

## **Two Brackish Clay Beds along the Chao Phraya River of Thailand**

by

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### **Abstract**

Two brackish clay beds of different age are found along the lower reaches of the Chao Phraya River of Thailand. The older one is from 2 to 6 m above M. S. L. forming a terrace surface, with the outcrop area 100 to 150 km inland from the Gulf of Thailand, and an equivalent bed is also to be found at a level 11 m below M. S. L. near the gulf coast. This older clay bed is assumed to be of upper Pleistocene age. The younger one extends over a broad area facing the gulf and forms a very flat plain 2 m above M. S. L. This is dated post-glacial by  $C_{14}$  dating.

### **I Three Quaternary Formations of Different Age**

Three Quaternary formations of different age are observed in the lower reaches of the Chao Phraya: Formation I, Formation II, and an older formation (Formation III equivalent?). Their relations are all unconformable (Takaya, 1968).

Formation I is the youngest. In the northern half of the surveyed area, it has developed as a levee-overbank deposit complex of riverine origin. By contrast, in the south it is composed predominantly of dark- to black-colored clay of brackish lagoonal origin. These sediments are loose and free of weathering.  $C_{14}$  datings for two wood fragments produced from the clay give the respective ages of  $5750 \pm 135$  years B. P. and  $6490 \pm 135$  years B. P.

Formation II, which is the next youngest, has a depositional cycle comprised of a coarse basal part overlaid by clayey middle and upper parts. The upper part is usually characterized by such weathering products as yellow-brown mottlings and/or manganese and iron pisolitic concretions. Stiffness is a further distinct characteristic which distinguishes Formation II from Formation I. Its average thickness is 5 m and its age is believed to be uppermost Pleistocene (Takaya, 1968).

The facies of the older formation (or Formation III?) change from one outcrop to another, ranging from clayish to coarse sandy ones. The sediment is usually well indurated

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and jointed. The most characteristic accessory is its secondarily evolved calcareous balls. The balls average 7 to 8 cm in diameter and have a zonal structure of highly crystallized inner most walls and an almost amorphous outer crust. The formation is often found covered by a thin (ca. 10 cm) lateritic veneer as a cap layer in the marginal part of the Chao Phraya basin. But such sequence is seldom seen in the surveyed area coinciding with the central axis of the basin. The sediments are sometimes fresh and sometimes very much weathered. The age is provisionally assigned to middle Pleistocene.

## II Evidence of Brackish Sediments

Gray to black (N6 to N3, when moist) clays composing the lower to middle horizon of Formation II produce gypsum needles and characteristic yellow (2.5 YR 8/8) colored spots (see Fig. 4-b). The yellow is believed to be jarosite (or basic ferric sulphate). Inasmuch as there is no hinterland section in the drainage area supplying any reasonable amount of sulphur, the author concludes that clays having such rich sulphate components have been formed under a brackish environment.

Formation I offers more direct evidence of marine origin. The gray to black (N6 to N2, when wet) loose clays of the formation often yield shells and crab claws of brackish genous. Gypsum crystals and jarosite are also commonly yielded. These facts give adequate evidence of the marine origin of the clay.

## III Distribution of Brackish Clay Beds along the Chao Phraya River

A profile drawn parallel to the Chao Phraya, spaced about 5 km from the river (Fig. 2) gives two kinds of evidence, the one topographical, the other geological.

Topographically the profile can be divided into the three following sections :

Section A : The high undulating area between Chainat and latitude 14°30'N. The ground surface is more than 5 m high, corresponding to that of the Sing Buri plain (cf. Takaya, 1969). It can be further subdivided into two subsections, A-1 and A-2, by the steep slope that appears about 8 km south of Loc. 2. The topographical break is most likely to have been produced tectocically after the formation of the surface.

Section C : The flat, low-lying area located between 14°15'N and the Gulf of Thailand. The ground surface averages 2 m in elevation and comprises the heart of the Bangkok plain.

Section B : The transitional area between Sections A and C.

The surface of Section C has commonly been called a (recent) deltaic plain. In this sense, the surface of Section A might be termed a Pleistocene terrace surface. The character of Section B's surface remains problematical, being described simply as a transitional area between the former two.

Geologically the profile shows the following :

- 1) The bulk of the sediments of Section A is composed of Formation II materials. Thus the ground surface most probably developed as the depositional surface of Formation II.
- 2) A brackish clay bed is tracable through the lower half of Formation II. The bed ranges from 2 to 6 m above M. S. L. in Subsection A-1, whereas in Subsection A-2 it is much higher, around 13 m above M. S. L.
- 3) Formation II is still near the ground surface in Section B, but it gradually submerges to a depth of 11 m below M. S. L. at Bangkok.
- 4) The flat surface of Section C is the depositional surface of Formation I. Its surface layers are predominantly composed of brackish clayey material.

#### Appendix (Description of Outcrops)

Locality: Locations of outcrops are indicated by number on the locality map of Fig. 1.  
 Ground height: No special survey was made during the field observation, so recorded heights are no more accurate than those that can be assessed from the 1:50,000 topographical map of series L 708.

#### Abbreviations

[F. P.]: Flood plain deposits (recent in age)  
 [I]: Formation I (recent in age)  
 [II]: Formation II (uppermost Pleistocene)  
 [III]: Formation III (provisionally middle Pleistocene)  
 G. H.: Ground height  
 Ca: Calcareous  
 Mn: Manganese  
 Fe: Iron  
 d: Dry condition  
 m: Moist condition  
 w: Wet condition

Loc. 1: Right bank of Chao Phraya, ca. 5 km N of Amphoe Sanphaya  
 G. H.: ca. 17.0 m, Bank height: 7.7 m (Jan. 6, 1969)

- Surface-2.0 m: [F. P] Dark brown (7.5 YR 3/2, w) loam: sharp boundary to.  
 2.0-2.6 m: [I] Pale red (2.5 YR 6/2, d) sandy loam; few to common light yellowish brown (10 YR 6/4) diffused small to medium cloudy mottlings; few irregular shaped Fe-concentrations (up to 1.5 cm long); few Mn-concentrations ( $\phi$  0.2-0.4 cm); gradual boundary to.  
 2.6-3.1 m: [I] Dark gray (N 4, d) clay loam; few Fe-concentrations; very few dark grayish brown (10 YR 4/2) fine to medium cloudy mottlings; very few Fe-pisolith ( $\phi$  0.2 cm); sharp boundary to.  
 3.1-3.6 m: [II] Gray (N 6, d) sandy clay loam; few to common light yellowish brown (2.5 Y 6/4) diffused medium cloudy and few to common yellow (10 YR 7/6) fine to medium cloudy mottlings; profuse Fe-concretions ( $\phi$  0.3-0.6 cm); gradual boundary to.  
 3.6-4.8 m: [II] Yellow (10 YR 7/6, d) sandy loam; few white (10 YR 8/2) fibrous mottlings; common Ca-nodules ( $\phi$  up to 7 cm); common Mn-concentrations; few Fe-spots; slightly current bedded; indurated by Ca-material; occasionally changes laterally to redder

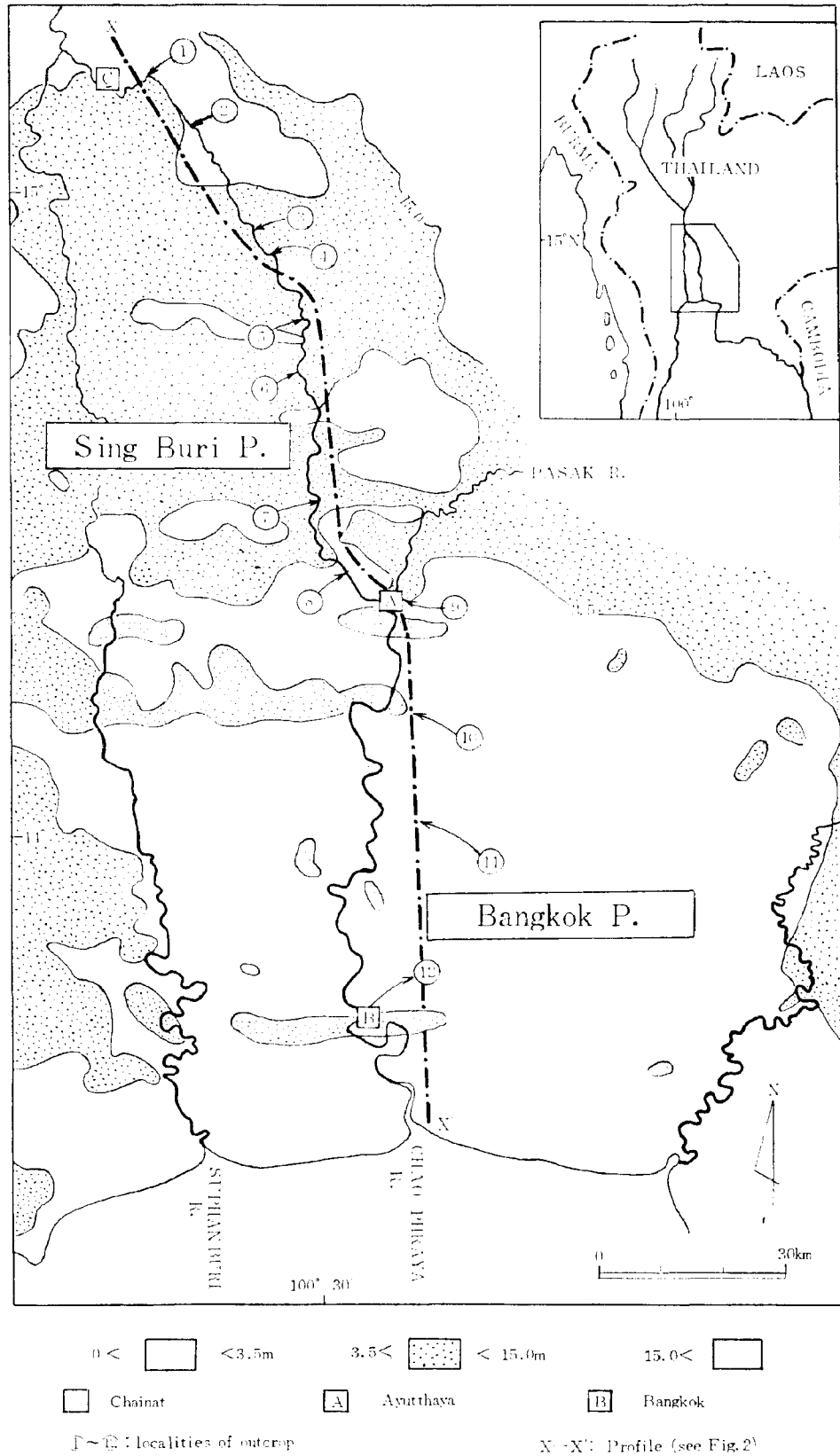


Fig. 1 Index map of the lower reach of the Chao Phraya River, with localities of outcrops described.

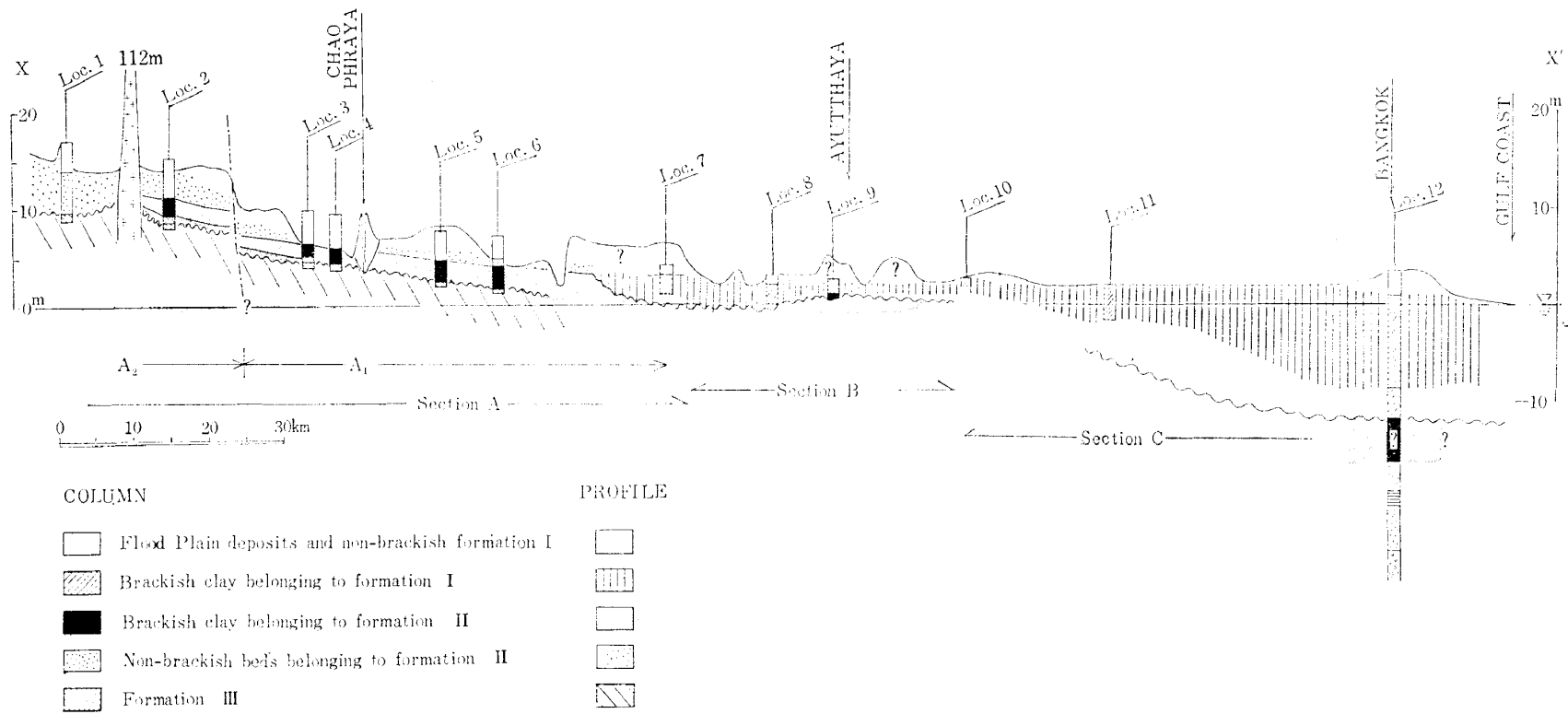


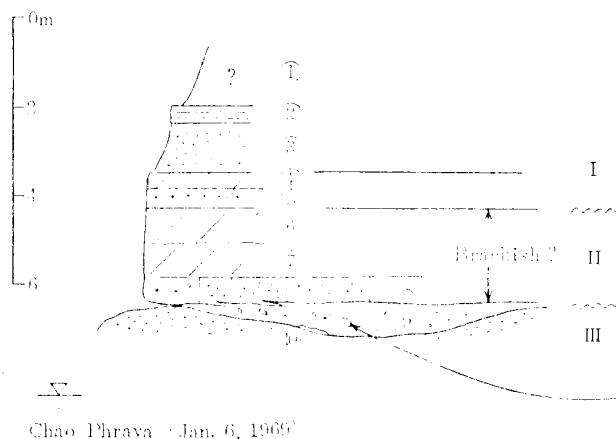
Fig. 2 N-S profile along the Chao Phraya River, showing two brackish clay beds.

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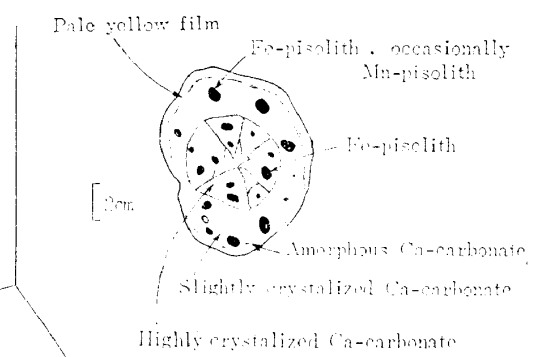
- in color due to more Fe-concentrations; gradual boundary to.
- 4.8-5.7 m: [II] Yellow (10 YR 7/6, d) sandy loam with common quartz granules; common Ca-nodules, Mn-concentrations and few Fe-concentrations; slightly current bedded; moderately indurated by Ca-carbonate; occasionally appears more redder because of more Fe-concentrations; gradual boundary to.
- 5.7-7.2 m: [II] Clayey sand with quartz and feldspar granules and few pebbles; common to many Mn-concentrations ( $\phi$  0.5-1.3 cm); current bedded; partly indurated; clay is white (N 8, d) and calcareous; sharp boundary to.
- 7.2-7.4 m: [II] Aggregate of weathered rock fragments, Fe-concretions, Mn-concretions and quartz grains; cemented by Fe; very sharp boundary to.
- 7.4-7.7 m: [III] Coarse sand and gravels; current bedded; well indurated; gravels are subround, 5 cm in maximum diameter and fresh.

**Loc. 2:** Right bank of Chao Phraya, ca. 7 km S of Amphoe Sanphaya  
G. H.: ca. 15.2 m (see Fig. 3).

- 1) Unknown
- 2) light gray (N 7, d), brown (10 YR and 7.5 YR, d) and dark gray (N 4, d) mixed clay; clear boundary to.
- 3) Medium sand with many muscovite and hydromica flakes; very loose; common irregular shaped Mn-concentrations in upper half; sharp boundary to.
- 4) Pinkish gray (5 YR 6/2, d) heavy clay; few to common reddish yellow (7.5 YR 6/8) spots and cloudy mottlings; few strong brown (7.5 YR 4/6) fibrous mottlings; few Mn-films along pore walls; partly more bluish; gradual boundary to.
- 5) Light gray (N 7, d), strong brown (7.5 YR 5.8) and pinkish gray (5 YR 6/2) finely mixed heavy clay; few Mn-pisolith ( $\phi$  0.2-0.4 cm); large angular blocky; clear boundary to.
- 6) Very dark gray (N 3, d) heavy clay; few brownish yellow (10 YR 6/6) and very pale brown (10 YR 7/4) medium cloudy mottlings; very few Fe-pisolith; very few Mn-pisolith ( $\phi$  0.2-0.3 cm); gradual boundary to.
- 7) Gray (N 6, d) heavy clay; few to common brownish yellow (10 YR 6/6) medium cloudy mottlings; very very few fine gypsum needles (0.3 cm long); gradual boundary to.
- 8) Light gray (N 7, d) and yellow (10 YR 7/6, d) finely mixed clay loam; few to common coarse fraction (composed of transported Mn- and Fe-pisoliths, feldspar and quartz grains, and lime nodules); well developed prismatic structure; gradual boundary to.
- 9) Mixture of light brownish gray (2.5 Y 6/2, d) light clay, light yellowish brown (10 YR 6/4) clay loam, light gray (2.5 Y 7/2) sandy clay loam and various kinds of granules (composed of



**Fig. 3-a** Outcrop of Loc. 2, ca. 5 km N of Amphoe Sanphaya.



**Fig. 3-b** Ca-nodules including Fe- and Mn-pisoliths.

Mn-pisolith, Fe-pisolith, quartz and feldspar grains, and large Ca-nodules (see Fig. 3-b); sharp boundary to.

- 10) Light gray (N 7, w) clay with many strong brown (7.5 YR 5/8) and reddish yellow (7.5 YR 6/8) clayey sand patches; common quartz, feldspar, muscovite and unidentified rock fragments of granule size; well indurated.

**Loc. 3: Right bank of Chao Phraya, 8 km N of Sing Buri**

G. H.: ca. 9.8 m, Bank height: ca. 5.8 m (Dec. 22, 1968).

Surface-1.7 m: [I] Medium sand; sharp boundary to.

1.7-2.5 m: [I] Pinkish gray (5 YR 7/2, d) light clay; few to common brown (7.5 YR 5/4) small to medium cloudy mottlings; few reddish yellow (7.5 YR 6/6) small to medium mottlings; few Mn-films; blocky and friable; gradual boundary to.

2.5-3.5 m: [I] Pinkish gray (7.5 YR 6/2, d) sandy loam; profuse coarse sand grained quartz; few to very few mica flakes and feldspar grains; few to common Fe-concentrations; sharp and clear boundary to.

3.5-4.7 m: [II] Gray (N 5, d) heavy clay; few brown (7.5 YR 5/4) cloudy mottlings; few Mn-pisolith ( $\phi$  0.2-0.4cm) with Fe-coating; few Fe-pisolith ( $\phi$  0.2-0.4cm); few to common desiccation cracks with sand fillings in a zone of 20 cm from top; clear boundary to.

4.7-5.3 m: [II] Pinkish gray (7.5 YR 7/2, d) clay loam; common Fe-pisolith; few irregular shaped Mn-concentrations (max.  $\phi$  2 cm); few Mn-films; few Fe-films; blocky; very sharp boundary to.

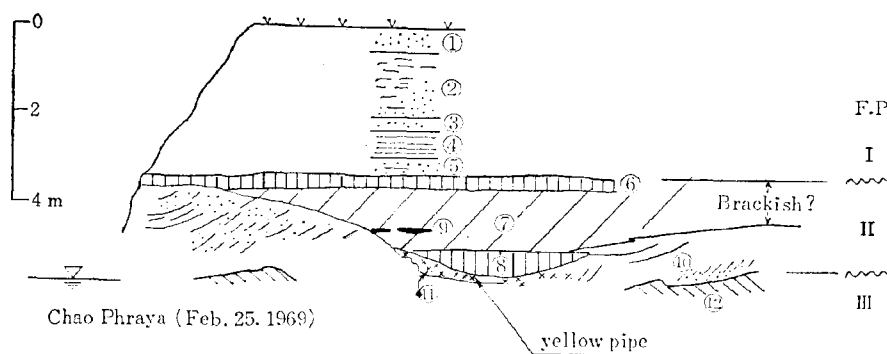
5.3-5.9 m: [III] Light gray (N 7, w) heavy clay; partly yellow (10 YR 7/6); strongly indurated; very angular blocky; common to many Ca-nodules as shown in Fig. 3-b, along cracks.

**Loc. 4: Right bank of Chao Phraya, 2 km N of Amphoe Sing Buri**

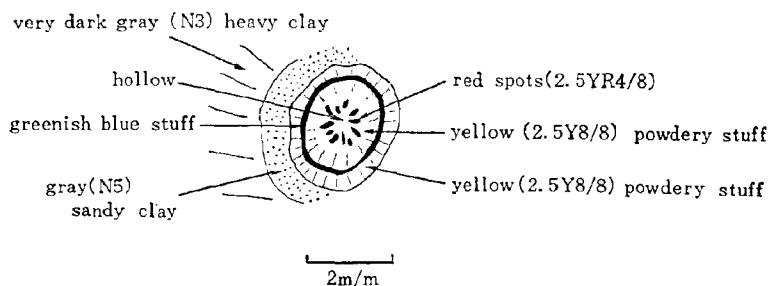
G. H.: ca. 9.5 m (see Fig. 4).

1) Pinkish white (5 Y 7/2, d) sand; loose; sharp boundary to.

2) Pale red (2.5 YR 6/2, d) loam; few Mn-films along grass roots; the upper, the coarser; gradual



**Fig. 4-a** Outcrop of Loc. 4, 2 km N of Amphoe Sing Buri.



**Fig. 4-b** Section of yellow pipe evolved in heavy clays (7), (8) and (11) in Fig. 4-a.

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- boundary to.
- 3) Pinkish white (5 Y 7/2, d) sandy clay loam ; common muscovite ; few reddish yellow (5 YR 6/8) spots and fibrous mottlings ; few irregular shaped Mn-concentrations (0.2–1.0 cm long) ; gradual boundary to.
  - 4) Pale red (2.5 YR 6/2 and 7/2, d) clay loam ; few to common irregular shaped Fe-concentrations ; few Mn-concentrations ; sharp boundary to.
  - 5) Pink (5 YR 7/4, d) sandy loam ; few reddish yellow spots and fibrous mottlings ; few to common Mn- and Fe-concentrations ; sharp and clear boundary to.
  - 6) Gray (N 6, d) clay ; very few fragmented plant remains ; onion structure ; clear boundary to.
  - 7) Gray (N 5, m) to light gray (N 7, d) heavy clay ; few yellowish red (5 YR 4/8, d) large films ; very few plant remains ; very few yellow pipes (see Fig. 4-b) ; few to common Mn-pisolith ( $\phi$  0.2–0.8 cm) ; very few Fe-pisolith (0.2–0.3 cm) in upper half ; gradual boundary to.
  - 8) Very dark gray (N 3, m) heavy clay ; few Fe-films ; few Mn-pisolith ; few to common Ca-nodules ( $\phi$  0.5–1.0 cm) ; few plant remains ; Very few yellow pipes ; prismatic ; clear boundary to (10).
  - 9) Very dark gray (N 3, m) clay with profuse fragmented plant remains ; interbedded in (7).
  - 10) Current bedded clayey sand ; few to common gray (N 5, m) clay balls ( $\phi$  0.5–1.0 cm), Fe-concentrations, Fe-pisolith, Mn-pisolith and coarse quartz grains ; sharp and clear boundary to (12).
  - 11) A part of (10) unit ; especially richly impregnated with yellow (2.5 Y 8/8) pipes and spots as shown in Fig. 4-b.
  - 12) Gray (N 6, m) sandy loam ; few yellowish red (5 YR 4/8) cloudy mottlings ; few quartz grains, mica flakes and weathered fine rock fragments ; few to common Fe- and Mn-pisolith ( $\phi$  0.2–0.5 cm) ; few to very few Ca-nodules ( $\phi$  up to 10 cm) well indurated.

**Loc. 5:** Right bank of Chao Phraya, ca. 2 km N of Amphoe Phrom Buri

G. H. : ca. 7.6 m, Bank height : ca. 5.2 m (Jan. 1, 1969).

- Surface-2.0 m : [F.P.] Pale red (2.5 YR 7/2, d) loam ; few diffused brown (10 YR) cloudy mottlings ; few loose irregular shaped Fe- and Mn-concentrations ; sharp boundary to.
- 2.0-2.4 m : [I?] Brown (7.5 YR 5/2, d) light clay ; few yellowish brown (10 YR 5/2) small cloudy mottlings ; few Mn-spots and concentrations ; few Fe-fibrous mottlings ; few to common mica flakes ; unclear boundary to.
- 2.4-3.0 m : [I?] Pale red (2.5 YR 6/2, d) light clay ; few reddish yellow (7.5 YR 7/6) small to medium cloudy mottlings ; few irregular shaped Mn-concentrations ; few mica flakes ; blocky ; clear boundary to.
- 3.0-3.5 m : [II?] Gray (N 6, d) clay loam ; common to many reddish yellow (7.5 YR 6/6) and brownish yellow (10 YR 6/6) small to medium cloudy mottlings ; few Mn-concentrations ( $\phi$  0.5–1.0 cm) ; few Ca-concretions (1.0–2.0 cm long) ; few desiccation cracks filled with pale red (2.5 YR 6/2) clay ; clear boundary to.
- 3.5-4.5 m : [II?] Pale red (2.5 YR 6/2, d), yellow (10 YR 7/8, d) and white (N 8, d) mixed sandy clay loam ; common to many Mn-concentrations (1.0 cm long) ; few mica flakes ; unclear and gradual boundary to.
- 4.5-4.9 m : [II?] Very dark gray (N 3, m) heavy clay ; common irregular shaped Ca-concretions (up to 3 cm long) ; few Fe-cloudy mottlings ; few Mn-pisolith ( $\phi$  0.2–0.8 cm) ; very few Fe-pisolith ( $\phi$  0.2–0.3 cm) ; very few gypsum needles (0.2 cm long) ; lenticular unit tapering off laterally ; very sharp boundary to.
- 4.9-5.2 m : [III] Dark gray (N 4, m) heavy clay ; very few Fe-pisolith ( $\phi$  0.2–0.4 cm) ; very few gypsum needles (0.2 cm long) ; very few yellow (2.5 Y 8/8) spots ; well indurated and thickly jointed.

**Loc. 6:** Right bank of Chao Phraya, Amphoe Wat Chaiyot

G. H. : ca. 7.1 m (see Fig. 5).

- 1) Pale red (2.5 YR 6/2, d) sandy clay.
- 2) Gray (N 6, d) clay loam ; few brown (7.5 YR) cloudy mottlings ; common Fe- and Mn-concentra-



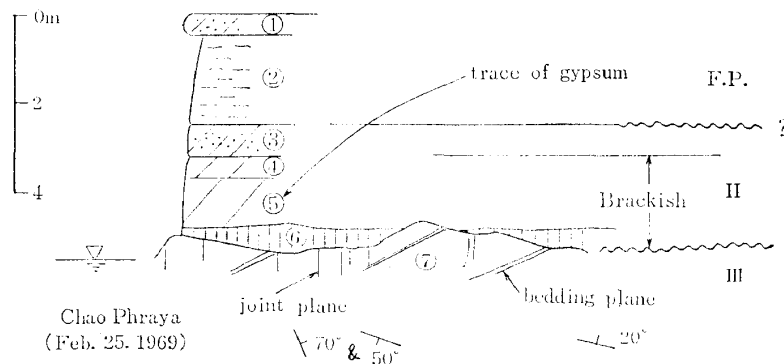


Fig. 5 Outcrop of Loc. 6, Amphoe Wat Chaiyot.

- tions ( $\phi$  0.3–1.0 cm); common mica flakes; sharp boundary to.
- 3) White (10 YR 8/2, partly 2.5 YR 7/2, d) silty clay loam; common to many yellowish brown (10 YR 5/6) spots and their aggregates; few Mn-films; small to medium prismatic structure; sharp boundary to.
  - 4) Gray (N 6, m) light clay; few to common strong brown (7.5 YR 5/8) concentrations; prismatic; unclear boundary to.
  - 5) Gray (N 5, m) light clay; common strong brown (7.5 YR 5/6) and olive brown (2.5 Y 4/6) spots and cloudy mottlings; common Mn-concentrations ( $\phi$  0.5–1.0 cm); very few gypsum needles (0.2 cm long); clear boundary to.
  - 6) Lenticular unit tapering off laterally; black (N 2, m) clay; few gypsum needles (0.3 cm long); very minutely jointed; sharp and uneven boundary to.
  - 7) Brownish yellow (10 YR 6/6, m) and pinkish gray (5 YR 6/2, m) mixed clay; few Fe-pisolith, few Ca-concretions (1.5 cm long) and few Mn-pisolith; very few gypsum needles (0.3 cm long) and very few yellow (2.5 Y 8/8) pipes; minutely jointed (N 30°W, 70°E and N 70°W, 50°S); few to common gypsum crystals (0.3 cm long) along joint surface; color changes laterally more grayish or occasionally bluish; unit seems to be suffered tectonic disturbance and inclines to N 70°W, 20°N.

**Loc. 7:** Right bank of Chao Phraya, ca. 10 km S of Ang Thong  
G. H.: ca. 4.0 m, Bank height: ca. 2.7 m.

- Surface–1.0 m: [F. P.] Fine to medium sand; loose; very sharp boundary to.
- 1.0–1.2 m: [I] White (10 YR 8/2, d) heavy clay; few to common reddish yellow (5 YR 6/8 and 7.5 YR 6/8, d) small to medium cloudy mottlings; few Mn-films; very few gypsum crystals (0.5 cm long) in lower part; unclear boundary to.
  - 1.2–1.4 m: [I] Pink (5 YR 7/4, d) and reddish yellow (7.5 YR 6/6, d) mixed light clay; very few gypsum needles (0.2 cm long); gradual boundary to.
  - 1.4–1.7 m: [I] Light gray (N 7, d) light clay; many yellowish red (5 YR 4/8) medium cloudy mottlings; many gypsum needles (0.3 cm long); prismatic structure; laterally changes to more sandy deposits like sandy loam; gradual boundary to.
  - 1.7–2.1 m: [I] Dark gray (N 4, m) heavy clay; red (2.5 YR 4/8) spots and their aggregates; few gypsum needles (0.3 cm long); prismatic; unclear boundary to.
  - 2.1–2.4 m: [I] Black (N 2, m) heavy clay; few red (10 R 4/8) spots and cloudy mottlings; few gypsum needles (0.2 cm long); gradual boundary to.
  - 2.4–2.7 m: [I] Light brownish gray (2.5 Y 6/2, m) heavy clay; common to many red (10 R 4/8) spots and cloudy mottlings; profuse gypsum needles (0.3 cm long);

**Loc. 8:** ca. 6 km N of Ayutthaya, along highway connecting Ayutthaya and Sing Buri  
G. H.: ca. 2.0 m, Surface: flat rice field without any standing tree.

- Surface–1.0 m: [F. P.] Grayish brown (10 YR 5/2, m) clay with thin fine sand seams; sharp and

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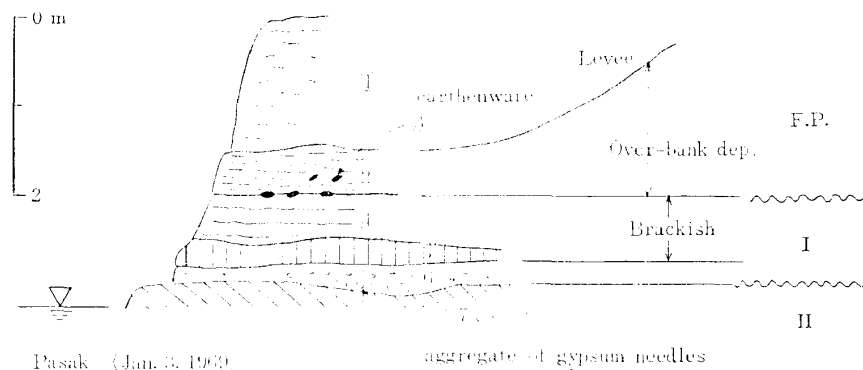
clear boundary to.

- 1.0–1.3 m: [I] Gray (N 5, m) heavy clay: common red (10 R 4/8 and 7.5 R 4/8) films and spots; few brownish yellow (10 YR 6/8) spots and their aggregates; very few yellow (2.5 Y 8/8) pipes; unclear boundary to.
- 1.3–1.5 m: [I] Gray (N 5, m) heavy clay: many brownish yellow (10 YR 6/8) pipes ( $\phi$  0.2–0.3 cm, up to 2 cm long); unclear boundary to.
- 1.5–3.0 m: [I] Gray (N 5, m) clay: few wood fragments (5750 ± 135 years BP) and fragmented plant leaves; few shell fragments; few sand pipe ( $\phi$  2 cm, up to 15 cm long) formed by boring animals.

**Loc. 9:** Left bank of Pasak, ca. 3 km N of Ayutthaya

G. H.: ca. 2.5 m (see Fig. 6).

- 1) Brown loam; stratified with sand seams.
- 2) Pinkish gray (7.5 YR 6/2, d) clay loam: few reddish yellow (7.5 YR 6/8) spots and cloudy mottlings; few fragments of earthenwares; unclear boundary to (4).
- 3) Fragments of earthenware: seem to have been creeping down to the upper surface of (4).
- 4) Gray (N 5, m) heavy clay; very few yellowish brown (10 YR 5/8) spots and their aggregates; very few Mn-concentrations ( $\phi$  0.2 cm); very few gypsum needles (0.3 cm long); strong to medium slickensides; desiccation cracks near upper surface; clear boundary to.
- 5) Gray (N 6, d) heavy clay; few to common red (10 R 4/8) and reddish yellow (7.5 YR 6/8) spots and their aggregates; few Fe-concentrations having replaced old grass roots; few gypsum needles (0.4 cm long); sharp boundary to.
- 6) Light gray (N 7, m), reddish yellow (7.5 YR 6/8, m) and red (10 R 4/8, m) finely mixed clay loam; occasionally pockets of Fe-pipes which are evolved by replacing old grass roots; many to profuse gypsum needles (up to 1 cm long); sharp and uneven boundary to.
- 7) Light gray (N 7, m) light clay: few red (2.5 YR 4/8) spots and their aggregates; few brownish yellow (10 YR 6/8) small to medium cloudy mottlings; few to common pisolitic clay balls ( $\phi$  0.2–0.4 cm); few Mn-spots; indurated and moderately jointed; occasionally profuse gypsum needles along the joints; the unit laterally changes in color to light olive gray (7.5 Y 6/2).



**Fig. 6** Outcrop of Loc. 9, left bank of Pasak, ca. 3 km N of Ayutthaya, or ca. 3 km N of Pasak's conjunction to Chao Phraya.

**Loc. 10:** ca. 1 km SE of Amphoe Bang Pa In

G. H.: ca. 2.5 m. Surface: Slightly elevated part in spacious paddy field.

- Surface–0.1 m: [I] Gray (N 6, d) clay loam: few reddish yellow (7.5 YR 6/6) medium cloudy mottlings; very few red (2.5 YR 4/8) concretionary cloudy mottlings; very few gypsum crystals (0.3 cm long); columnar blocky; sharp boundary to.
- 0.1–0.6 m: [I] Black (10 YR 2/2, d) light clay; common red (10 R 4/8) medium to large cloudy mottlings; few reddish yellow (7.5 YR 6/6) fibrous mottlings; very few gypsum needles (0.3 cm long); gradual boundary to.

0.6-0.9 m : [I] Pinkish gray (7.5 YR 6/2, m) heavy clay ; few red (2.5 YR 4/8) and few brownish yellow (10 YR 6/6) distinct medium to big cloudy mottlings ; very few dark brown (7.5 YR 4/4) medium cloudy mottlings ; gradual boundary to.

0.9-1.1 m : [I] Black (N 2, m) heavy clay ; yellow (2.5 Y 8/8) powdery stuff ; few wood fragments.

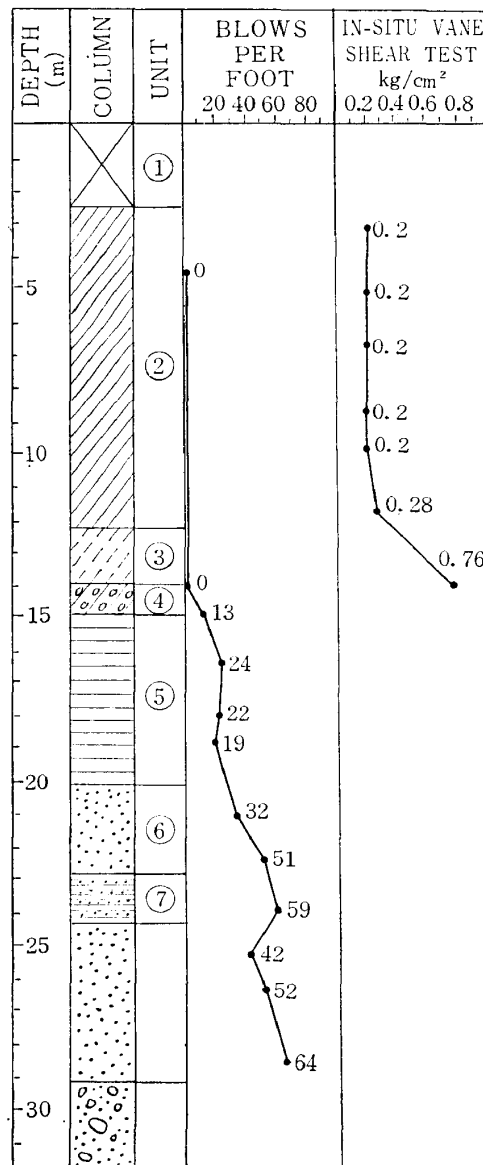
**Loc. 11 : ca 8 km N of Amphoe Rangsit**

G. H. : ca. 2.0 m, Surface : Flat paddy field without any standing tree.

Surface-0.1 m : Brown clay ; disturbed part ; sharp and clear boundary to.

0.1-0.5 m : [I] Reddish gray (5 YR 5/2, d) clay ; common red (10 R 4/8) films and spots ; common yellow (2.5 Y 8/8) pipes and spots ; the red spots dominate in upper half whereas the yellow spots dominate in lower half ; gradual boundary to.

0.5-1.3 m : [I] Reddish gray (5 YR 5/2, d) heavy clay ; common strong brown (7.5 YR 5/8)



**Fig. 7** Drilling column at Petchaburi fly-over bridge, Pratoonam, Bangkok. (quoted from a report by K. E. C. of Bangkok)

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pipes and films ; few yellow (2.5 Y 8/8) spots.

1.3-1.9 m : [I] Dark reddish gray (5 YR 4/2, m) clay and gray (N 5, m) fine sand alternated layer ; few to common twigs and leaves ; gradual boundary to.

1.9-3.5 m : [I] Black (N 2, w) sandy clay ; partly very dark brown (10 YR 2/2) due to concentration of plant remains ; few wood fragments (up to  $\phi$  20 cm, 1 m long).

**Loc. 12 :** Pechaburi fly-over bridge, Pratoonam, Bangkok (see Fig. 7).

- 1) Piled up material.
- 2) Very soft gray clay with partially shell.
- 3) Medium gray clay partially with gravel ; decayed wood at a depth of 12.9 m.
- 4) Greenish gray clay partly with gravel ; stiff.
- 5) Very stiff brown clay with lime binder.
- 6) Very stiff dark yellow fine sand partially with clay and gravel.
- 7) Hard dark brown clay partially with sand and gravel.
- 8) Hard yellow brown fine sand.
- 9) Hard yellow brown medium sand partially with gravel.

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