	21.6	22.2	23.2	25.0	25.2
6	Fukamachi A	13.9	19.9	25.9	29.9	33.4	35.7	37.5	40.1	42.3	42.8
9	Tomoji	14.3	19.0	24.0	26.9	28.0	28.5	29.1	30.1	30.9	31.1
5	Takasu	15.3	21.8	30.4	35.4	40.0	42.5	45.0	48.5	51.5	53.0
10	Mizuochi	15.4	24.3	34.1	39.4	42.6	44.0	45.6	47.0	49.0	49.4
11	Uenohara	14.8	24.5	32.3	36.2	38.9	42.0	44.0	45.3	47.9	48.5
3	Kanae	14.0	25.5	35.5	41.8	47.0	51.5	54.0	57.2	60.9	62.4
8	Shirahama	16.0	26.3	33.8	39.6	42.4	45.3	46.8	48.8	51.8	52.8
12	Seto A	13.7	19.0	23.6	26.6	29.1	31.4	32.8	33.3	34.8	35.9
13	// B	13.8	19.8	24.7	28.7	31.6	33.1	39.9	37.4	38.5	39.0
14	Ôkura	14.0	22.6	32.9	38.4	41.6	43.6	44.9	49.1	51.3	52.5
15	Ôkubo	15.3	22.6	30.1	33.1	35.4	37.9	39.1	40.9	43.6	44.6

The proportion of moisture absorption and quantity of evaporation of soil moisture by drying at 100°C in an oven to a constant weight is indicated as an index of evaporation quantity at 100°C.

11) Variation of temperature by exposing to the direct rays of the sun

Coating the stems of mat rushes by mud water is very useful for early drying of the stems. So, the rising of temperature of soil by exposing to the direct rays of the sun has an influence on the progress of drying of the stem. Therefore variation of temperature of soil by exposing to the direct rays of the sun was determined.

Place 100 g fine soil in 100 cc volume beaker, add 30 cc water and stir to mud condition; expose it to the direct rays of the sun and determine the temperature at 2 cm below on the surface every hour from 9 a.m. to 6 p.m. Representative samples were selected from the section of various colors.

Variation of temperature of the soil which coats the stems of the mat rushes by exposing to the direct rays of the sun shows some differences owing to the kinds of soils.

Table 24. Evaporation and absorption quantity

No.	Locality	Evaporation quantity (mg)	Absorption quantity (mg)	Index (%)	
				Evaporation	Absorption
1	Kamura	32.7	29.6	100	82.3
2	Hongô	49.5	39.5	100	79.8
7	Fukamachi B	64.9	50.7	100	78.1
4	Kajiyamada	29.0	25.2	100	86.9
6	Fukamachi A	53.0	42.8	100	80.8
9	Tomoji	39.6	31.1	100	78.5
5	Takasu	67.0	53.0	100	79.1
10	Mizuochi	63.2	49.4	100	78.2
11	Uenohara	62.8	48.5	100	77.2
3	Kanae	80.2	62.4	100	77.8
8	Shirahama	67.0	52.8	100	78.8
12	Seto A	57.8	35.9	100	62.1
13	〃 B	59.5	39.0	100	65.5
14	Ôkura	75.1	52.5	100	69.9
15	Ôkubo	58.6	44.6	100	76.1

Table 25. Variation of temperature (°C)

Locality	Kamura	Kajiya-mada	Takasu	Kanae	Ôkura	H_2O	Earth's surface
Soil color	whitish grey	light, yellowish grey	yellowish grey	light, brownish grey	bluish grey		
9 a.m.	28.0	27.0	27.5	28.5	28.0	27.5	28.0
10	34.0	34.8	34.1	34.7	35.0	35.8	43.0
11	37.0	38.8	37.0	37.5	39.5	39.0	48.5
12	39.0	40.0	39.1	40.5	40.2	40.8	45.5
1 p.m.	39.5	41.5	40.5	40.9	41.5	41.0	45.0
2	39.5	40.2	40.2	40.0	41.5	39.5	40.0
3	38.2	39.0	39.6	39.5	39.0	37.5	39.8
5	32.0	32.1	32.0	32.7	33.0	32.0	31.0
6	28.5	29.5	28.0	28.7	28.1	28.1	26.5

(III) SUMMARY

The authors investigated the geological systems and productive condition of producing districts of soils used for the coating of mat rushes in Hiroshima Prefecture and Hyôgo Prefecture, collected samples of soils and examined the physical and chemical properties of these soils.

For chemical properties, hot hydrochloric acid analysis and total analysis of soil colloid were carried out and the calculated silica-alumina ratio, base exchange capacity and proportion of Fe^{++} and Fe^{+++}, color reaction and dying of soil colloid were determined.

For physical properties, the soil colloid was separated by the sedimentation method and the quantity of colloid was determined. Specific gravity, dehydration curve, absorption power and variation of temperature of soil by exposing to the rays of the sun were determined.

1) The producing district in Hiroshima Prefecture is a region which centers in Mihara, Onomichi and Matsunaga, and is limited to the southeast region of Hiroshima Prefecture.

2) Geological system at Kamura, Hongô, Kanae, Takasu, Fukamachi, Shirahama, Tomoji, Mizuochi and Uenohara belongs to Palaeozoic, at Kajiyamada to Granite, and at Seto to Granite Porphyry.

3) Producing districts in Hyôgo Prefecture are Ôkura and Ôkubo in Akashi, and their geological system belongs to Diluvium and form hillock.

4) Soil color is divided into five kinds such as whitish grey, light yellowish grey, yellowish grey, light brownish grey and bluish grey. pH value shows 4.55 in the lowest and 6.70 in the highest.

5) Clay with particle diameter less than 0.002 mm is considered to be soil colloid. This was separated by the Pipette Method. Quantity of colloid is 39.65% in the highest, 8.32% in the lowest and 23.07% in average.

6) Relationship between soil color and pH value can not be recognized as a definite relation, but quantity of colloid has a tendency of being less in light-colored soil, and on the contrary, much more in dark-colored ones.

7) On the average, values of total nitrogen, Fe_2O_3, CaO and MgO in soils of Hyôgo Prefecture are very much more, and K_2O and Na_2O are a little more than in those in Hiroshima Prefecture.

8) On total analysis the amount of H_2O, CaO and MgO is very much more but Fe_2O_3 and P_2O_5 are less in soil colloid of Hyôgo Prefecture than in those of Hiroshima Prefecture.

9) SiO_2/Al_2O_3 and SiO_2/R_2O_3 of colloid by total analysis are higher in Hyôgo Prefecture, but the difference between them is not great.

10) Base exchange capacity of soil colloid in Hiroshima Prefecture is 21.6 m eq in the highest, 7.46 m eq in the lowest and 13.38 m eq in average. In Hyôgo Prefecture it is 18.0 m eq and 13.3 m eq. Little differences between them are recognizable.

11) Quantity of Fe^{++} and Fe^{+++} is closely associated with soil color. Proportion of Fe^{++} and Fe^{+++} in whitish grey and yellowish grey soil is 10～14 to 86～90, and in brown soil Fe^{++} is decreased but Fe^{+++} is increased. In soils of Hyôgo Prefecture the quantity of Fe^{++} is very much more than Fe^{+++}, and the proportion is 90 to 10. Fe^{+++} is found more in Hiroshima Prefecturc soils and Fe^{++} more in Hyôgo Prefecture soils.

12) Results of color reaction by benzidine and dying by safranine T can be recognized that clay mineral of Kaolinite group is adulterated.

13) Specific gravity by picnometer is 2.730 in the highest, 2.248 in the lowest and 2.595 in average.

14) Dehydration curve examined at from 100°C to 900°C is similar to that of clay minerals such as Kaolinite and Halloysite.

15) Absorptive power of colloid seems to depend more upon soil property than upon the quantity.

16) Variation of temperature of soil used for the coating of mat rushes by exposing to the direct rays of the sun shows some different result owing to the kinds of soils.

Though discovering a substitute for soils used for the coating of mat rushes was the task of this study, in coating the stems, when the stems were treated with other materials such as bentonite or Japanese acid clay and dried and moreover when a finished mat was produced, commercial value as a mat was much reduced unless the usual soil was used.

Therefore under the present phase it does not solve the problem of a substitute. The quantity of production of the soil used for the coating of mat rushes in Hiroshima Prefecture seems to be less than in Hyôgo Prefecture and the future reserves are also less.

Hence we can use the soil produced at Akashi, Hyôgo Prefecture as a substitute, but as mentioned before, the quality and property of Fe of Hyôgo Prefecture soils are diferent from that of Hiroshima Prefecture. Since the color of the mat may be somewhat bluish, the commercial value is as yet uncertain.

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EXPLANATION OF PLATES

Plate 1. Electron photomicrographs of soil colloid (Magnitude × 10,000)

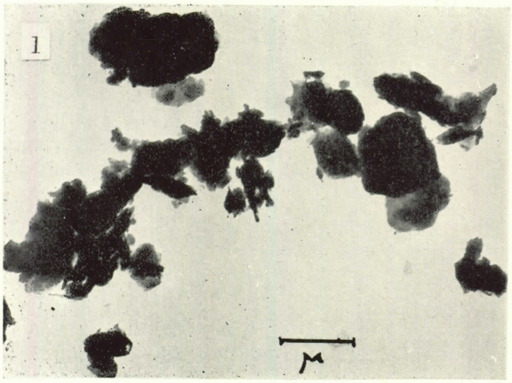
Fig. 1. Kamura (No. 1).
Fig. 2. Kanae (No. 3).
Fig. 3. Kajiyamada (No. 4).
Fig. 4. Takasu (No. 5)
Fig. 5. Seto A (No. 12).
Fig. 6. Ôkura (No. 14).

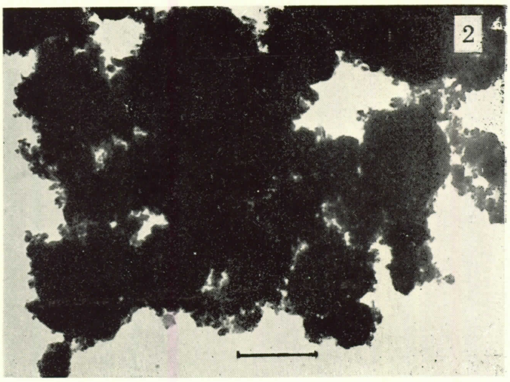
Plate 2. Hiroshima Prefecture

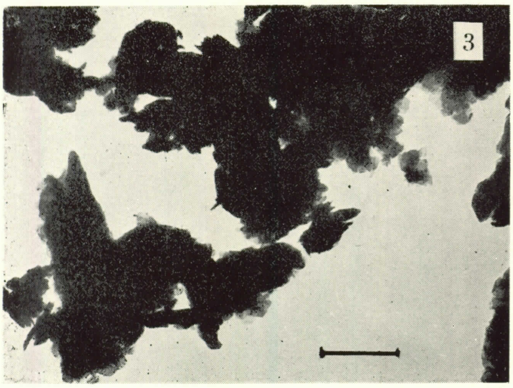
Fig. 1. Distant view, Kajiyamada.
Fig. 2. 〃 , 〃
Fig. 3. Removing soil, 〃
Fig. 4. 〃 , 〃
Fig. 5. Breaking up soil, 〃
Fig. 6. Loading of soil, 〃

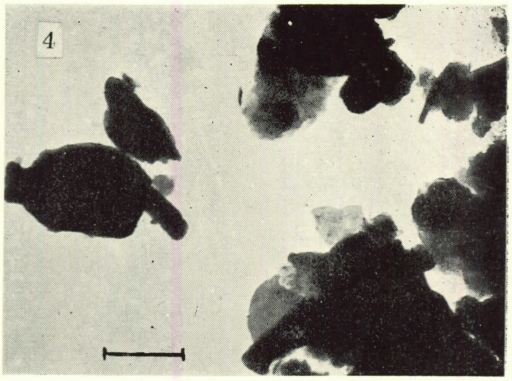
Plate 3. Hyôgo Prefecture

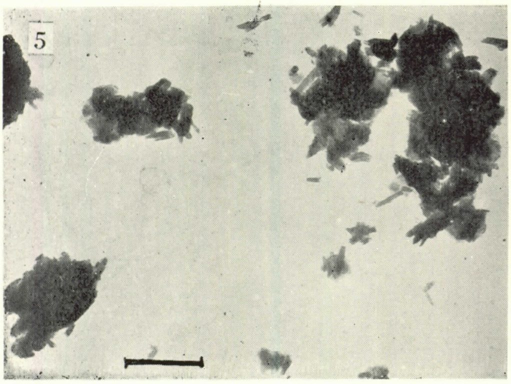
Fig. 1. Thick horizon of soil, Ôkura.
Fig. 2. 〃 , 〃
Fig. 3. Loading for drying, 〃
Fig. 4. Spreading for drying, 〃
Fig. 5. Drying of soil and breaking up in pieces, 〃
Fig. 6. 〃, Ôkubo.

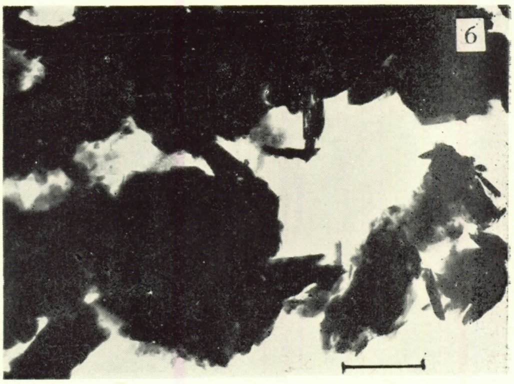




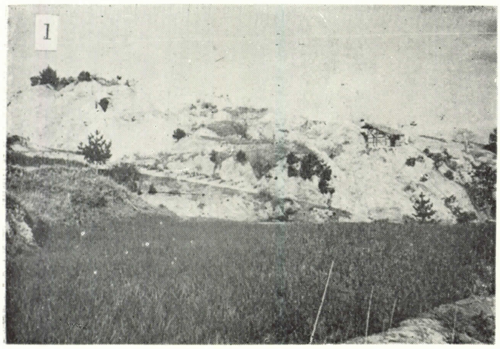








IKEDA & MATSUI: Soil for Coating Mat Rushes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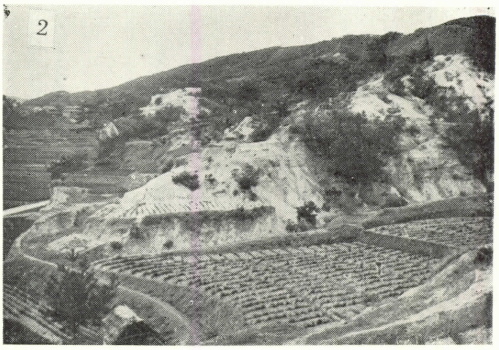
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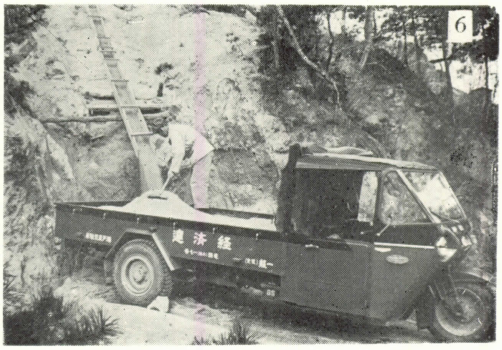
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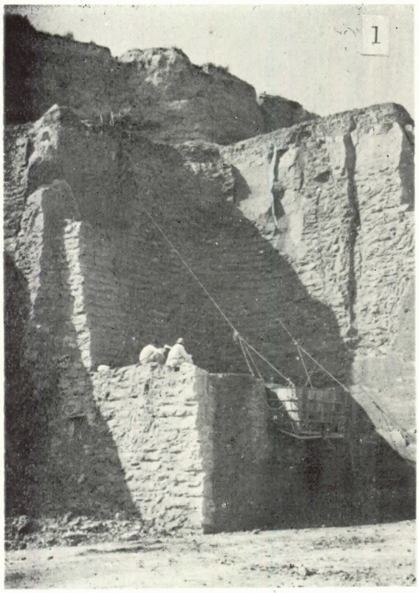

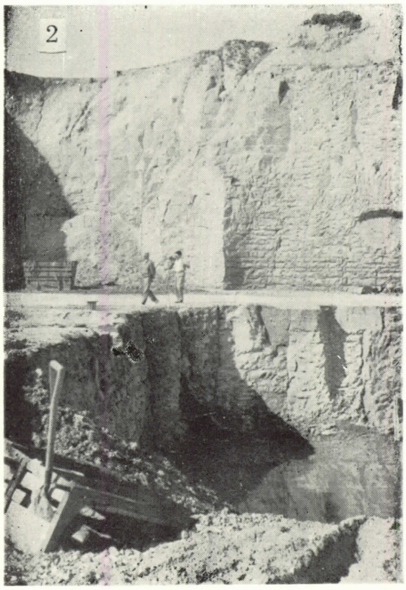

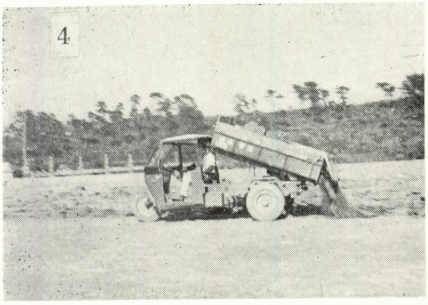

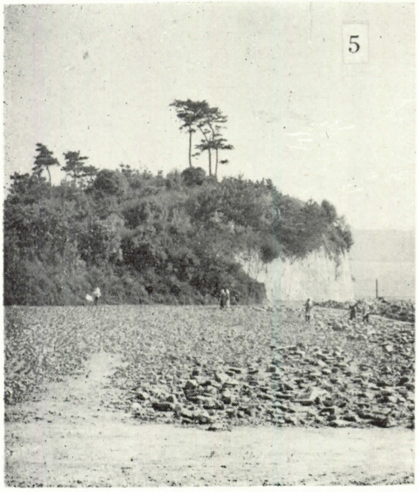

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