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Clay mineralogy of some alluvial soils of Assam under long -term paddy cultivation

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Abstract

Clay mineralogy assemblage of paddy and non-paddy soils from two major valleys viz. Brahmaputra valley and Barak valley of Assam were investigated. In most of the soils, mica is dominant mineral (44-69%) followed by kaolinite (22-33%) and feldspars (4-9%). The content of smectite, vermiculite and chlorite are low (3-13%). The content of K- feldspars is less than that of plagioclases. The mica is dominated by its dioctahedral counterpart. Paddy cultivation accelerated weathering of mica leading to formation of smectite and vermiculite through chlorite intergrade. The mica content decreased by 22 to 50% in surface horizon of paddy soils. There was, however, greater stability of smectite and vermiculite in poorly drained paddy soils.

Additional keywords : Brahmaputra valley, Barak valley, Paddy soils.

Introduction

Characteristic hydrology associated with paddy cultivation is reported to bring about change in clay mineralogy depending on degree of soil acidity and parent material. Changes range from partial destruction of layered silicate minerals (Brinkman 1977) to Al - and Fe-interlayering of 2:1 clay (Egashira and Ohtsubo 1983; Wakatsuki *et al.* 1984). Zhang (1981) observed decrease in mica content and increase in vermiculite and kaolinite contents, after long term paddy cultivation in China. In India, Swahney and Sehgal (1992) reported transformation of mica to smectite in traditionally rice growing soils of Punjab. There are reports that paddy cultivation bring about change in taxonomic classification (Moormann 1978; Moormann and van de Watering 1985). Assam being a traditionally rice growing state, paddy soils dominate cultivable land. But, report on the effect of paddy cultivation on clay mineralogy in these soils is scanty. Therefore, the present investigation was undertaken to study change in clay mineralogy in traditionally rice growing soils of the state.

Materials and methods

The study area is situated between latitudes of $24^0 29'$ to $27^0 14'$N and longitudes of $92^0 48'$ to $94^0 7'$ E. Three sites were selected in the Brahmaputra valley and one in Barak valley of Assam. Soils with a record of more than 50 years of paddy cultivation were selected. The pedons P1 and P2, P3 and P4, P5 and P6 are located in North Lakhimpur, Titabor and Kaki respectively in the Brahmaputra valley. The pedons P7 and P8 are located in Cachar in the Barak valley. Pedons P1, P3, P5 and P7 represented paddy soils and the pedons P2, P4, P6 and P8 represented their associated non-paddy soils.

The soil samples (< 2mm) from representative horizons were dispersed with 0.01 N Na_2CO_3, followed by ultrasonic treatment for 5 minutes. The clay suspension was siphoned off after requisite settling time (Jackson 1956). The clay samples were flocculated with excess of KCl and $MgCl_2$. The magnesium saturated clay samples were x-rayed, then glycolated and x-rayed again, using Philips diffractometer. Potassium saturated clay samples were x-rayed after heating to 400^{0}C for 1 hour and again after heating to 500^{0}C for 1 hour. Based on the peak area of different reflections, a semi-quantitative analysis of different minerals in the clay fractions was undertaken following the procedure of Klages and Hopper (1982). Physical and chemical characteristics were analysed as per procedure of Jackson (1956,1967).

Results and discussion

X-ray diffractograms of Mg-saturated and glycolated clays showed strong reflections at 16.5 A^o (in some soils), 14 A^o, 10 A^o and 7.2 A^o (Fig. 1 & 2). The reflection at 10A^o which resisted collapse even after heating, confirms the presence of mica. The part of 14 A^o which resisted collapse on heating to 500^{0}C is due to chlorite. The peaks at 7.2 A^o and 3.5 A^o in the Mg-saturated clays after 2M HCl treatment indicated the presence of kaolinite. The peak at 4.14 A^o in the Mg-saturated clays which disappeared on heating indicated the presence of goethite. The presence of peaks at 4.21 A^o, 3.31 A^o and 3.18 A^o regardless of treatments indicated the presence of quartz, plagioclases and alkali feldspars, respectively.

Per cent distribution of different minerals (Table 1) shows variations among soils under diferent cultivation practices and within each profile. Comparing mineral assemblage of non-paddy soils from different locations (P2, P4, P6, P8), it is clear that mica is the most abundant mineral (44-69%) followed by kaolinite (20-33%) and feldspars (4-9%) in all soils except Titabor (P3), where kaolinite is the most abundant mineral (35-51%), followed by mica (29-43%). Chlorite, vermiculite and smectite are in lesser amount (13%). The content of geothite and quartz is very low.

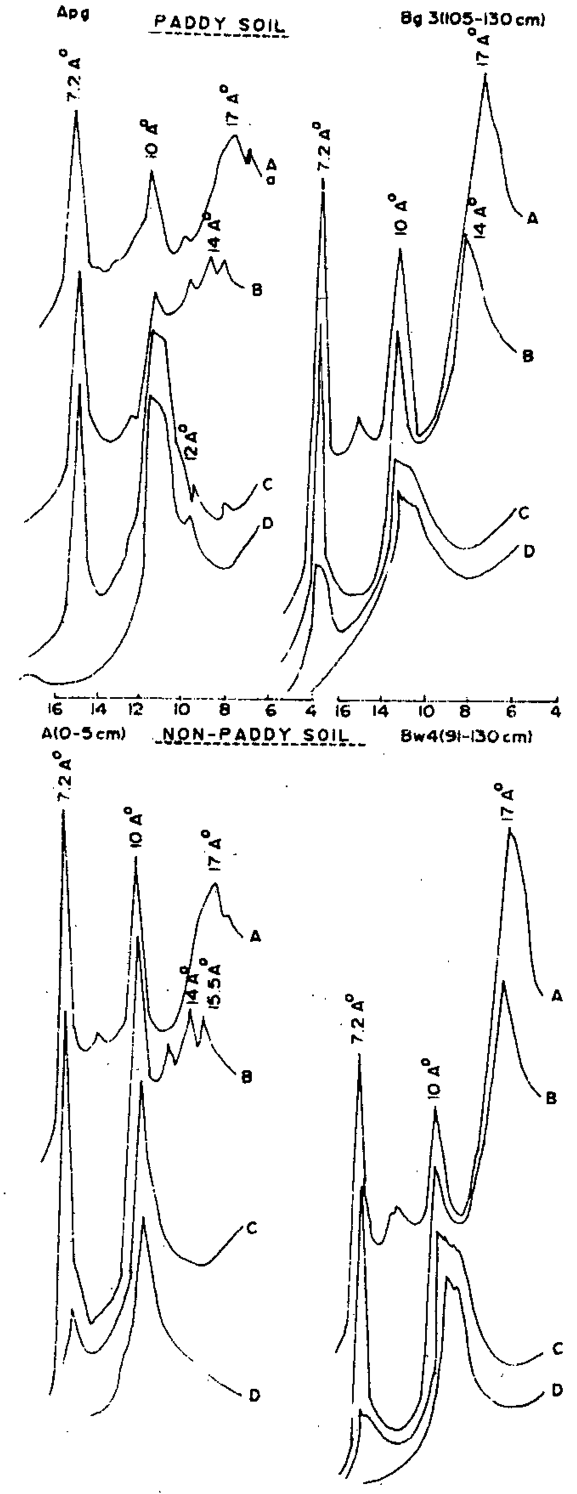
Table 1. Relative abundance of clay minerals in the studied soils (%)

Horizon	Depth (cm)	Clay (%) Coarse	Fine	Ch	Mi	V	S	K	Feldspars A	P
Pedon 1 : Paddy soil, North Lakhimpur										
Ap	0-10	7.0	2.5	Tr	20	20	12	40	Tr	Tr
Bg2	17-30	4.3	2.7	Tr	21	18	20	32	Tr	Tr
Bg5	70-90	3.5	1.3	7	44	5	6	32	Tr	Tr
Pedon 2 : Non-paddy soil, North Lakhimpur										
A	0-5	8.8	4.4	8	49	Tr	5	24	Tr	Tr
Bw2	53-105	5.3	1.4	Tr	44	9	5	31	Tr	Tr
TrBC2	135-155	3.6	1.2	Tr	46	9	7	29	Tr	Tr
Pedon 3 : Paddy soils Titabor										
Apg1	0-10	7.3	1.1	Tr	40	10	-	41	Tr	Tr
Apg2	10-15	6.5	4.6	12	27	Tr	-	53	Tr	Tr

Bg2	20-39	7.1	4.7	Tr	4‘	14	-	38	Tr	Tr
Bg5	117-145	6.0	3.2	5	29	5	-	48	Tr	Tr
Pedon 4 : Non-paddy soil, Titabor										
A1	0-5	5.6	3.2	3	39	7	-	44	Tr	Tr
Bw2	42-60	8.6	4.3	5	29	9	-	51	Tr	Tr
BC1	110-135	3.4	3.2	10	43	5	-	35	Tr	Tr
Pedon 5 : Paddy soil, Kaki										
Apg	0-20	38.7	18.3	-	51	-	5	37	Tr	Tr
Bg1	20-27	39.0	16.0	-	63	-	Tr	26	Tr	Tr
Bg3	105-130	39.3	12.9	-	54	-	13	24	Tr	7
Pedon 6 : Non-paddy soil, Kaki										
A	0-5	20.1	11.9	-	69	-	Tr	22	Tr	Tr
Bw2	28-60	24.9	9.2	-	68	-	7	24	6	Tr
Bw4	91-130	29.5	6.9	-	58	-	13	24	Tr	Tr
Pedon 7 : Paddy soil, Cachar										
Apg	0-15	31.4	15.0	-	45	Tr	-	43	Tr	5
EBg	15-27	38.4	17.5	-	58	Tr	-	25	5	Tr
Btg2	65-75	42.6	14.5	-	60	9	-	23	Tr	Tr
Bcg3	115-145	29.0	13.1	-	51	10	-	25	6	4
Pedon 8 : Non-paddy soil, Cachar										
A	0-10	26.4	12.0	-	51	6	-	33	Tr	5
Bt2	55-73	39.1	16.3	-	64	5	-	21	Tr	5
BC3	125-150	29.3	15.9	-	69	11	-	20	5	Tr

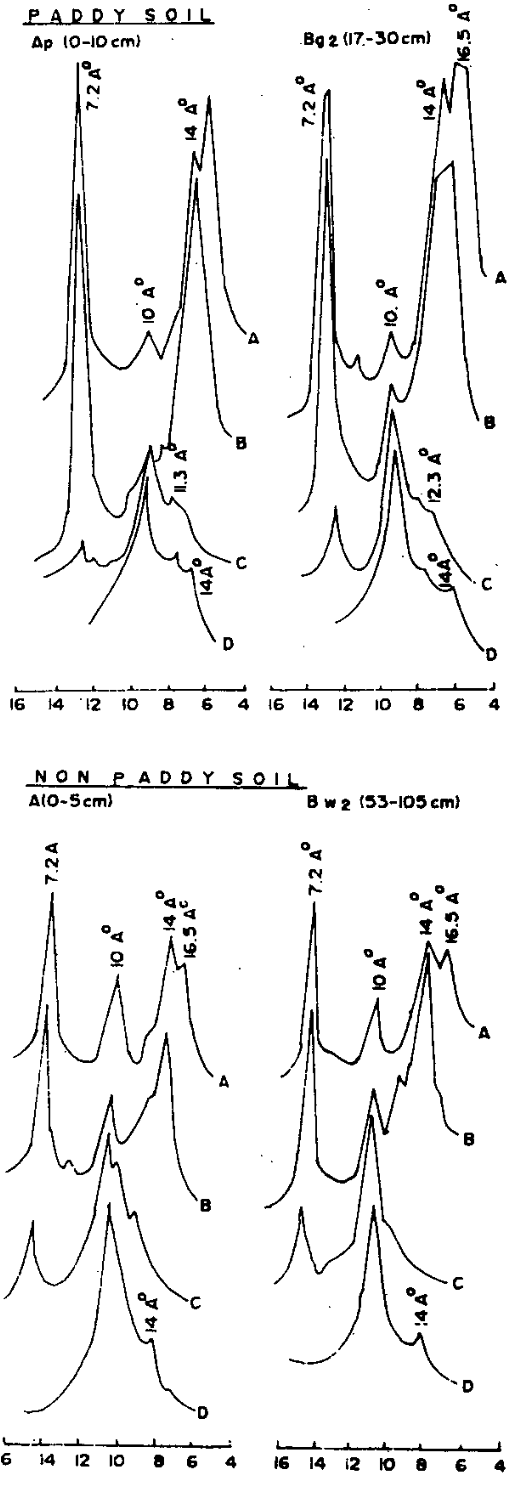
Ch = chlorite, M = mica, V= vermiculite, S = smectite, K = kaolinite,
A = alkali P = plagioclase,

Generally mica content of paddy soils is lower (by 22 to 59%) than that of the associated non-paddy soils and the difference is more pronounced in the surface horizons. A comparison of the shape of 10 A^{o} reflections from both the soil groups indicated that the peak is relatively more asymmetrically broadened towards higher d-spacings in the surface horizons of paddy soils than that of non-paddy soils (Figs 1 & 2). It appears that pronounced asymmetrical broadening of 10 A^{o} reflections indicates greater replacement of K by hydrated cations in paddy soils. The ratio of the intensities of 5 A^{o} and 10A^{o} reflections in these soils (Table 2) appears to be too high for the predominance of trioctahedral mica (Bradley and Grim 1961) thus indicating the dominance of dioctahedral nature of mica.



A: Mg-Saturated glycolated, B: Mg-Saturated
C:K-Saturated 400°C, D:K-Saturated 500°C

Fig. 1. X-ray Diffractograms of clay fractions of paddy and non-paddy soils from north Lakhimpur (P1 and P2) from Piedmont



A: Mg-Saturated glycolated, B: Mg-Saturated,
C:K- Saturated 400°C, D:K- Saturated 500°C

Fig. 2 X-ray diffractograms of clay fractions of paddy and non paddy soils from Kak (P5 and P6) from old filled up channel

Table 2. The Ratios of the intensities (peak area) of 5A^{0} to 10A^{0} reflections calculated from x-ray diffractograms of clay fractions of the soils.

Location	Paddy Soil		Non Paddy Soil	
	Depth (cm)	Ratio	Depth (cm)	Ratio
North	0-10	-	0-5	0.67
Lakhimpur	17-30	-	53-105	0.45
	70-90	0.33	135-155	0.29
Titabor	0-10	-	0-5	0.88
	10-15	-	42-60	-
	20-39	0.59	110-135	0.42
Kaki	0-20	-	0-5	0.73
	20-27	0.91	28-60	-
	105-130	-	91-130	0.71
Cachar	0-15	-	0-10	-
	15-27	-	55-73	1.00
	65-75	0.84	125-150	-

The decrease in mica content in paddy soils is accompanied by pronounced increase in the content of kaolinite and to a lesser extent that of vermiculite, smectite and chlorite. This is consistent with earlier report (Zhang 1981) that longterm paddy cultivation decreased mica content with corresponding increase in the content of kaolinite and vermiculite in paddy soils of China. Although there is no difference in smectite content of paddy and non-paddy soils from Kaki (P5, P6), the paddy soil from North Lakhimpur (P1) has higher smectite content than non-paddy soils (P2). The paddy soils from North Lakhimpur also has higher kaolinite content than the non-paddy soils. In submerged tropical environment mica is subjected to depotassication and transformed to smectite through vermiculite interphase in presence of calcium and magnesium rich environment (Norrish 1972). Oxy and hydroxy polymers of Al released during the process of decomposition of smectite and vermiculite, may partially enter the interlayer of the expanding 2:1 lattice transforming it to chlorite intergrade (Brinkman 1970). Presence of chlorite integrade in the upper horizon of paddy soils is confirmed by 11-12 A^{0} peak which resisted collapse on heating of K-saturated clay to 500^{0}C. Higher smectite and vermiculite content in paddy soils from North Lakhimpur (P1) as compared with its non-paddy conterpart (P2) shows that there is greater stability of smectite and vermiculite phase under poor drainge conditions of these soils. Among all paddy soils under study, the one from North Lakhimpur has the most impeded drainage with permanent water table at a depth of 68 cm. In a similar situation, traditionally rice growing soils from Punjab reported to contain higher amount of smectite as compared to nonpaddy counterparts (Swahney and Sehgal, 1992). It has been reported that mica readily transforms to smectite under condition of impeded drainage (Mohr *et al.* 1992)

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