

## **Clay Mineral Compositions of the Soils and Substrata of Some Quaternary Outcrops in the Saraburi and Lop Buri Area of the Central Plain of Thailand**

by

TOMOO HATTORI\*

### **Introduction**

This paper has two objectives. One is to describe about 20 additional Quaternary outcrops in Saraburi and Lop Buri—Khok Samrong areas of the Central Plain of Thailand, following the line of previous studies by Takaya.<sup>1,2)</sup> The other is to clarify the stratigraphy of the area through the study of the mineralogical characteristics of the soils and substrata, thus making another contribution to the knowledge of geomorphology of the Central Plain.

### **I Geomorphic setting and distribution of soils in the surveyed areas**

The Saraburi area, which is drained by the Pasak river, comprises a part of the fan complex areas of the Central Plain described in a previous paper.<sup>2)</sup> This area has a slightly undulating ground surface with sparse standing trees and is utilized for rice cultivation. According to Dent's soil survey report,<sup>3)</sup> the soils in this area are gray podzolic soils (Hin Khon series) and low humic gley soils (Manorom series on old alluvia and Saraburi and Nakhon Phatom series on semirecent alluvia). The former occupies the upper part of the fan and the latter the lower part.

The Lop Buri area skirts a paleozoic limestone hill region located in the northeastern part of the Central Plain, and the southern part of this area smoothly merge in the Saraburi area. The Khok Samrong area spread on the foot of a Mesozoic sandstone hill located to the east of Amphoe Khok Samrong. The geomorphic setting of the Lop Buri—Khok Samrong area was described in a preceding paper<sup>2)</sup> in relation to the calcareous formation occurring in the same area. The soils that occur in this area are grumsols (Lop Buri series and Takhli series) and grumsol-like soils (humic gley soil, Ban Mi series).

\* 服部共生, The Faculty of Agriculture, Kyoto Prefectural University.

## II Description of outcrops and samples

Notes on the description of outcrops and samples:

*Location*—Location of each outcrop is shown by a location number on the map of Fig. 1. The location numbers for the newly described outcrops start from 201, following those in the previous papers.<sup>1,2)</sup> Some of the previously described outcrops having location numbers below 200 are also dealt with in this paper in relation to clay mineralogical studies.

*Ground height*—The height recorded here is no more accurate than can be assessed from the 1:50,000 topographical map (AMS series L-708).

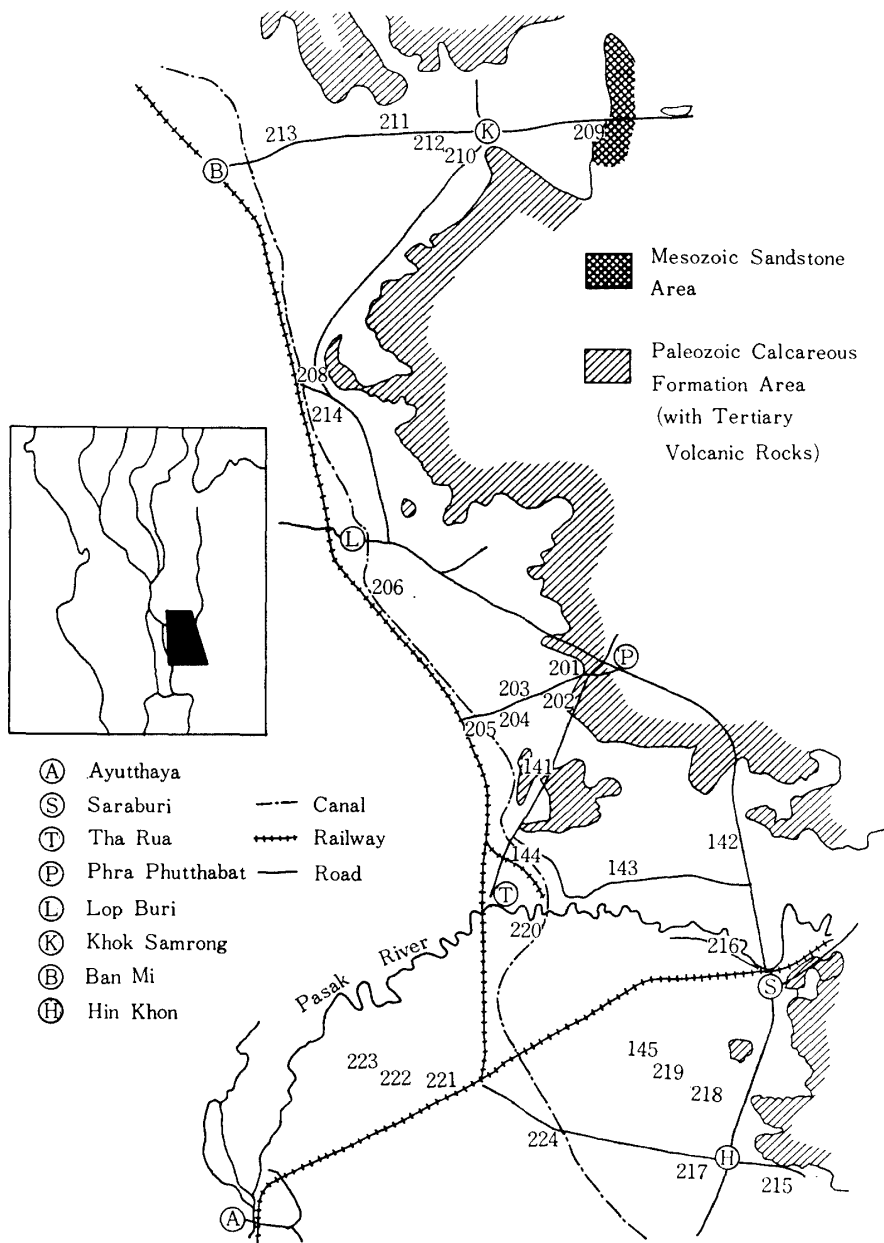


Fig. 1 Location map of sampling sites

*Color of materials*—The Munsel color notation as observed on the standard color chart was recorded.

*Stratigraphical horizon*—At the end of description of each sedimental bed and/or soil horizon, a probable stratigraphical horizon is shown by one of the following abbreviations;

(BVC) Black vertic clay (I) Formation I (II) Formation II  
(III) Formation III (Cal) Calcareous formation

In the Lop Buri—Khok Samrong area, surface or near-surface layers with a few to several decacentimeter thickness are often made up of black colored vertic clay. Though they are associated with calcareous formation, they are described separately under the name of black vertic clay, because of their wide distribution and characteristic nature.

*Sample number*—Sample numbers are given in parentheses at the end of description.

[Abbreviations]

(Texture) heavy clay:HC, light clay:LiC, clay loam:CL, sandy clay loam:SCL, sandy loam:SL, sand:S, silty loam:SiL  
(Color) yellow:yl, white:wh, gray:gr, brown:br  
(Moisture) dry:d, moist:m, wet:w  
(Others) Calcareous:Ca, Manganese:Mn, iron:Fe, ground height:G. H.

#### Lop Buri—Khok Samrong Area

- Loc. 201** Ca 2.5 km. SWS of Amphoe Phra Phutthabat; G. H. 31 m; slightly undulating  
0–50 cm; Dark gr-br (7.5YR 2/2, m) HC; granular structure; very few Mn-pisoliths; gradual boundary (BVC, 201-1)  
50–120 cm; Mixed gr-br (7.5YR 5/2, m) and yl-br (10YR 5/4, m) HC; very few Mn-pisoliths ( $\phi$  0.2–0.4 cm); clear boundary (BVC, 201-2)  
120 cm– ; Layer of wh Ca-nodules (Cal)
- Loc. 202** Ca 5.5 km. SWS of Amphoe Phra Phutthabat; G. H. 22 m; slightly undulating rice land  
0–30 cm; Dark red-br (5YR 2/2, d) HC; few Ca-nodules; few Mn-pisoliths ( $\phi$  0.2–0.5 cm); very hard when dry; gradual boundary (BVC, 202-1)  
30–70 cm; Very dark br (10YR 2/2, m) HC; few concentric pisoliths; very few yl-red (5YR 5/8, m) fine spots; common pressure faces; gradual boundary (BVC, 202-2)  
70–100 cm; Dark br (7.5YR 4/2, m) HC; few yl (10YR 7/8) fine to medium spots; few Mn-pisoliths ( $\phi$  0.2–0.5 cm); common slickensides; clear boundary (BVC, 202-3)  
100–150 cm; Light yl-br (10YR 6/4, m) HC; profuse Ca-nodules; very few Mn-pisoliths (Cal, 202-4)
- Loc. 203** Ca 6.5 km. SWW of Amphoe Phra Phutthabat; G. H. 20 m; very slightly sloping rice land  
0–30 cm; Dark red-br (5YR 2/2, d) HC; very few Mn-Fe pisoliths and Ca-nodules; clear boundary (BVC, 203-1)  
30 cm– ; Layer of wh Ca-nodules (Cal)
- Loc. 204** Near Loc. 203; G. H. 20 m; slightly sloping rice land  
0–30 cm; Very dark br (7.5YR 2/2, d) HC; few Ca-nodules; few Mn-pisoliths ( $\phi$  0.2–0.5 cm); very hard when dry; gradual boundary (BVC, 204-1)  
30–80 cm; Light yl-br (10YR 6/4, d) LiC; few Ca-spots; few Ca-fissure fillings and Ca-nodules; very few Mn-pisoliths; clear boundary (BVC, 204-2)  
80–130 cm; Layer of wh Ca-nodules (Cal)

- Loc. 205** Ca 10.5 km. SWW of Amphoe Phra Phutthabat; G. H. 7 m; flat rice land  
0- 30 cm; BVC with very few Mn-pisoliths ( $\phi$  0.2 cm) (205-1)
- Loc. 206** Ca 300 m. N of Ban Khlong Bun Railway Station; G. H. 5 m; slightly undulating rice land  
0- 70 cm; Dark br (7.5YR 3/2, d) HC; very few Mn-pisoliths ( $\phi$  0.2-0.3 cm); common slicken-sides; gradual boundary (BVC, 206-1)  
70-140 cm; Dark gr (N 3, m) HC; very few dark olive gr (5Y 3/2, m) medium cloudy mottles; few Ca-nodules ( $\phi$  0.3-1.0 cm); few fine to medium Ca-spots; very few Mn-pisoliths; gradual boundary (BVC, 206-2)  
140-170 cm; Gr (N 6, m) HC; few to common pale yl (2.5Y 7/4) small cloudy mottles; few Ca-nodules ( $\phi$  0.3-1.0 cm); few Mn-pisoliths with yl and wh clay; gradual boundary (I, 206-3)  
170-200 cm; Same as above; more mottles than above; larger nodules than above; (I)
- Loc. 141** Refer to Takaya's report.<sup>2)</sup>  
1) (141-1)      3) (141-2)      4) (141-3)      5) (141-4)  
7) (141-5)      8) (141-6)      9) (141-7)      10) (141-8)
- Loc. 144** Refer to Takaya's report.<sup>2)</sup>  
4.0-4.4 m; (144-1)      4.4-4.7 m; (144-2)      4.7-4.9 m; (144-3)  
4.9-6.4 m; (144-4)
- Loc. 208** Near Ban Khok Krathiam Railway Station; G. H. 8 m; slightly undulating rice land  
0- 30+cm; Mixed dark red-br (5YR 4/2, d) and very dark br (10YR 2/2, d) HC; very few pisoliths (I, 208-1)
- Loc. 209** Ca 8 km. E of Amphoe Khok Samrong; G. H. 40 m; slightly undulating bush land  
0- 20 cm; Gr-wh (N 7, d) SL; profuse pink quartz sands; profuse botryoidal and pisolitic concretions ( $\phi$  0.2-1.0 cm); clear boundary (?, 209-1)  
20- 70+cm; Br (7.5YR 5/4, m) SL; many pink quartz sands; many Mn-pisoliths ( $\phi$  0.2-0.8 cm); very few irregular shaped Ca-nodules (up to 1.5 cm) (?, 209-2)
- Loc. 210** Ca 2 km. SW of Amphoe Khok Samrong; G. H. 30 m; Ca-carbonate quarry  
0- 20 cm; Dark br (7.5YR 3/2, d) LiC; many coarse sands; few small limestone gravells; few pink quartz sands; hard fine to medium angular blocky structure; shells, bones and ceramic wares burried; clear boundary (BVC, 210-1)  
20- 45 cm; Dark br (7.5YR 3/4, d) HC; common Ca-nodules ( $\phi$  0.1-0.6 cm); gradual boundary (BVC, 210-2)  
45-100 cm; Ca-nodule layer; accidently slate blocks; gradual boundary (Cal, 210-3)  
100-150+cm; Wh powdery materials with light gr (10YR 7/2, d) SL; original rock structure remains (Cal, 210-4)
- Loc. 211** Ca 5.5 km. W of Amphoe Khok Samrong; G. H. 22 m; slightly undulating rice land with few standing trees  
0- 40 cm; Very dark br (10YR 2/2, m) HC; few Mn-pisoliths ( $\phi$  0.2-0.3 cm); common pressure faces; fine angular blocky structure; clear boundary (BVC, 211-1)  
40- 80 cm; very dark gr-br (10YR 3/2, m) SCL; very few pink quartz grains; very few Ca-spots and nodules ( $\phi$  0.3-0.5 cm); very few Mn-pisoliths ( $\phi$  0.2-0.4 cm); gradual boundary

(BVC, 211-2)

at 100 cm ; Gr-br (10 YR 5/2, m) SCL; more Ca-spots and nodules and pink quartz grains than above; gradual boundary (? , 211-3)

at 120 cm ; Same as 211-3; few to common sand lenses [yl-br (10 YR 5/4) SL with profuse pink quartz grains]; gradual boundary (? , 211-4)

at 160 cm ; Same as 211-4 (? , 211-5)

at 200 cm ; Gr (N 4, m) CL; common sand lenses; very few Ca-spots and nodules; very few Mn-pisoliths (? , 211-6)

**Loc. 212** Ca 4.5 km. W of Khok Samrong; G. H. 23 m; gently sloping rice land

30- 60 cm ; Mixed weak red (2.5 YR 5/2, m) and pale red (10 R 6/4, m) S; very hard when dry; common Fe-Mn pisoliths (? , 212-1)

**Loc. 213** Ca 7 km. E of Ba Hi Railway Station; G. H. 18 m; slightly undulating rice land with sparse standing trees

0- 70 cm ; Gr (N 4, w) HC; very few yl-red (5 YR 5/6) very fine spots; common slickensides; looks like weathered porphyllite (? , 213-1)

**Loc. 214** Ca 2.5 km. SEE of Ban Khok Krathiam Railway Station; G. H. 13 m

0- 50 cm ; Very dark br (7.5 YR 2/2, d) LiC; few quartz grains; few Ca-spots; very few Mn-pisoliths ( $\phi$  0.2-0.3 cm); very few round transported materials; gradual boundary (BVC, 214-1)

50-150 cm ; Dark gr-br (10YR 4/2, d) SCL; few to common sand grains; few Mn-pisoliths ( $\phi$  0.2-0.7 cm); common transported materials ( $\phi$  0.3-0.5 cm) (I, 214-2)

#### Saraburi Area

**Loc. 215** Ca 3 km. E of Amphoe Hin Khon; G. H. 5 m; slightly undulating and sloping rice land

0- 30 cm ; Mixed pinkish wh (7.5 YR 8/2, d) and strong br (7.5 YR 5/6, d) CL; profuse Fe-Mn concretions; common pink quartz grains; clear boundary (III, 215-1)

30- 90 cm ; Pale red (2.5 YR 6/2, d) LiC; red (10 R 4/8) spots and their aggregates; few Fe-Mn pisoliths and many concretions (up to 3.0 cm) (III, 215-2)

**Loc. 142** Refer to Takaya's report.<sup>2)</sup>

1) (142-1) 4) (142-2) 5) (142-3) 6) (142-4) 7) (142-5)

**Loc. 216** Ca 3 km. W of Changwat Saraburi; G. H. ?; brick factory

0- 15 cm ; Wh (10 YR 8/2, d) SiL; common red-yl (7.5 YR 7/8) fibrous mottles; very few red-yl (7.5 YR 6/8) spots; clear boundary (II, 216-1)

15- 45 cm ; Wh (10 YR 8/2, d) SL; profuse Fe-pisoliths and botryoidal concretions; few to common br (7.5 YR 5/4) small cloudy mottles; clear boundary (II, 216-2)

45-130 cm ; Red-yl (7.5 YR 6/8, m) HC; common to many red (2.5 YR 4/8) spots and their aggregates; common red-br (5 YR 5/4) and yl (10 YR 7/6) medium cloudy mottles; common to many concretions; common Fe-Mn pisoliths; gradual boundary (II, 216-3)

130-225 cm : Yl-red (5 YR 5/6, m) HC; few to common pinkish wh (7.5 YR 8/2) cloudy mottles with Mn-films; pinkish beige (2.5 YR 7/3) cloudy mottles (II, 216-4)

**Loc. 217** Ca 2 km. W of Amphoe Hin Khon; G. H. 7 m; the bank of a small stream

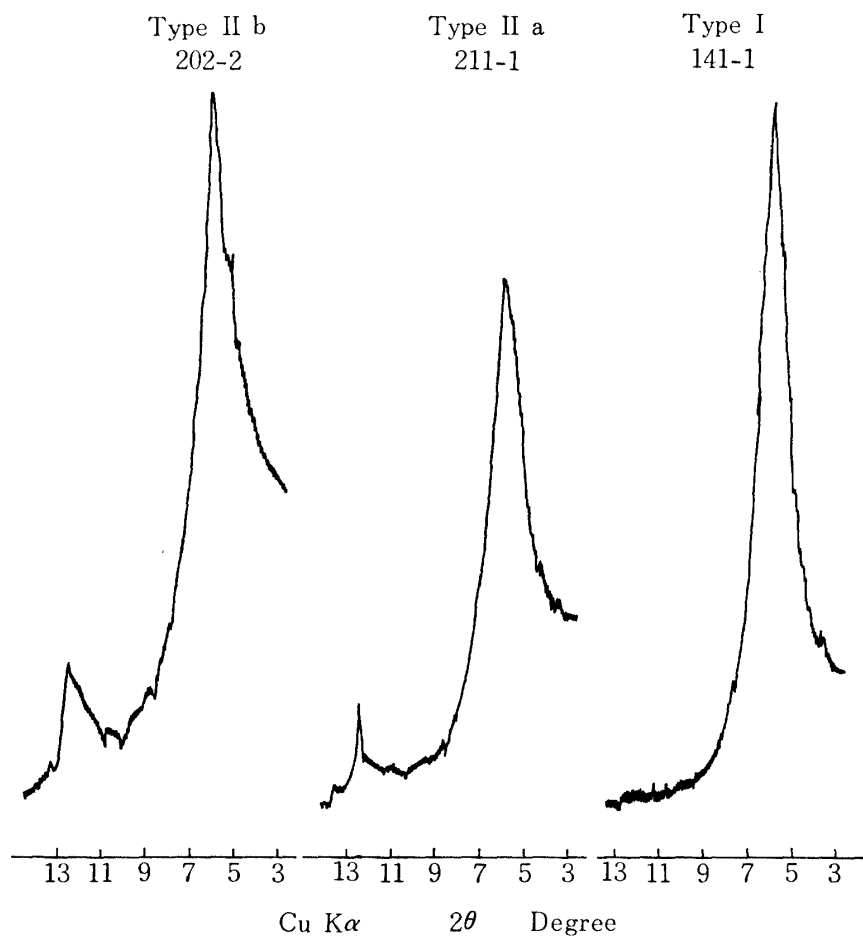
- Natural levee; Red-br (5 YR 5/2, d) CL (217-1)
- Old fan deposits; Dark yl-br (10 YR 3/4, d) HC; common Mn-pisoliths ( $\phi$  0.2-0.4 cm, up to 1.2 cm); few red (2.5 YR 5/8) soft concretions (217-2)
- Loc. 218** Ca 4 km. W of Ban Nong Khrek; G. H. 12 m  
 0- 20 cm ; Mixed light br-gr (2.5 Y 6/2, d) and gr (N 6, d) HC; few pisoliths; very few red-yl (5 YR 6/8) fibrous mottles (II, 218-1)
- Loc. 219** Ca 7 km. W of Ban Nong Khrek; G. H. 11 m  
 0- 10 cm ; Surface soil  
 10- 50 cm ; Pinkish beige (2.5 YR 7/2, d) SL; common to many red (2.5 YR 4/8), red-yl (7.5 YR 7/6) and Mn spots and their aggregates; gradual boundary (II, 219-1)  
 50-170 cm ; Yl-br (10 YR 5/6, m) CL; profuse Mn-pisoliths and Ca-nodules; many slickensides (Cal, 219-2)
- Loc. 145** Refer to Takaya's report.<sup>2)</sup>  
 1) (145-1) 3) (145-2) 4) (145-3) 5) (145-4)
- Loc. 220** South of canal gate at Tha Rua; G. H. 11 m  
 0- 4 m ; Probably (I)  
 4-4.4 m ; Dark gr (N 4, d) HC; common br-yl (10 YR 6/6) and red-yl (7.5 YR 7/6) cloudy mottles; clear boundary (I, 220-1)  
 4.4-4.7 m ; Yl-br (10 YR 5/4, d) SC; profuse round and botryoidal pisoliths; thin laterite layer; clear boundary (III, 220-2)  
 4.7-4.9 m ; Gr-wh (N 8, d) HC; common red (10 R 4/8) and br-yl (10 YR 6/6) cloudy mottles; few pisoliths and concretions; gradual boundary (III, 220-3)  
 4.9-5.0+m ; Gr (N 6, d) HC; less mottles than 220-3 (III, 220-4)
- Loc. 143** Refer to Takaya's report.<sup>2)</sup>  
 0- 0.1 m ; (143-1) 0.1-0.2 m ; (143-2) 0.2-0.4 m ; (143-3 & 4)  
 0.4-0.6 m ; (143-5) 0.6-1.4 m ; (143-6, 7 & 8) 1.4-1.6 m ; (143-9 & 10)
- Loc. 221** Ca 2 km. W of Amphoe Pachi; G. H. 3 m; depressional part on slightly undulating swampy region in rice land  
 0- 30 cm ; Black HC; (recent clay ?)  
 30- 80+cm ; Gr-br (10 YR 5/2, w) HC; common red (10 R 4/8) spots and their aggregates; common yl (10 YR 8/6 and 10 YR 7/6) cloudy and fibrous mottles; common Mn-films and spots; few Fe-concretions ( $\phi$  up to 2.0 cm); few fine pisoliths; few slickensides (I, 221-1)
- Loc. 222** Ca 7 km. W of Amphoe Pachi; G. H. 4 m; very slightly undulating rice land  
 0- 10 cm ; Surface soil  
 10- 50 cm ; Gr (N 4, d) HC; common strong br (7.5 YR 5/8) pipes and fibrous mottles; common yl-br (10 YR 5/4) cloudy mottles; very few dark red-br (2.5 YR 3/4) films; few Mn-films; very few loose Mn-concretions (I, 222-1)
- Loc. 223** Ca 8.5 km. E of Amphoe Nakhon Luang; G. H. ?; almost flat rice land without standing trees  
 10- 30 cm ; Weak red (2.5 YR 5/2, d) LiC; few strong br (7.5 YR 5/8) fibrous and filmy mottles; very few Ca-nodules ( $\phi$  0.5-1.0 cm) and Mn-concretions (I, 223-1)

- Loc. 224** Ca 1.5 km. W of Pasak Canal on the road to Pachi from Hinkhon; G.H. 5 m; slightly undulating rice land with common standing trees
- 0- 10 cm ; Surface soil
- 10- 50 cm ; weak red (2.5 YR 5/2, m) HC; few to common red-yl (5 YR 6/8) fibrous mottles; few red (2.5 YR 5/6) cloudy mottles; very few concretions gradual boundary (I, 224-1)
- 50- 80+cm ; Br (7.5 YR 5/2, m) LiC; common red (10 R 4/8) spots and their aggregates; few yl (10 YR 8/8) fibrous mottles; well indurated; hard (I, 224-2)

### III Clay mineralogical characteristics of soils and substrata of the observed outcrops

The X-ray diffraction procedure (cf. Hattori *et al.*<sup>4)</sup>) was used for the mineralogical study of clays in the soils and substrata of the above described outcrops. Some of the representative X-ray diffraction patterns are shown in Fig. 2 and 3.

The X-ray diffraction patterns of the samples taken from the Lop Buri and Khok



**Fig. 2** X-ray diffraction patterns of Mg-saturated oriented specimens prepared from soils and substrata in Lop Buri—Khok Samrong Area

Samrong area are classified into three types—I, IIa and IIb.

Type I; the clay is composed almost purely of montmorillonite.

Type IIa; the clay is composed dominantly of montmorillonite but contain a small amount of kaolin minerals that show a sharp peak at 7 Å.

Type IIb; similar to Type IIa, but kaolin minerals show a broad 7 Å peak.

The samples from the Saraburi area may be classified into five types according to their X-ray diffraction patterns, as shown in Fig. 3.

Type IIc; similar to Type IIa and IIb, but some vermiculite is present.

Type IIIa; the clay contains kaolin minerals in nearly equal quantities. 14 Å minerals are dominantly montmorillonite.

Type IIIb; similar to Type IIIa, but 14 Å minerals are composed of montmorillonite and vermiculite and/or Al-intergrade minerals in about halves.

Type IIIc; similar to Type IIIa and IIIb, but 14 Å minerals are mainly vermiculite and Al-intergrade minerals.

Type IV; the clay is composed of kaolin minerals.

The clay mineralogical characteristics of the samples from the Lop Buri—Khok Samrong area and from the Saraburi area are given in Tables 1 and 2, respectively.

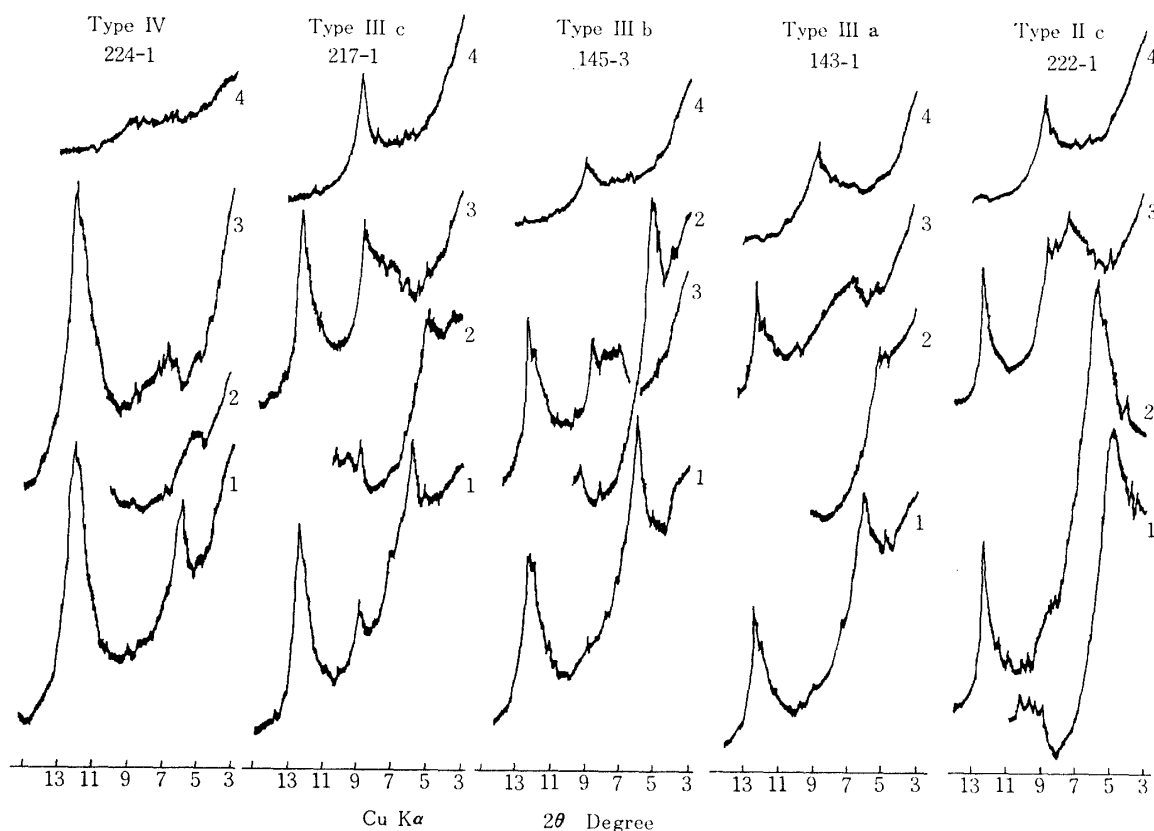


Fig. 3 X-ray diffraction patterns of oriented specimens prepared from soils and substrata in Saraburi Area (1. Mg-AD, 2. Mg-Gly, 3. K-AD, 4. K-500°heat)



From the results given in the tables the clay mineralogical characteristics can be pointed out as follows: the following general

1) The samples taken from calcareous formations are composed mainly of montmorillonite. But there are slight local variations:

1a) Calcareous formations in the Lop Buri and Saraburi areas contain a small amount of kaolin minerals whose 7 Å peak is broad.

1b) Those in the Khok Samrong area contain a small amount of kaolin minerals whose 7 Å peak is very sharp.

2) Black vertic clays are composed of montmorillonite and a small amount of kaolin minerals. The kaolin minerals of black vertic clays show either a sharp or a broad 7 Å peak depending on the type of kaolin minerals contained in the underlying calcareous formations.

3) Most samples taken in the Saraburi area are composed of kaolin minerals and montmorillonite in nearly equal quantities but some samples taken in the area south of Pasak river contain small amounts of vermiculite and illite.

**Table 1** Mineralogical characteristics of clay fractions separated from soils and substrata of outcrops in Lop Buri and Khok Samrong area

Location	Sample Number	Feature of materials	Clay mineralogical characteristics				Notes on soils
			Kaolin mineral %	Kinds of minerals	Sharpness of 7Å peak	Type	
Khok Samrong area	208-1, 210-1, 2, 211-1, 2	Black vertic clay with pink quartz grains					Grumusol (Lop Buri series and Takhli series) and Humic gley soil (Ban Mi series) at Loc. 208
	210-3, 4	White and pale brown clay and calcium nodules	30	Mt	Sharp	IIa	
	209-1, 2, 211-3, 4, 5, 211-6, 212-1, 213-1	Dark gray clay with many pink quartz grains					
Lop Buri area	141-1, 2, 6	Black vertic clay					
	141-3, 4, 5, 7	White and pale brown clay and/or calcium nodules	0	Mt	-	I	
	201-1, 202-1, 203-1, 204-1, 205-1, 2, 206-1, 144-1	Black vertic clay					
	201-2, 202-2, 3, 4, 204-2, 206-2, 3, 144-2, 3, 4	Dark gray to gray clay with calcium nodules	30	Mt	Broad	IIb	
Khok Samrong area	214-1, 2	Look like heavily weathered porphyllite					unknown

Mt; montmorillonite

**Table 2** Mineralogical characteristics of clay fractions separated from soils and substrata of outcrops in the Saraburi area

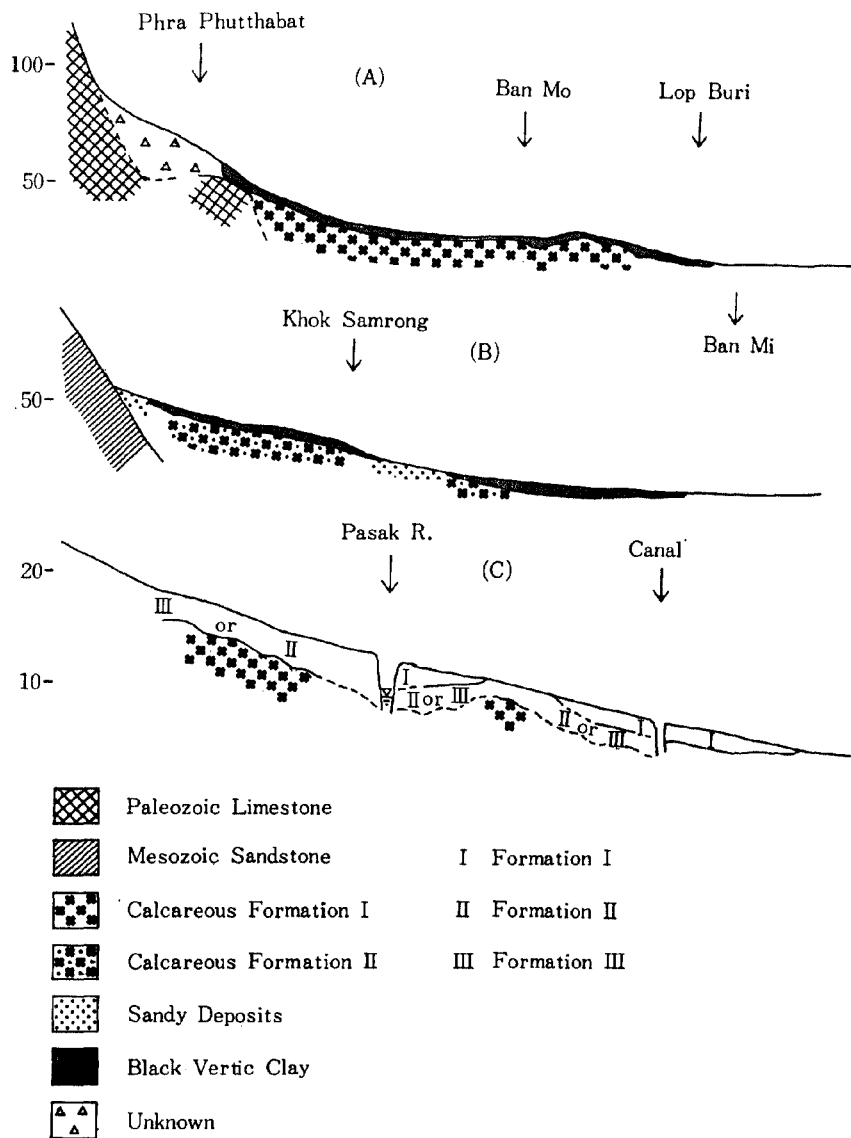
Sample Number	pH (1 : 5)		clay mineralogical characteristics				Note on soils and geologic formation
	in H <sub>2</sub> O	in N-KCl	Kaolin minerals %	Mica minerals %	Kinds of 14 Å minerals	Type	
215-1	5.6	4.2	55	+	Al-, Mt, Ver	IIIb	gray podzolic soil (Hin Khon series)
2	6.2	4.0	65	5	Ver, Mt	IIIb	
142-1	5.3	3.9	40		Mt	IIIa	low humic gley soil (Manorom series) ----- Calcareous formation
2	5.3	3.9	40		Mt	IIIa	
3	8.9	6.7	60		Mt	IIIa	
4	8.9	7.2	20		Mt	Iib	
5	9.5	7.8	10		Mt	Iib	
216-1	4.9	4.1	60	+	Mt>Ver>Al-	IIIb	low humic gley soil (Manorom series)
2	5.6	4.2	60	10	Mt>Ver>Al-	IIIb	
3	5.7	3.7	60	5	Mt>Ver>Al-	IIIb	
4	6.1	3.8	30	20	Ver>Mt>Al-	IIIc	
217-1	4.2	3.5	45	10	Ver>Mt>Al-	IIIc	recent deposits by small stream fan deposits
2	6.6	5.5	40	5	Ver, Mt	IIIb	
218-1	6.3	5.0	50		Mt	IIIa	low humic gley soil (Manorom series)
219-1	4.9	3.9	60		Mt	IIIa	----- calcareous formation
2	8.8	6.9	10		Mt	Iib	
145-1	5.4	4.0	65		Mt, Ver	IIIb	low humic gley soil (Manorom series)
2	5.2	3.8	50		Mt, Ver	IIIb	
3	6.1	4.9	50		Mt, Ver	IIIb	
4	8.2	6.2	45		Ver>Mt	IIIc	
220-1	6.6	5.8	25	5	Mt, Ver	Iic	formation I
2	6.2	5.9	70		Mt, Ver	IV	-----
3	6.4	5.8	60		Mt	IIIa	formation III
4	7.4	6.2	65		Mt	IIIa	
143-1	4.5	3.7	50		Mt	IIIa	low humic gley soil (Saraburi series)
3	6.2	5.1	50		Mt	IIIa	
5	5.9	4.6	50		Mt	IIIa	
6	5.9	4.5	50		Mt	IIIa	
10	7.1	5.8	50		Mt	IIIa	
221-1	4.3	3.6	60		Mt, Ver	IIIb	
222-1	6.7	5.5	30		Mt, Ver	Iic	low humic gley soil (Nakhon Pathom series)
223-1	7.3	5.9	30		Mt, Ver	Iic	
224-1	5.3	4.3	70		Mt	IV	low humic gley soil (? )
2	4.8	3.7	70		Mt	IV	

Mt; Montmorillonite      Ver; Vermiculite      Al-; Al-intergrade minerals

**Conclusion**

Based on the observation of outcrops and the clay mineralogical studies the stratigraphy of the surveyed areas may be drawn as in Fig. 4.

There seem to be two kinds of calcareous deposits; one is the Kanker deposits (Cal-I, which is formed either in Paleozoic calcareous shales or in Tertiary volcanic rocks) and the other is the deposits of calcium carbonate nodules (Cal-II) precipitated within the Quaternary strata. The calcareous deposits in the outcrop at Loc. 141 and 210 of the Lop Buri area represent the former type, while the one at Loc. 211 of the



**Fig. 4** Stratigraphy of surveyed areas illustrated schematically  
 (A) Khok Samrong area (B) Lop Buri area  
 (C) Saraburi area

Khok Samrong area is representative of the latter type.

The surface materials of the Saraburi area are considered to have been deposited by the present and old Pasak river. But there seem to be hidden calcareous bodies like limestone and/or Tertiary volcanic rocks beneath the ground surface. Thus the soils and substrata sometimes show mixed nature of the fluvial and calcareous materials.

#### Acknowledgement

The field survey and sampling were conducted at 1968/69 with the permission of the National Research Council of Thailand. The author is deeply indebted to the staff of Geology Department of the Chulalongkorn University of Thailand for their kind assistance in supplying the author valuable information. Dr. Takaya of Kyoto University who was with the author during the whole period of the field survey assisted the author very much in the geomorphological description of the outcrops.

#### References

- 1) Takaya, Y. 1968. "Quaternary Outcrops in the Central Plain of Thailand," *Geology and Mineral Resources in Thailand and Malaya*. Reports on Research in Southeast Asia, the Center for Southeast Asian Studies, Kyoto University, pp. 7-68.
- 2) \_\_\_\_\_. 1972. "Quaternary Outcrops of the Southern Part of the Central Plain of Thailand," *Tonan Ajia Kenkyu* (South East Asian Studies), Vol. 10, No. 2, pp. 298-320.
- 3) Dent, F. J. and Mana Cheuthongdee. 1966. "Soil Series Survey of the MERS Lopburi Area," (Mimeographed), Soil Survey Report No. 50, Ministry of Natural Development, Bangkok.
- 4) Hattori, T., H. Furukawa and K. Kawaguchi. 1965. "Some Consideration on the Clay Minerals of Lowland Rice Soils in Thailand," *Tonan Ajia Kenkyu* (South East Asian Studies), Vol. 3, No. 3, pp. 93-108 (in Japanese).