Southeast Asian Studies, Vol. 26, No. 3, December 1988

Studies on Peat in the Coastal Plains of Sumatra and Borneo

Part I: Physiography and Geomorphology of the Coastal Plains

SUPIANDI Sabiham*

Abstract

The physiography and geomorphology of the coastal plains in Jambi and South Kalimantan were studied with the aim of describing the recent sediments deposited there. For this purpose, borings were made along transects from inland to the coast to a depth of up to 6 meters.

The results of these studies indicate the presence of five physiographic regions and fifteen geomorphic units in the coastal plain of Jambi. In the coastal plain of South Kalimantan, four physiographic regions and eleven geomorphic units were established.

The landforms in both of these coastal plains were developed by peat and mineral soil deposits. These deposits started to accumulate during the Holocene period. In Jambi, peats situated in the ombrogenous peats zone, which sometimes exceed 6 meters in depth, have been deposited since the terrestrial soils on the Pleistocene terrace were transformed into fluviatile swampy soils to form the so-called peat-capped terrace. Peats on mangrove deposits situated in the riverine to brackish deposits zone were formed in later periods. In the brackish to marine deposits zone, the thin peats are very young.

In South Kalimantan, peats situated in the riverine to brackish deposits zone have been deposited on mangrove deposits and on sand or gravel. I believe that the peat formation on sand or gravel is of the same age as the older peat in Jambi.

Introduction

Since the 1930s, soil scientists have demonstrated the presence of peats in the coastal plains of Insular Southeast Asia. However, the geomorphic process of peat development in the plains of Indonesian river basins was not clear, and available data on landform development were limited. Therefore, I examined the peats and the physiography and geomorphology of recent sediments along the Batang Hari river in Jambi, Sumatra and the Barito river in South Kalimantan, Borneo.

The alluvial sediments in the coastal plains of Jambi and South Kalimantan consist mostly of mineral materials containing plant debris derived from former vegetation. As the vegetation continues to grow, this plant debris becomes buried by further remains of vegetation and is stratified into horizons as peat deposits develop. In swampy depressions, peat deposits

* Department of Soil Sciences, Bogor Agricultural University, Bogor, Indonesia

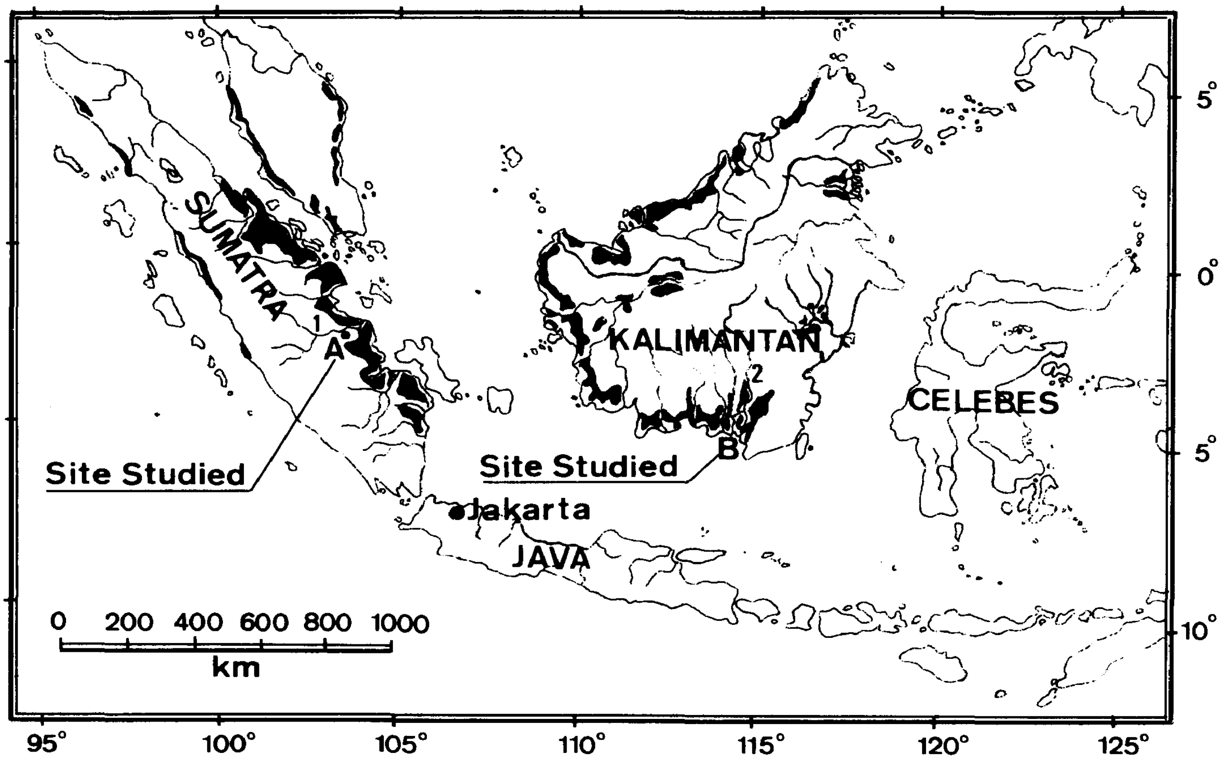
have gradually developed into thick, dome-shaped formations of ombrogenous lowland peat. The study of these peat deposits was divided into four parts, of which the results are presented in separate papers. Part one presents the physiography and geomorphology of the coastal plains in Jambi, Sumatra and South Kalimantan, Borneo. Part two describes the clay mineral composition in order to differentiate the sediments which underlie the peat deposits. Part three is a micromorphological study of peats, which aims to characterize the micromorphology of peats at varying stages of decomposition. Part four describes the floral composition of peat in the coastal plains of Brunei in order to study the vegetational change from the basal clay to the present-day forest on the basis of pollen analysis.

Part one, presented in this paper, discusses the collected data on the physiography and geomorphology of the Sumatra and Kalimantan coasts.

Field Studies and Sampling

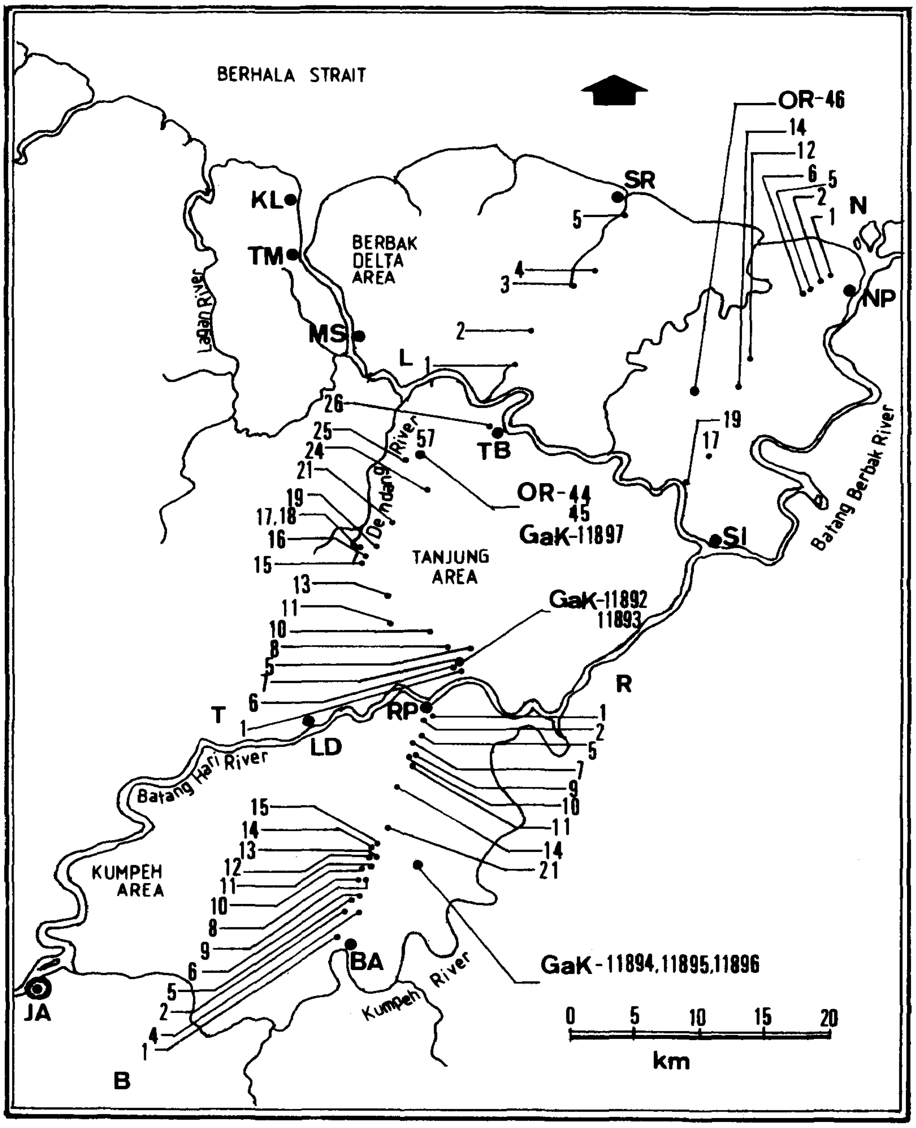
Field study in the coastal plains of Jambi was carried out along the Batang Hari river from October to November, 1983, and in South Kalimantan along the Barito river from August to September, 1985. Site maps of the study area are illustrated in Fig. 1.

In Jambi, field study was concentrated in the Kumpeh, the Tanjung, the Dendang and the Berbak Delta areas (Fig. 2). In the center of the Kumpeh and Tanjung areas, dense forest still covers most of the deep peats. In the Dendang and the Berbak Delta areas, however, the land is used mainly for rice cultivation.



A, Jambi; B, South Kalimantan; 1, Batang Hari river; 2, Barito river; ■ Lowland peats

Fig. 1 The Location of Study Areas



• : Soil Sampling Site

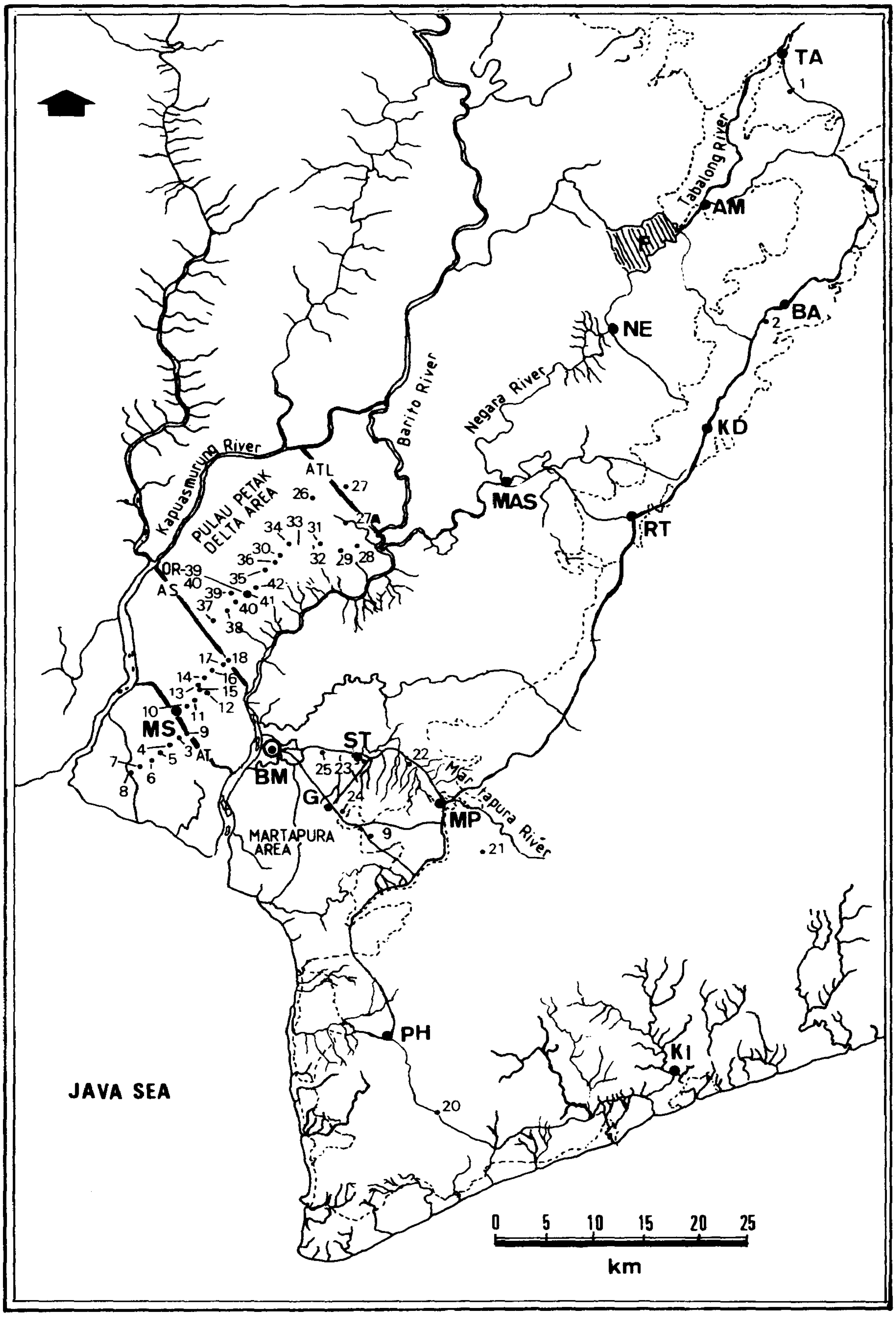
JA, Jambi; BA, Bangso; RP, Rantaupanjang; LD, Londerang; SI, Simpang; TB, Telukbuan; MS, Muarasabak; TM, Telukmajelis; KL, Kampunglaut; SR, Simburnaik; NP, Nipahpanjang

Fig. 2 Field Study Area in the Coastal Plain of Jambi

In South Kalimantan, field study was conducted in the Pulau Petak Delta and the Martapura areas (Fig. 3). The coastal plain in South Kalimantan has almost entirely been exploited for paddy growing.

In both of the study areas, soil borings were made along transects at intervals 0.5 to 2.0 km to a depth of up to 6 meters. The soil properties observed were color, texture, consistency and the depth of organic matter.

Soil samples were collected from several profiles using gouge type augers and peat samplers, and wrapped up as core samples. To study the vegetation types, specimens were collected of the dominant species along the transects, and others were collected by H. Furukawa and Erizal from several observation points. These specimens were identified by



• : Soil Observation Site

AT, Anjir Tamban (Tamban canal); AS, Anjir Sarapat; ATL, Anjir Talaran; BM, Banjarmasin; MP, Martapura; RT, Rantau; KD, Kandangan; BA, Barabai; TA, Tanjung; AM, Amuntai; F, Folder of Alabio; NE, Negara; MAS, Margasari; MS, Mekarsari; PH, Pleihari; KI, Kintap; G, Gambut; ST, Sei Tabuk

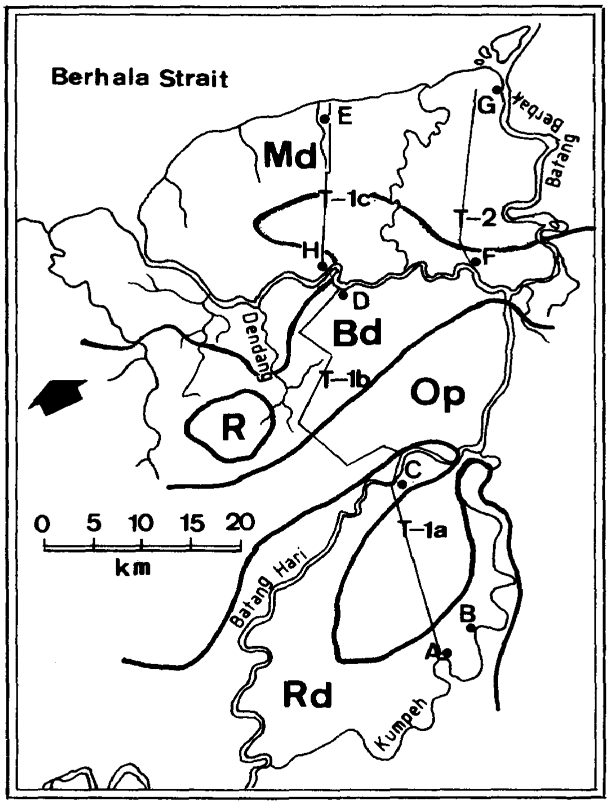
Fig. 3 Field Study Area in the Coastal Plain of South Kalimantan staff of the Herbarium Bogoriense.

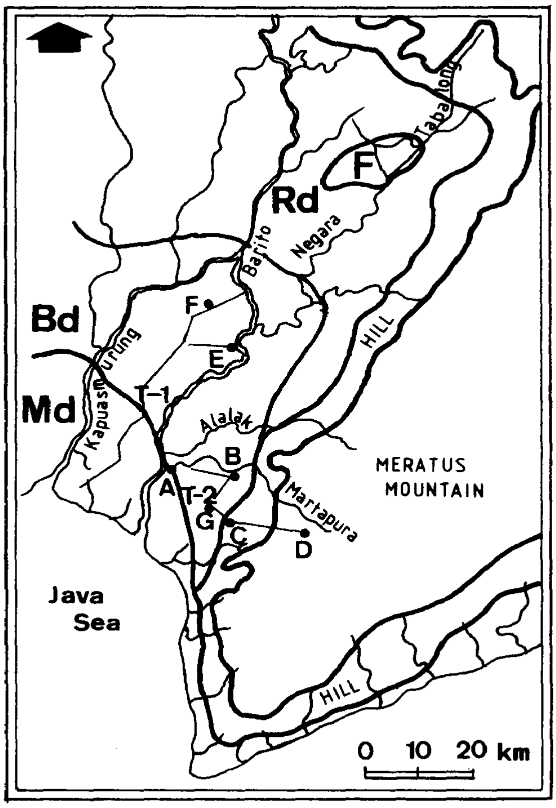
^{14}C-datings were done at Gakushuin University, Tokyo (GaK) and the Radiation Center of Osaka Prefecture, Osaka (OR).

The degree of decomposition of peats was ascertained by determination of the humification degree [Kaila 1956]. A colorimetric method based on the extraction of air-dried and ground peat samples with 0.025 *M* Na-phyrophosphate was used for this determination.

Physiographic Regions of Coastal Plains

Physiographic regions of study areas in the coastal plains of Jambi and South Kalimantan are delineated as shown in Fig. 4 and 5, respectively. They are based on the author's field observations, with supplementary information from air photos and topographic maps. Based on the results of field observations, the phys-





Rd, Mineral Riverine Deposits Zone; Op, Ombrogenous Peats Zone; Bd, Riverine to Brackish Deposits Zone; Md, Brackish to Marine Deposits Zone; R, Remnant Hill; F, Flooded Zone

A, Bangso; B, Pulaumentaro; C, Rantaupanjang; D, Telukbuan; E, Simburnaik; F, Puding; G, Nipahpanjang; H, Lambur Luar

T-1a, Transects: from Bangso to Rantaupanjang; T-1b, from Rantaupanjang to Telukbuan; T-1c, from Lambur Luar to Simburnaik; T-2, from Puding to Nipahpanjang

Fig. 4 Physiographic Regions in the Coastal Plain of Jambi

A, Banjarmasin; B, Sei Tabuk; C, Pembataan; D, Padangpanjang; E, Marabahan; F, Antaraya; G, Gambut

T-1, Transects: from Antaraya to the coast; T-2, from Padangpanjang to Banjarmasin

Fig. 5 Physiographic Regions in the Coastal Plain of South Kalimantan iographic regions of these plains are obviously related to the vegetation types, hydrography of main rivers, topography and human influence.

Since the present vegetation was observed along the transects, the observed patterns can be interpreted as being characteristic vegetation types. The present vegetation in the coastal plains of Jambi can be divided into five types: (i) freshwater-swamp forest, which occurs mainly near the rivers; (ii) peat-swamp forest, which normally starts about 2 to 5 km distance from the rivers; (iii) riverine forest covering the levees along the rivers; (iv) present mangrove forest; and (v) present beach forest covering the coastline. In the following discussion, only commonly occurring species are mentioned in the characterization of these vegetation types. It cannot be ruled out that rare species are typical of certain vegetation types.

The freshwater-swamp forest is characterized by *Alstonia pneumatophora* in the upper storey, and *Antidesma spicatum* in the under storey. In the peat-swamp forest, the palm *Licuala acutifida* and *Pandanus* sp. grow well in the undergrowth, and *Koompassia malaccensis* and *Shorea* sp. in the upper storey.

In the riverine forest, I had some difficulty in studying the vegetation type, because I always started to observe the soils and vegetation from villages situated on the natural levees. Species like *Eugenia* sp. and *Callophyllum* sp., which are normally associated with riverine forest, were seldom found in the area around the villages, where almost all of the land had been cleared for fruit trees or rubber gardens, and no extensive riverine forest remained.

The present mangrove and beach forests are characterized by the presence of only a few species, because the local people have successfully exploited this area for coconut plantation and rice cultivation. *Rhizophora* sp. normally dominates the present mangrove forest. In the present beach forest, *Avicennia* sp. is dominant.

In South Kalimantan only beach forest and small areas of mangrove forest remain, which are dominated by *Avicennia* sp. and *Rhizophora* sp., respectively. In more open mangrove forest, the fern *Acrostichum* sp. may occur in the undergrowth. On the levees along the river estuaries, very few *Sonneratia* sp. sometimes with *Nipa* sp. were found. However, the freshwater-swamp and peat-swamp forests were already devastated. Likewise, the riverine forests have almost completely disappeared, having been cleared for settlement. After the completion of drainage canals, the soils gradually dry out, causing loss of peat and release of sulfate acidity (pH oxidation[1)] 1), which eventually hamper crop growth. This is evidenced by the extensive areas of the abandoned agricultural lands, which are now covered by *gelam* (*Melaleuca leucadendron*) trees, and by *Acrostichum aureum* and *Eleocharis dulcis* in the undergrowth.

In some places around Anjir Tamban and Anjir Sarapat (Tamban and Sarapat canals) rubber plantations remain. In fact, exploitation of the coastal plain for paddy and rubber in South Kalimantan started after the construction of the Ulin road in the 1920s and Anjir Tamban and Anjir Sarapat in the 1930s.

The hydrography of main rivers is characterized by two types of water level fluctuation: (i) daily fluctuation near the coastline; and (ii)

1) pH oxidation was measured after the sample was boiled with 30 percent of H_2O_2.

annual fluctuation inland. The water level fluctuations in these rivers are influenced by rainfall and tidal action, and play an important role in determining the nature of sediments. Furukawa and Supiandi [1985] reported that the water level of Batang Hari river around Telukmajelis in the estuary is characterized by daily fluctuation. The difference in water level between high and low tides is about 3.0 m. This means that at high tide, the area near the sea is probably inundated by sediment-bearing brackish water, and at low tide these sediments are deposited on the soil surface.

In contrast, the river level around Londrang (about 80 km from the coastline) is characterized by annual fluctuation. In the rainy season (November to January), even at low tide, the water level rose to about 3.0 m. In the dry season, however, the water levels at high and low tide were about −0.5 and −1.5 m, respectively. This means the area near the river, was mostly inundated by freshwater during the rainy season.

In South Kalimantan, the water movement around the Pulau Petak Delta and the Martapura areas is largely governed by daily fluctuation. Due to the area's low elevation, the water level fluctuation in these rivers is very important for all aspects of life. When the water levels are high, the rivers overflow their banks and flood the adjacent land through numerous small streams. This means that during high water, these areas are mostly inundated. In the dry season, brackish water probably inundates these areas at high tide.

In the area near to the Polder Alabio, the river level is characterized by annual fluctuation. During the rainy season (September to March), this area is mostly influenced by freshwater flooding.

The coastal plains of Jambi and South Kalimantan have a flat topography, except remnant hill near the Dendang river in Jambi and the Meratus mountain in South Kalimantan.

A description of the physiographic regions in the coastal plains of Jambi and South Kalimantan is presented below.

Jambi

The coastal plain of Jambi can be divided into five physiographic regions as shown in Table 1 and Fig. 4.

Mineral Riverine Deposits Zone

This zone mostly covers the Kumpeh area along the Batang Hari and Kumpeh rivers. The elevation of this zone is about 4.0 to 5.5 m above mean sea level (MSL) along the Kumpeh river, and about 3.0 to 5.0 m above MSL along the Batang Hari river. The important factor in the sedimentation here is the slow accumulation of sediments in a belt stretching parallel to the rivers. These sediments are mainly transported by the rivers during high water. Those deposited near the rivers form the natural levees. During the rainy season, the area behind the levees is mostly covered by freshwater flooding.

Both banks of the Batang Hari river are generally 2.0 to 3.0 m higher than backswamps and are utilized for rubber and fruit gardens. Along the Kumpeh river, however, the levees lie about 0.5 to 1.0 m lower than the backswamps. Almost all of the backswamps are used for rice cultivation during the rainy season.

Vegetation cover is characterized by extremely few species, like *Alstonia pneumatophora, Eugenia* sp., *Koompassia malaccensis* and *Durio* sp. Where the forest is more open,

Table 1 Physiographic Regions of the Coastal Plain of Jambi: Vegetation Types, River Hydrography, Topography, and Air Photo Appearance

No.	Physiographic Region*	Vegetation Type	River Hydrography	Topography	Air Photo Appearance
1.	Mineral Riverine Deposits Zone	Freshwater Swamp Forest	Annual Fluctuation	Level	Meandering Scars; Natural Levees; Agricultural Land
2.	Ombrogenous Peats Zone	Peat-swamp Forest	Annual Fluctuation	Level	Dense Forest; Natural Levees
3.	Riverine to Brackish Deposits Zone	Swamp Forest and Food Crops	Partly Annual Fluctuation and Partly Daily Fluctuation	Level	Partly Dense Forest and Partly Agricultural Land; Natural Levees
4.	Brackish to Marine Deposits Zone	Mangrove and Beach Forests; Food Crops	Daily Fluctuation	Level	Partly Mangrove and Beach Forests and Partly Agricultural Land; Coastline
5.	Remnant Hill	Secondary Forest and Fruit Trees	–	Hilly	Very Small Area of Secondary Forest; Agricultural Land

* Modified after Furukawa and Supiandi [1985].

the grass *alang-alang* (*Imperata cylindrica*) may occur in the undergrowth.

Ombrogenous Peats Zone

This zone is characterized by the presence of deep peat, and is covered by dense forest. The elevation of the summit of peat deposits is about 7.0 m above MSL. Many tree species grow well here, including *Koompassia malaccensis, Durio carinatus, Jackia ornata, Tetramerista glabra, Shorea* sp., *Eugenia* sp., *E. acuminatissima, E. clavamyrtus, E. claviflora* and *Dyera* sp.; and *Licuala acutifida* may occur in the undergrowth. In places, the original vegetation of peat-swamp forest has disappeared due to human influence. People extracted useful trees of high commercial value, like *Shorea* sp., *Jackia ornata, Durio carinatus* and *Tetramerista glabra.*

Peat deposits here accumulate under stagnant fresh water supplied by riverflood. Vertical peat growth led to gradually drier conditions and less frequent flooding, so the peats became rain-dependent to form the ombrogenous-peat domes. Andriesse [1974] suggested that the peats developed from the center of the peat dome (with older peat) towards the edge of the dome. ^{14}C-dating shows the ombrogenous-peat in the Tanjung area to be older than that in the Kumpeh area. Since these peat deposits were formed under the influence of inundation, these ^{14}C-dating data clearly indicate that, during the transgression period, water stagnation took place much later in the Kumpeh area than in the Tanjung area. This is supported by the fact that the Kumpeh area lies further from the sea.

The natural levees lie about 2.0 m below the summit of the peat dome, but higher than terrestrial soil surface underlying the peat. Water stagnation on this saucer-shaped topography hampered the decomposition of organic matter and caused the peat deposits to be formed.

Riverine to Brackish Deposits Zone

This zone occupies the northern part of Tanjung and the southern part of the Berbak Delta. Its elevation is about 3.0 to 5.0 m about MSL. Almost all of the zone is utilized for rice cultivation and coconut gardens; only small area is still covered by dense forest containing many tree species, including *Alstonia pneumatophora, Eugenia curranii, E. jamboloides, E. zippeliana, Santiria laevigata,* and *Scaphium macropodum*. The grasses *Cyperus platystylia* and *Panicum incomtum* and the fern *Acrostichum aureum* were also found here in the undergrowth.

In former times, this zone was submerged by the sea during the transgression period. The intrusion of lagoonal sea formed mangrove deposits, which are now overlain by thin peats.

Natural levees have developed along the Batang Hari and Dendang rivers with an elevation of about 3.0 to 4.0 m above MSL. Around the village of Telukbuan, former beach ridges were found underlying the present natural levee. During the transgression period, stagnant water in the Dendang area containing large amounts of sediments was dammed up by these beach ridges, thereby increasing the sedimentation which eventually formed the so-called lagoon.

Brackish to Marine Deposits Zone

This zone is situated along the coast of the Berbak Delta. Near the sea (up to about 0.5 km from the coastline), the process of deposition is always influenced by marine action, because this area lies near to MSL. At high tide, the area covered by the present mangrove forest is almost completely covered by saltwater, resulting in soils with high salinity. These soils are characterized by a sodium saturation of more than 15 percent, and are grouped as Halic Hydraquents with a neutral reaction in all layers (pH 5.9 to 6.1) and fine clay texture [Institut Pertanian Bogor Team 1975]. Very few tree species remain. Only the present mangrove and beach forests cover the coastal fringe.

Behind the present mangrove forest the elevation increases to about 2.0 to 3.0 m above MSL. Large areas have been exploited for rice cultivation and coconut gardens, for which purpose numerous canals have been dug across this zone by local people and the government. The small canals dug by local people mostly form so-called fish-bone channel networks. The main function of these canals is to drain floodwater and take in relatively good water from the river in order to leach away of acids formed from organic matter deposits.

Remnant Hill

The monadnock in the Dendang area is an outcrop of the Tertiary formation situated in the middle of East Sumatra. Van Bemmelen [1949] states that downwarp of the pre-Tertiary basement complex is filled with Neogen sediments which were folded in Plio-Pleistocene time. During or after the main phase of folding, a dome was elevated, and during the period of high sea level in the past this dome was probably an island.

This zone lies about 2 km west of the Dendang river, and it is exploited for upland crops. In the valleys, however, the inhabitants cultivate the rice.

South Kalimantan

The coastal plain of South Kalimantan is demarcated by the Kapuasmurung, Barito and Martapura rivers in the coastal area, and the Barito, Tabalong, Alabio, and Negara rivers inland. This coastal plain can be divided into four physiographic regions (Table 2 and Fig. 5).

Mineral Riverine Deposits Zone

This zone is enclosed by the Tabalong, Negara and Barito rivers (see Fig. 5). Its

Table 2 Physiographic Regions of the Coastal Plain of South Kalimantan: Vegetation Types, River Hydrography, Topography, and Air Photo Appearance

No.	Physiographic Region	Vegetation Type	River Hidrography*	Topography	Air Photo Appearance
1.	Mineral Riverine Deposits Zone	Food Crops and Grasses	Annual Fluctuation	Level	Meandering Scars; Natural Levees; Agricultural Land
2.	Riverine to Brackish Deposits Zone	Food Crops; *Gelam*** and Grasses	Partly Annual Fluctuation and Partly Daily Fluctuation	Level	Secondary Forest; Natural Levees; Agricultural Land
3.	Brackish to Marine Deposits Zone	Mangrove and Beach Forests; Food Crops; *Gelam*	Daily Fluctuation	Level	Partly Mangrove and Beach Forests and Partly Secondary Forest; Coastline; Agricultural Land
4.	Flooded Zone	Grasses	Annual Fluctuation	Level	Floodwater; Natural Levees

* Based on the author's field observations
** *Melaleuca leucadendron*

elevation is about 3.0 to 6.0 m above MSL. The sediments deposited here are mainly transported by these rivers.

Downstream from Amuntai to near the Polder of Alabio, the Tabalong river becomes relatively narrow with banks about 3.0 to 4.0 m high. The river carries large amounts of sediments and has formed natural levees along both banks. During the rainy season, a large volume of river water spills over into the backswamps. When the flood begins to recede, rice is planted in the backswamps. The vegetation types here are mostly grasses with very few tree species.

Along the Negara and Barito rivers, there are also unbroken natural levees. In the backswamps, there are stretches of the mineral riverine deposits, which are sometimes covered by a thin layer of organic matter. These swamps are used only for rice cultivation, from the time the flood recedes. During the rainy season, the area becomes a broad expanse of floodwater.

Riverine to Brackish Deposits Zone

This zone lies between Anjir Sarapat and the Barito river near to Antaraya village in the Pulau Petak Delta, and between Gambut village and Banjarmasin in the Martapura area. Its elevation is about 2.0 to 3.0 m above MSL. The banks of the Barito, Kapuasmurung and Martapura rivers are about 0.5 m lower than the backswamps.

The Pulau Petak Delta was probably submerged during the transgression period due to the rise in sea level. This is substantiated by the presence there of mangrove deposits, which sometimes underlie the peat deposits. In the Martapura area, however, peat deposits cover the white coarse sand and gravel. Today, this area is partly covered by *gelam* (*Melaleuca leucadendron*) and partly exploited for rice cultivation and coconut gardens. It is traversed by numerous canals dug by local people and the government. The main canals run perpendicular to the rivers, and the secondary canals perpendicular to the main canals.

In the dry season, the large volume of brackish water in the river at high tide influences the backswamps. In the rainy season, however, a large volume of fresh water overflows onto the soil surface of the backswamps.

Brackish to Marine Deposits Zone

This zone occupies the coasts of the Pulau Petak Delta and the Martapura area. Lying near the sea, it has a flat topography throughout, with elevations varying from 2.0 to nearly 0 m above MSL. The sediments here are mainly categorized as mangrove deposits on tidal flat.

The area near the coastline is influenced by seawater at high tide and is now covered by mangrove and beach forests. The area behind the mangrove forest is exploited for rice cultivation.

This zone is also traversed by numerous canals dug by local people and the government for irrigation purposes. Near Anjir Tamban, people have tended to switch from rice cultivation to coconut plantation because, according to local farmers, the soil productivity of paddy fields degrades after 5 or 6 years of paddy planting. This is supported by the fact that the area has been extensively farmed, and so many drainage canals (tertiary canals) have been cut that the soils dry out, which hampers the growth of rice. In other places, around profile of BM- 8, abandoned agricultural lands had recovered secondary forest, which was dominated by tree species of *gelam,* and by the fern *Acrostichum aureum* and the grass *Eleocharis dulcis* in the undergrowth.

Flooded Zone

This zone is roughly coterminous with the Pandamaan village. Its topography and its slight gradient towards the central depression cause floods in the center of the area, where the water depth is more than two meters in all seasons. During the rainy season (from September to March), flooding usually extends across the whole area.

This region is mostly used for fisheries. It has also been used for rice cultivation, known locally as *sawah sela tahun.*[2] Here, people start to plant rice in June-July.

Geomorphology of Coastal Plains

Geomorphic Units and Stratigraphic Layers

Since soil borings from several observation points represented the same physiographic region, a one typical profile of each physiographic region was selected in order to describe the soil layers. Brief descriptions of soil profiles from each physiographic region are given below. The descriptions include the number and location of the profile.

Table 3 shows the geomorphic units of the coastal plains of Jambi and South Kalimantan distributed successively from inland to the coast. The determination of these geomorphic units was based on the boring data and observation of outcrops. Fifteen geomorphic units were established in Jambi, and 11 units in South Kalimantan.

Jambi

Diagrams of boring data have appeared in a former paper [Furukawa and Supiandi 1985]. The additional boring data presented here were taken from the transect T-2 (Fig. 6). These boring data represent sediments formed by marine processes in the past.

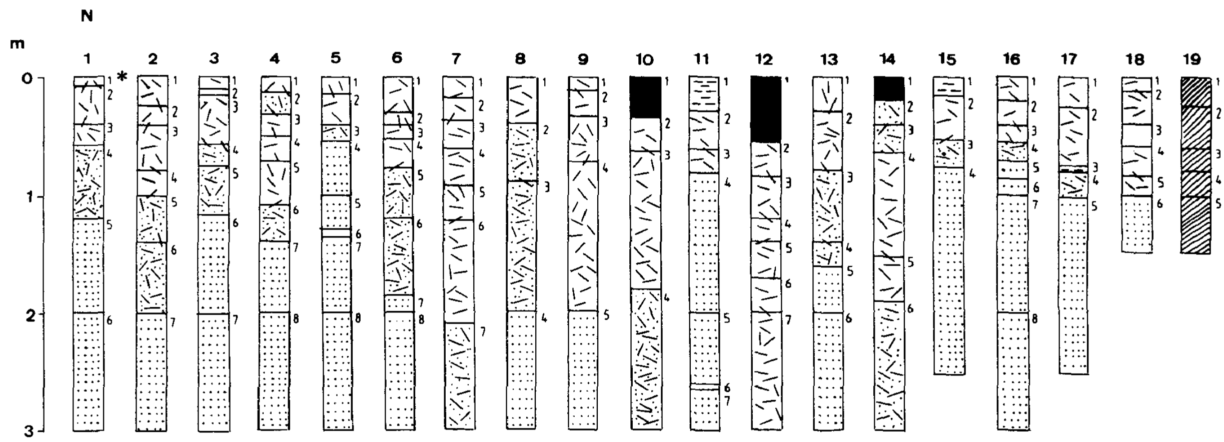
Mineral riverine deposits zone. The sediments contain, in the upper layer, light clay which is brown to grayish brown in color, and in the bottom layer, heavy clay which is grayish white with yellowish brown iron mottles.

2) *Sawah sela tahun* is a kind of rice cultivation in South Kalimantan that involves transplanting after the floodwater has begun to recede.

Table 3 The Geomorphic Units of the Coastal Plains of Jambi and South Kalimantan

Jambi*		South Kalimantan	
Physiographic Region	Geomorphic Unit	Physiographic Region	Geomorphic Unit
1. Mineral Riverine Deposits Zone	(1) Natural Levees (2) Meandering Scars (3) Low Terrace	1. Mineral Riverine Deposits Zone	(1) Natural Levees (2) Meandering Scars
2. Ombrogenous Peats Zone	(4) Peat-capped Terrace (5) Natural Levees	2. Riverine to Brackish Deposits Zone	(3) Peat-capped Mangrove Deposits (4) Peat-capped Coarse Sand and Gravel Deposits (5) Natural Levees (6) Former Beach Ridges
3. Riverine to Brackish Deposits Zone	(6) Terrestrial Soil on the Terrace (7) Intruding Mangrove on Peat-capped Terrace (8) Mangrove Deposits on the Terrace (9) Natural Levees (10) Former Beach Ridges	3. Brackish to Marine Deposits Zone	(7) Mangrove Deposits on Tidal Flat (8) Former Thick Sand Ridges (9) Mangrove Belt Covering the Present Coastline
4. Brackish to Marine Deposits Zone	(11) Mangrove Deposits on Tidal Flat (12) Mangrove Belt Covering the Present Coastline (13) Thick Sand Ridges	4. Flooded Zone	(10) Natural Levees (11) Perennially Flooded Area
5. Remnant Hill	(14) Hillslopes (15) Shallow Valley Bottoms		

* Modified after Furukawa and Supiandi [1985]



▨: Terrestrial Soils ■: Peats : Mangrove Deposits : Sand Beach Deposits
: Mangrove Deposits mixed with Fine Sand : Peaty Mineral * Numbers of soil layer

Fig. 6 Diagrams of Boring Data from the Coastal Plain of Jambi, from Puding to Nipahpanjang in the Brackish to Marine Deposits Zone

In this zone three geomorphic units were found. Along the Batang Hari and Kumpeh rivers, (1) the natural levees have been developed under freshwater conditions. In some places, the natural levees have been breached by flood waters, resulting in crevasses and crevasse splays. These areas eventually formed (2) meandering scars. (3) The Pleistocene terrace (low terrace) was also found here. The surface of this terrace is covered by fluviatile swampy soil derived from the sediments carried by the rivers during flooding.

A typical profile description is as follows (Profile RTP-1, 1 km South of Rantaupanjang village):

1. 0- 8 cm Dull brown (7.5YR 5/3) light clay; little organic matter; massive, soft.
2. 8- 22 cm Brownish gray (10YR 6/1) light clay; few yellowish brown (10YR 5/8) iron mottles; massive, rather compact.
3. 22- 44 cm Grayish brown (7.5YR 6/2) light clay; few fine wood blocks; massive, rather compact.
4. 44-160 cm Brownish black (7.5YR 3/1) peat, fibric; moderate plant remains, branches and wood blocks.
5. 160-200 cm Samples lost during observation because the soil was very soft.
6. 200-260 cm Grayish white (N7/) light clay; moderate yellowish brown (10YR 5/8) iron mottles; massive, rather compact.
7. 260-325 cm Grayish white (N7/) heavy clay; abundant dark reddish brown and yellowish brown (2.5YR 3/6 + 2.5Y 5/6) iron mottles; massive, very compact.

This profile indicates that the layers down to the depth 200 cm are riverine deposits. During high water level, fresh water from the Batang Hari and Kumpeh rivers, which contains large amounts of sediments, spills over into this area. These sediments were gradually deposited here.

The soils at the depth of 200 to 325 cm are categorized as the Pleistocene terrace, and are characterized by dark reddish brown iron mottles in a heavy clay matrix. The clay mineral is predominantly kaolin, as will be discussed in separate paper. The light clay and grayish white layer at the depth of 200 to 260 cm indicates that in the first stage of deposition during the transgression period, the terrace was inundated.

Ombrogenous peats zone. This zone is mostly covered by peat deposits. The thickness of organic matter accumulated on the mineral soil (Pleistocene terrace) varies from 2 to more than 6 meters. These deposits were found in the center of the Kumpeh and Tanjung areas. Peat deposits in the Tanjung area, however, are mostly very soft, due to their high water content, and are characterized by the presence of undecomposed materials. During the fieldwork, this zone was still covered by dense forest.

This zone comprises two geomorphic units, (4) peat-capped terrace and (5) natural levees. The peat surface topography rises gradually from the levees towards the summit of the peat dome.

A typical profile description is as follows (Profile B-15, the center peat dome in the Kumpeh area):

1. 0- 24 cm Very dark reddish brown (5YR 2/3) peat; humification degree 45.5 percent; pH 3.4; EC 370 micro mho; loss on ignition 96.2 percent.
2. 24- 36 cm Brownish black (7.5YR 2/2) peat; humification degree 66.8 percent; pH 3.7; EC 150 micro mho; loss on ignition 96.8 percent.
3. 36- 73 cm Brownish black (5YR 2/2) peat; humification degree 86.6 percent; pH 3.6; EC 130 micro mho; loss on ignition 98.6 percent.
4. 73-100 cm Brownish black (5YR 2/2) peat, very soft; humification degree 45.3 percent; pH 3.3; EC 180 micro mho; loss on ignition 98.7

percent.

5. 100–142 cm Sample lost during observation.
6. 142–230 cm Very dark reddish brown (5YR 2/3) peat, very soft; humification degree 26.7 percent; pH 3.4; EC 190 micro mho; loss on ignition 96.0 percent.
7. 230–305 cm Very dark reddish brown (5YR 2/3) peat, soft; fine branches; humification degree 26.9 percent; pH 3.4; EC 270 micro mho; loss on ignition 95.9 percent.
8. 305–343 cm Very dark reddish brown (5YR 2/3) peat; humification degree 11.5 percent; pH 3.6; EC 320 micro mho; loss on ignition 96.0 percent.
9. 343–372 cm Brownish black (7.5YR 2/2) peat; humification degree 4.7 percent; pH 3.5; EC 320 micro mho; loss on ignition 97.6 percent.
10. 372–540 cm Brownish black (7.5YR 2/2) woody peat; humification degree 8.0 percent; pH 3.6; EC 290 micro mho; loss on ignition 93.2 percent.
11. 540–560 cm Brownish gray (10YR 6/1), heavy clay; massive, compact; pH 4.7; EC 33 micro mho.
12. 560–600 cm Light gray (2.5Y 7/1) heavy clay; massive, very compact; pH 4.8; EC 26 micro mho.

This profile indicates that the layers down to the depth of 540 cm are peat deposits. These peat deposits started to accumulate when the terrestrial soils on the terrace had been transformed into fluviatile swamps during the transgression period. This is substantiated by the sediments underlying the peats at the depth of 540 to 600 cm, namely, heavy clay, which is brownish gray to light gray in color, and without iron mottles.

Peat deposits here developed under freshwater conditions. This is substantiated by low electric conductivity (EC), which from the bottom to the upper layers varies from only 130 to 370 micro mho. Since the peat deposits have a loss on ignition of about 93.2 to 98.7 percent, and are poor in nutrient content (Table 4), they can be categorized as poor oligotrophic ombrogenous peats.

Peats in the layers at the depth of 100 to 540 cm are very soft, due to high water content, and are characterized by fibric material of low humification degree, from 4.7 to 26.9 percent. The layers at depths of 0 to 100 cm, however, are categorized as hemic to sapric peats, characterized by relatively high humification degrees of from 45.3 to 86.6 percent.

The most important feature of peat deposits to emerge from this study is that they develop in a stratified sequence of the former vegetation. To clarify the vegetational change from the basal clay to the present-day forest it is necessary to analyse fossil pollen sedimentation in each layer of peat deposits. The Erdtman method [Brown 1960], which was modified by Takeoka (Kyoto Prefectural University), can be used for extraction of fossil pollen in the soil samples. Supiandi and Furukawa [1986] reported that based on the results of pollen analysis, ombrogenous peat deposits in the Kumpeh area taken from profile of B-8 were divided into four layers. In the first layer, at the depth of 0 to 138 cm, peat deposits are derived from mixed swamp forest; all samples from this layer show a heterogeneous pollen content. In the second layer, at the depth of 138 to 162 cm, which is peaty mineral soil, the vegetation type was categorized as swampy forest dominated by *Ganua* sp. In the third layer, at the depth of 162 to 347 cm, peat

Table 4 The Total Content of CaO, K_2O, and P_2O_5 of Ombrogenous Peat According to the Percent on Dried Basis

Profile	Depth (cm)	Ash Content (%)*	Total Content of					
			CaO (%)		K_2O (%)		P_2O_5 (%)	
B- 5	175–395	10.11	0.23	(O)	0.10	(M–E)	0.01	(O)
B-10	0- 20	3.20	0.33	(M–O)	0.05	(M–O)	0.09	(M–O)
	20–146	2.75	0.06	(O)	0.03	(O)	0.02	(O)
	186–249	21.04	0.05	(O)	0.26	(E)	0.03	(O)
	249–262	50.30	0.14	(O)	0.47	(E)	0.06	(M–O)
	262–304	34.24	0.18	(O)	0.30	(E)	0.04	(O)
	304–460	33.26	0.24	(O)	0.37	(E)	0.03	(O)
B–15**	0- 24	3.79	0.28	(M–O)	0.05	(M–O)	0.12	(M–O)
	24- 36	3.16	0.14	(O)	0.02	(O)	0.05	(O)
	36- 73	1.37	0.07	(O)	0.003	(O)	0.02	(O)
	73–100	1.30	0.05	(O)	0.005	(O)	0.02	(O)
	142–230	4.00	0.01	(O)	0.03	(O)	0.02	(O)
	230–305	4.13	0.03	(O)	0.03	(O)	0.02	(O)
	305–343	3.99	0.06	(O)	0.02	(O)	0.02	(O)
	343–372	2.45	0.10	(O)	0.004	(O)	0.01	(O)
	372–540	6.76	0.14	(O)	0.03	(O)	0.02	(O)

Note: Samples were taken from the coastal plain of Jambi.
* On oven-dried basis
** Taken from the center peat dome
E, eutrophic peat; M, mesotrophic peat; O, oligotrophic peat

deposits derived from swampy forest were dominated by *Eugenia* sp. In the fourth layer, at the depth of 347 to 418 cm, the vegetation type was dominated by fern association.

The ombrogenous peats in the Tanjung area, taken from profile T-7, are, however, rather different in pollen content from those in the Kumpeh area. These peat deposits were divided into five layers according to the supposed former vegetation. In the first layer, at the depth of 0 to 120 cm, peat deposits are derived from mixed swamp forest; in this layer many kinds of arboreal pollen types were found. In the second layer, at the depth of 120 to 220 cm, peat deposits mostly containing a uniform pollen type are derived from swampy forest in which *Eugenia* sp. dominates. In the third layer, at the depth of 220 to 400 cm, peat deposits are mostly derived from non-arboreal vegetation, which is characterized by the abundance of *Pandanus* sp.; this clearly indicates that this layer was formed in a swampy area. In the fourth layer, at the depth of 400 to 420 cm, which is peaty mineral soil, the vegetation type was dominated by *Stemonurus* sp. and *Lithocarpus* sp. or *Quercus* sp. In the fifth layer, at the depth of 420 to 470 cm, the vegetation type was dominated by fern association; in this layer *Oncosperma* sp. was also found, and this clearly shows that this layer was previously a transitional site from brackish to fresh water.

Riverine to brackish deposits zone. The sediments are categorized as mangrove deposits of clayey texture and gray to grayish yellow-brown in color. The soil surface was covered by thin peat. In the bottom layer, a low terrace was found underlying the mangrove deposits.

In this zone five geomorphic units were established. During the Post-Glacial period, when the sea level rose, (6) the terrestrial soil was transformed into fluviatile swampy soils covering the Pleistocene terrace. After the first peat deposits developed on the terrace, mangrove vegetation intruded to form (7) intruding mangrove on peat-capped terrace. Thus, (8) the mangrove deposits developed much later. The soil surface is sometimes covered by thin peat deposits. (9) The natural levees continue along the Batang Hari and the Dendang rivers to the village of Telukbuan. Near this village a former river debouched into the sea, breaking through (10) the former beach ridges.

A typical profile description is as follows (Profile T-57, SK-8 near to Telukbuan village):

1. 0– 5 cm Olive black (5Y 3/2) heavy clay (mud clay).
2. 5– 25 cm Grayish olive (5Y 5/2) heavy clay (mud clay).
3. 25– 75 cm Grayish yellow (2.5Y 7/2) heavy clay (mud clay); compact.
4. 75–100 cm Brownish gray (10YR 4/1) heavy clay (mud clay); compact; dirty.
5. 100–335 cm Gray (5Y 5/1) heavy clay with unripen mud clay; very sticky.
6. 335–390 cm Peat, fibric; moderate plant remains.
7. 390–480 cm Peat, fibric containing mineral materials; few plant remains.
8. 480–550 cm Terrace; heavy clay.

Remark: This profile was taken by H. Furukawa in April 1984.

SK means secondary canal.

This profile indicates that the layers at the depth of 0 to 335 cm are mangrove deposits. In other places, these mangrove deposits have sometimes been covered by peats. The layers at the depth of 335 to 480 cm are peats deposited on the terrace.

In other profiles, like T-26 and T-51, around Telukbuan village, former beach ridges were found. This is substantiated by the presence of sand deposits at the depth of 138 to 420 in the profile T-26, and at 115 to 323 cm in the profile T-51. I believe that these sand ridges were deposited by the marine processes, and thus the areas around these profiles were previously the coastline. This is substantiated by the presence of marine deposits underlying the sand ridge deposits.

Based on the results of pollen analysis [Supiandi and Furukawa 1986] from profile T-24, peat deposits are mostly derived from mangrove vegetation dominated by *Nipa* sp. This clearly indicates that these peat deposits developed under brackish water. This is substantiated by the high EC of peat taken from Profile T- 24, which varies from 7,500 to 11,800 micro mho. The samples taken from mangrove deposits show a fairly homogeneous pollen content of *Rhizophora* sp. and *Sonneratia* sp.

Brackish to marine deposits zone. The soils in the upper layer contain fine clay of gray to greenish gray color. In the bottom layer, thin alternating layers of clay and fine sand were deposited. The area along the coastline is covered by mangrove forest with sedges and salt-tolerant grasses in the undergrowth. Behind the mangrove forest, people use the land for rice cultivation.

The sediments in this zone are (11) mangrove deposits on tidal flat. On the coastline, *Avicennia* sp. and *Rhizophora* sp. grow well; this area is subdivided into (12) mangrove belt covering the coastline. In former times the depositional process was mostly influenced by tidal and wave actions, resulting (13) former thick sand ridges advancing offshore.

A typical profile description is as follows (Profile L-5, near to Simburnaik village):

1. 0- 7 cm Dull yellowish brown (10YR 5/4) heavy clay; massive, compact; pH 4.9; EC 2,250 micro mho.
2. 7- 27 cm Dull yellowish brown (10YR 5/3) heavy clay; few bright yellowish brown (10YR 6/8) iron mottles; massive, compact; pH 5.3; EC 2,400 micro mho.
3. 27- 40 cm Dark grayish (2.5Y 5/2) heavy clay; few plant remains; massive, compact; pH 3.5; EC 5,200 micro mho.
4. 40- 61 cm Gray (7.5Y 4/1) heavy clay; abundant plant remains, tree bark, branches; massive, compact; pH 2.7; EC 8,700 micro mho.
5. 61-178 cm Greenish gray (7.5GY 5/1) heavy clay; abundant plant remains; massive, compact; pH 2.9; EC 5,600 micro mho.
6. 178-244 cm Olive gray (2.5GY 5/1) light clay; few plant remains, sea-shells; massive, rather compact; pH 3.1; EC 5,400 micro mho.
7. 244-366 cm Alternating greenish gray (7.5GY 5/1) light clay and dark greenish gray (10GY 4/1) fine sand; sea-shells; massive, rather compact; pH 3.6; EC 4,500 micro mho.
8. 366-500 cm Greenish gray (7.5GY 5/1) heavy clay; sea-shells; massive, very compact; pH 5.9; EC 3,200 micro mho.
9. 500-600 cm Alternation greenish gray (7.5GY 5/1) heavy clay and dark greenish gray (10GY 4/1) fine sand; massive, compact; pH 6.9; EC 4,200 micro mho.

Remark: This profile was taken from the site of a coconut plantation about 5 km from the coast; many small canals were dug here.

This profile indicates that the soils are derived from marine and brackish deposits. This is substantiated by the high EC of soils in all layers, varying from 2,250 to 8,700 micro mho.

The soils at the depth of 0 to 366 cm are mangrove deposits. The soil pHs from the layers at the depth of 27 to 366 cm are very low varying from 2.9 to 3.6, and this indicates that these are potential acid sulfate soils, as will be discussed in a separate paper. The fact that the soil pHs at the depth of 366 to 500 cm and 500 to 600 cm were respectively 5.9 and 6.9 indicates that the soils are derived from offshore tidal flat deposits.

The results of boring data taken from the transect T-2 (see Fig. 6) indicate that the sediments in the bottoms layers are the former thick sand ridges underlying the mangrove deposits. In former times, these sand ridges were deposited by marine processes advancing offshore. This means that during the transgression period in the past, this area was submerged by the sea. The present thin peats sometimes cover the mangrove deposits.

Typical profile descriptions are as follows:

I. Profile N-5, 2.5 km South of Nipahpanjang.

1. 0- 17 cm Grayish brown (7.5YR 4/2) light clay; massive, rather soft; little organic matter.
2. 17- 40 cm Grayish yellow brown (10YR 6/2)

light clay; moderate yellowish brown (10YR 5/6) iron mottles; massive, rather soft; little organic matter.

3. 40– 55 cm Grayish brown and grayish yellow brown (7.5YR 5/2 + 10YR 6/2) loam; few yellowish brown (10YR 5/6) iron mottles; rather loose; few plant remains.
4. 55–100 cm Brownish gray (5YR 5/1) sandy loam; moderate bright yellowish brown (10YR 6/6) iron mottles; rather loose; few plant remains.
5. 100–132 cm Gray (7.5Y 5/1) sandy loam; loose.
6. 132–136 cm Wood blocks.
7. 136–200 cm Gray (10Y 5/1) sandy loam; loose.
8. 200–300 cm Dark olive gray (10GY 4/1) sand; loose.

II. Profile N–17, 3 km North of Puding.

1. 0– 25 cm Dull brown (7.5YR 5/3) light clay; massive, rather compact; moderate plant remains.
2. 25– 75 cm Grayish yellow brown to dull yellow orange (10YR 6/2– 6/3) light clay; massive, rather soft; few wood blocks.
3. 75– 80 cm Black (10YR 1.7/1) peaty mineral; moderate plant remains.
4. 80–100 cm Yellowish gray and grayish yellow brown (2.5Y 5/1 + 10YR 6/2) loam; rather loose; moderate plant remains.
5. 100–250 cm Gray (5Y 5/1) coarse sand; loose; few wood blocks.

Remnant hill. In this remnant hill, (14) hillslopes and (15) shallow valley bottoms were found. The hillslopes are covered by brush, rubber gardens and fruit trees, and the shallow valley bottoms are utilized for a bush-fallow cultivation of wet rice in the rainy season.

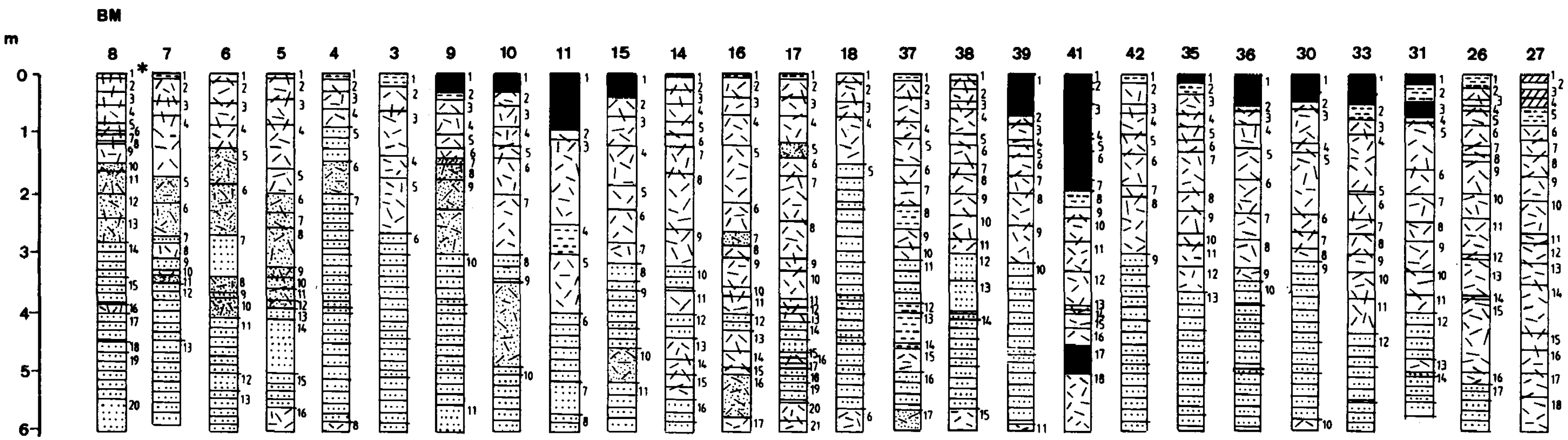
The soils here can be classified as Ultisols which are clay to silty clay loam in texture and dark brown to reddish yellow in color. Although I did not carry out boring in this region during the fieldwork, when I was there in 1975, I observed the following profile near Pulaukemang village. This profile was taken from an outcrop.

1. 0– 17 cm Dark brown (7.5YR 5/6) clay; moderately, angular blocky to blocky; firm to friable; clear, smooth.
2. 17– 40 cm Dark brown (7.5YR 5/8) silty clay loam; moderately, blocky to angular blocky; friable; diffuse, smooth.
3. 40– 64 cm Reddish yellow (7.5YR 6/8) silty clay loam; moderately, blocky to angular blocky; friable; clear, smooth.
4. 64– 94 cm Reddish yellow (7.5YR 6/8) clay; moderately, angular blocky; diffuse, smooth.
5. 94–120 cm Reddish yellow (7.5YR 6/8) clay; moderately, blocky.

South Kalimantan

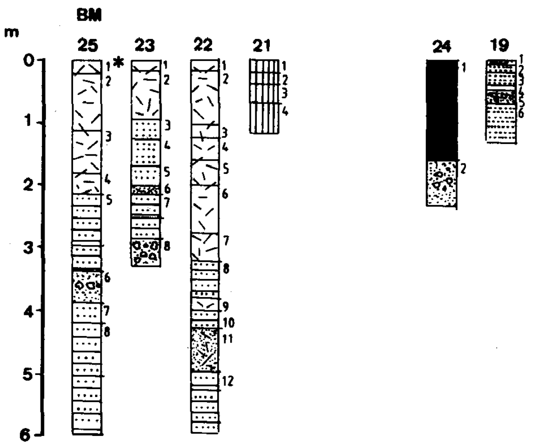
To study the stratigraphic layer in the coastal plain of South Kalimantan, borings were made along transects distributed from inland to the coast. Diagrams of boring data are presented in Fig. 7 and 8.

Mineral riverine deposits zone. This zone covers most of the area along the Negara and Barito rivers (see Fig. 5). Because extensive study was concentrated in the Pulau Petak Delta and the Martapura areas, I did not carry out boring here. But from field observations and from the air photo appearances, two geomorphic units were found here. A narrow strip of (1) natural levees is slightly elevated and sometimes inundated by river overflow.



▨: Terrestrial Soils ■: Peats ⊟: Peaty Mineral
Mangrove Deposits
Sand Beach Deposits
Mangrove Deposits mixed with Fine Sand
Tidal Flat
* Numbers of soil layer

Fig. 7 Diagrams of Boring Data from the Coastal Plain of South Kalimantan, from Anjir Talaran to the coast in the Pulau Petak Delta



High Terrace
White Sand
White Sand and Gravel
■: Peats
Mangrove Deposits
Tidal Flat
Sand Beach Deposits
Mangrove Deposits mixed with Fine Sand
* Numbers of soil layer

Fig. 8 Diagrams of Boring Data from the Coastal Plain of South Kalimantan, from Martapura to Banjarmasin in the Martapura Area

Where the poorly developed levees have been breached by flood waters, (2) meandering scars have formed. The sediments in the natural levees and in the meandering scars are categorized as riverine deposits.

Riverine to brackish deposits zone. This zone is mostly covered by thin peat deposits overlying mangrove deposits and sand or gravel. These deposits were found in two places, (i) in the Pulau Petak Delta area, covering mangrove deposits ; and (ii) in the Martapura area near to Gambut village, covering sand and gravel. Local inhabitants use this region for rice and coconut plantation.

The following four geomorphic units were established. Mangrove deposits in the Pulau Petak Delta, formed during the period of marine transgression, were overlain by peat after emergence from the sea, resulting in (3) peat-capped mangrove deposits. The peats are characterized by wood blocks and fibric material.

In the area near to Gambut village, (4) peat-capped sand and gravel were found. The peats are mostly derived from grasses with very few wood blocks.

(5) Natural levees continue until Sei Tabuk village, where sediments contain admixtures of shell and sand. These are (6) former beach ridges.

Typical profile descriptions are as follows :

I. Profile BM-41, 9.85 km 50°North of Anjir Sarapat along Handil* Ubak.

1. 0- 15 cm Dark reddish brown (5YR 3/2) hemic to sapric peats ; abundant plant remains ; pH 4.0.
2. 15- 25 cm Grayish brown (5YR 4/2) hemic peat ; few mineral materials ; pH 4.0.
3. 25- 50 cm Dark reddish brown (5YR 3/2) hemic peat ; abundant plant remains ; pH 4.0.
4. 50-100 cm Dark reddish brown (5YR 3/3) fibric peat ; abundant plant remains ; very soft ; pH 4.0.
5. 100-107 cm Dark reddish brown (5YR 3/4) fibric peat.
6. 107-128 cm Dark reddish brown (2.5YR 3/2-3/3) fibric peat ; abundant plant remains ; pH 4.0.
7. 128-178 cm Dark reddish brown (5YR 3/2) fibric peat, abundant plant remains ; few, wood blocks ; pH 4.0.
8. 178-194 cm Brownish black (5YR 2/1) peaty soil ; abundant plant remains ; pH 4.0.
9. 194-223 cm Yellowish gray (2.5Y 5/1) clay ; abundant organic matter ; pH 4.0, pH oxidation 2.0.
10. 223-240 cm LiC and wood blocks.
11. 240-280 cm Gray (5Y 5/1) fine clay ; moderate organic matters, plant remains ; massive, soft ; pH 4.0, pH oxidation 1.0.
12. 280-331 cm Gray (5Y 4/1) fine clay ; few plant remains ; massive, soft ; pH 4.0, pH oxidation 1.0.
13. 331-387 cm Gray (7.5Y 4/1 + 10Y 6/1) fine clay ; few plant remains, massive ; pH 4.0, pH oxidation 1.0.
14. 387-400 cm Dark olive gray and light yellow (5GY 4/1 + 2.5Y 7/3) silty clay ; few organic matter ; massive ; pH 4.0, pH oxidation 1.0.
15. 400-426 cm Yellowish gray (2.5Y 5/1) fine clay ; few plant remains ; massive soft ; pH 4.0, pH oxidation 1.0.
16. 426-453 cm Olive gray (5GY 5/1) fine clay ; few plant remains ; massive ; pH 4.0, pH oxidation 1.0.
17. 453-500 cm Dark olive gray (5GY 4/1) peat ;

* Handil is a local term of canal.

few mineral materials; pH 4.0, pH oxidation 1.0.

18. 500–600 cm Gray (10Y 4/1) fine clay; massive rather compact; pH 4.0, pH oxidation 1.0.

In this profile, the layers down to the depth of 194 cm are peat deposits. Down to the depth of 50 cm, the peat deposits are more decomposed, resulting in hemic to sapric peats due to the extensive use this land for rice cultivation. At the depth of 50 to 194 cm, all peat layers are characterized by fibric material and are very soft, due to their high water content.

At the depth of 194 to 600 cm, all layers are mangrove deposits of clay to fine clay in texture. The presence of yellowish gray and olive-gray to light yellow soils indicates that pyrites occur in these deposits, as will be discussed in a separate paper.

II. Profile BM-24, around Gambut village.

1. 0– 85 cm Dark reddish brown (2.5YR 3/3–3/2) fibric to hemic peats; abundant plant remains.
2. 85–160 cm Dark reddish brown (2.5YR 3/3) fibric peat; abundant plant remains.
3. 160–215 cm Coarse sand with small amount of gravel; very loose.

Based on the results of field observation, these peat deposits are mostly derived from grasses. The organic matter deposited here is mainly characterized by species of recognizable botanical origin and is of low bulk density, as will be discussed in a separate paper.

The coarse sand and gravel can be categorized as low terrace.

Brackish to marine deposits zone. This zone covers relatively flat areas of land with elevations of up to several meters. Until recently, these areas were covered by mangrove vegetation. Today, this vegetation grows well only near the coastline. The area behind the present mangrove vegetation has been used by local people for rice and coconut plantation.

The geomorphic units of this region consist of (7) mangrove deposits on tidal flat, (8) former thick sand ridges and (9) mangrove belt covering the present coastline.

A typical profile description is as follows (Profile BM-8, near to Sakata village):

1. 0– 8 cm Brownish gray (7.5YR 4/1) clay; abundant organic matter, plant remains; massive, rather soft.
2. 8– 29 cm Grayish brown (7.5YR 6/2) heavy clay; moderate bright brown (7.5YR 5/6) iron mottles; moderate plant remains in standing position.
3. 29– 58 cm Grayish brown (7.5YR 5/2) heavy clay; moderate bright brown (7.5YR 5/6) iron mottles; few plant remains.
4. 58– 82 cm Brownish gray and yellowish gray (10YR 6/1 + 2.5Y 5/1) heavy clay; few, bright brown (7.5YR 5/6) iron mottles; moderate organic matter, plant remains; massive soft.
5. 82– 95 cm Gray (5Y 4/1) fine clay; few wood blocks; massive, soft.
6. 95–100 cm Grayish yellow brown (10YR 4/2) fine clay; abundant organic matter, plant remains in standing position; massive, soft.
7. 100–112 cm Gray (7.5Y 4/1) clay; moderate plant remains in standing position; little organic matter; massive, soft.
8. 112–116 cm Brownish gray (7.5YR 5/1) peaty clay; the color changes rapidly to

black (10YR 2/1); few plant remains in standing position; massive, very soft.

9. 116–148 cm Brownish gray (7.5YR 5/1) clay; few plant remains in standing position; massive, soft.

10. 148–163 cm Yellowish gray (2.5Y 5/1) clay alternating with fine sand; moderate plant remains; few sea-shells; massive, soft.

11. 163–200 cm Yellowish gray (2.5Y 5/1) sand alternating with thin layers of fine clay; few sea-shells; massive, soft.

12. 200–239 cm Gray (5Y 5/1) sand alternating with thin layers of fine clay; plant remains; abundant sea-shells; massive, soft.

13. 239–281 cm Gray (10Y 5/1) sand alternating with thin layers of fine clay; moderate plant remains in horizontal position, sea-shells; massive, soft.

14. 281–337 cm Dark greenish gray (7.5GY 4/1–3/1) sand alternating with thin layers of clay; moderate plant remains, organic matter; sea-shells; massive, very soft.

15. 337–384 cm Yellowish gray (2.5Y 6/1) fine clay alternating with fine sand; few thin organic layers; massive, soft.

16. 384–400 cm Yellowish gray and dark greenish gray (2.5Y 5/1 + 7.5GY 4/1) clay alternating with thin organic matter layers; massive, soft.

17. 400–448 cm Gray (10Y 5/1) fine clay alternating with olive gray (2.5GY 5/1) sand and thin organic matter layers; few plant remains in standing position; massive, soft.

18. 448–464 cm Gray (10Y 5/1) fine clay alternating with yellowish brown (2.5Y 5/3) coarse sand and thin organic matter layers; few plant remains in standing position; massive.

19. 464–545 cm Gray (10Y 5/1) clay alternating with greenish gray (7.5GY 5/1) sand and thin organic matter layers; few plant remains in standing position; massive.

20. 545–600 cm Sand beach deposits; abundant sea-shells; few organic matters.

In this profile, the layers down to the depth of 148 cm are mangrove deposits. These deposits contained bright brown iron mottles at the depth of 8 to 82 cm, indicating the presence of pyrites accompanying with the plant remains derived from mangrove vegetation.

All layers at the depth of 148 to 545 cm are tidal flat deposits. Sometimes, thin organic layers were found here alternating with fine clay.

Sand beach deposits were found at the depth of 545 to 600 cm with abundant sea-shells. A sand beach was probably formed here during the past transgression period.

Flooded zone. Because this region is always covered by floodwater, I had difficulty in observing the soil in detail. From the area near the levees, however, I saw that the mineral deposits here are probably categorized as low terrace. This terrace is constantly influenced by flooding, so the soil surface has turned light gray. This is different from the terrace situated in the upper part of this region, which is mostly chracterized by yellowish brown soils. Thus, the soil surface of the low terrace in the flooded zone is probably covered by terrestrial soils which have been transformed into fluviatile swampy soils.

During the field study, I found two geomorphic units here. Along the Tabalong and Alabio rivers, (10) natural levees have developed. During the rainy season, floodwater from these rivers enters this region, and because the levees dam up this water, (11) a perennially flooded area is formed.

Geomorphic History

Fig. 9 and 10 show the integrated stratigraphic layers of coastal plains in Jambi and South Kalimantan, respectively, in cross-section from inland to the coast. These figures indicate that the stratigraphic evolution of the two study areas is different. For instance, deep peat deposits were found in the coastal plains of Jambi, but not in South Kalimantan. In contrast, Fig. 5 shows that the coastal plains of South Kalimantan contain an extensive flooded zone, while this is not the case in Jambi.

Landform development in the coastal plains of Jambi and South Kalimantan has been influenced by the vegetation there and by the transgression and regression cycle in the past. When the

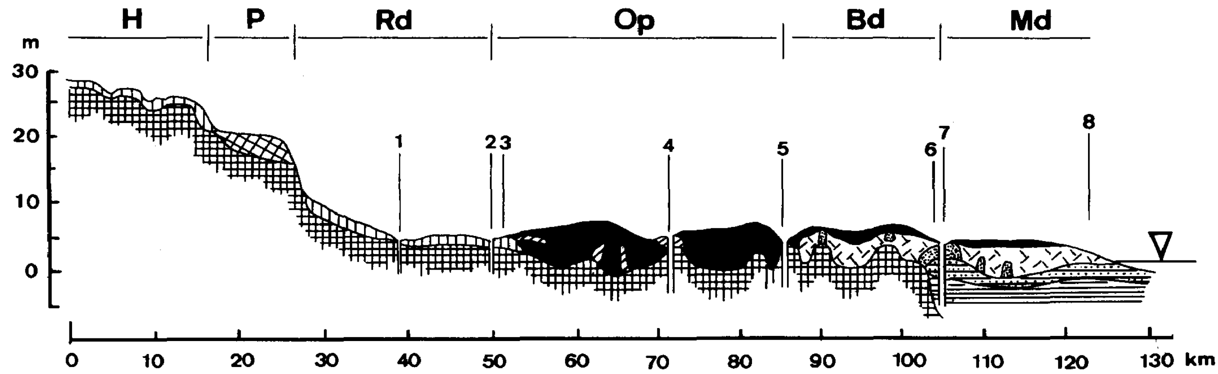


Fig. 9–1 From Jambi to Simburnaik (after Furukawa [1986])

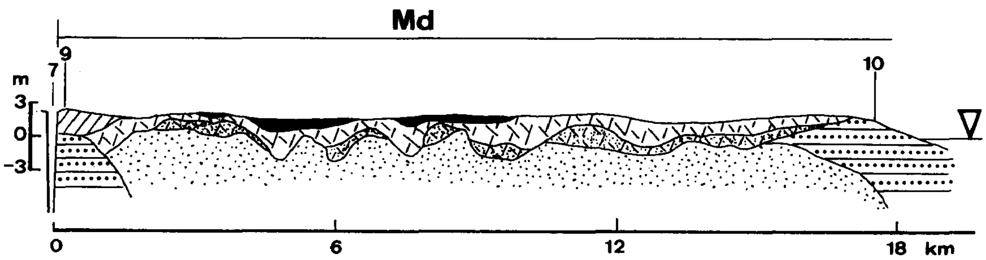


Fig. 9–2 From Puding to Nipahpanjang

: Peats : Terrestrial Soils : Pleistocene Terrace :Tidal Flat
: Mangrove Deposits : Sand Beach : Marine Deposits
: Mangrove Deposits mixed with Sand Beach : Podzol : Red-yellow Soil

H, Hill; P, Podzol; Rd, Riverine Deposits; Op, Ombrogenous Peats; Bd, Riverine to Brackish Deposits; Md, Brackish to Marine Deposits

1, Jambi; 2, Kumpeh river; 3, Bangso village; 4, Batang Hari river; 5, Dendang river; 6, Telukbuan village; 7, Batang Hari river; 8, Simburnaik; 9, Puding village; 10, Nipah Panjang

Fig. 9 Integrated Stratigraphic Layers of the Coastal Plain of Jambi in Cross-section from Inland to the Coast

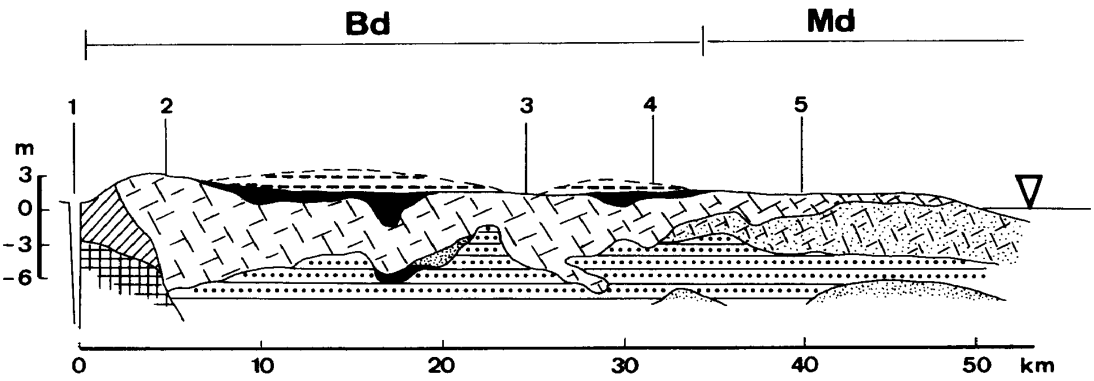


Fig. 10-1 From Antaraya to the coast

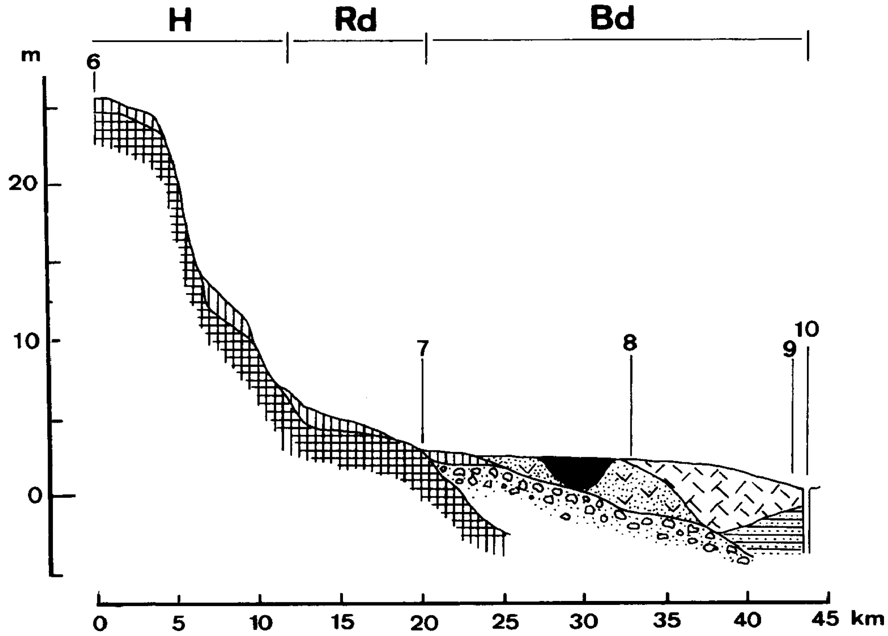


Fig. 10-2 From Martapura to Banjarmasin

■: Peats ▨: Terrestrial Soils ▦: Pleistocene Terrace ▤: Tidal Flat ⊠: Mangrove Deposits
□: Sand Beach ⊠: Mangrove Deposits mixed with Sand Beach ⊡: White Sand or Gravel
⊠: Clay mixed with White Sand ▥: Red-yellow Soil

H, Hill; Rd, Riverine Deposits; Bd, Riverine to Brackish Deposits; Md, Brackish to Marine Deposits
1, Barito river; 2, Anjir Talaran; 3, Anjir Sarapat; 4, Anjir Tamban; 5, Sakata Baru village;
6, Martapura; 7, Pembataan; 8, Sei Tabuk village; 9, Banjarmasin; 10, Barito river

Fig. 10 Integrated Stratigraphic Layers of the Coastal Plain of South Kalimantan in Cross-section from Inland to the Coast

sea level rose, big estuaries choked the free discharge of rivers, so the coastal plains were submerged during the transgression. Mangrove deposits were formed in the lagoons. After the final regression, the coastline advanced to expose alluvial deposits. Mangrove vegetation settled on these deposits and expanded mangrove deposits towards the sea. In the course of sea level changes, many sand ridges were formed on tidal flats.

Thus, the mangrove deposits in the coastal plains of Jambi and South Kalimantan appear to consist of old and young deposits. The old deposits are related to the deposition processes during the transgression and regression of the sea and are characterized by a heavy clay texture and dull yellowish brown to grayish yellow-brown color. This is supported by the fact that in the brackish to marine deposit zone of the coastal plain of Jambi, in the area between Puding and Nipahpanjang villages, the old mangrove deposits lie on the marine sand (Fig. 9-2) and were formed while the sea level was stationary. Around Telukbuan village (see Fig. 9-1), this marine sand was also found underlying the old mangrove deposits. The top of this marine sand formation is related to an ancient sea level at least 3.0 m above the present level. The old mangrove deposits, represented by charcoal sample of GaK-11897 (Table 5), started to accumulate approximately 5,900 years ago, which indicates that their accumulation rate was about 0.6 mm/yr. Until recently, the old mangrove deposits were cov-

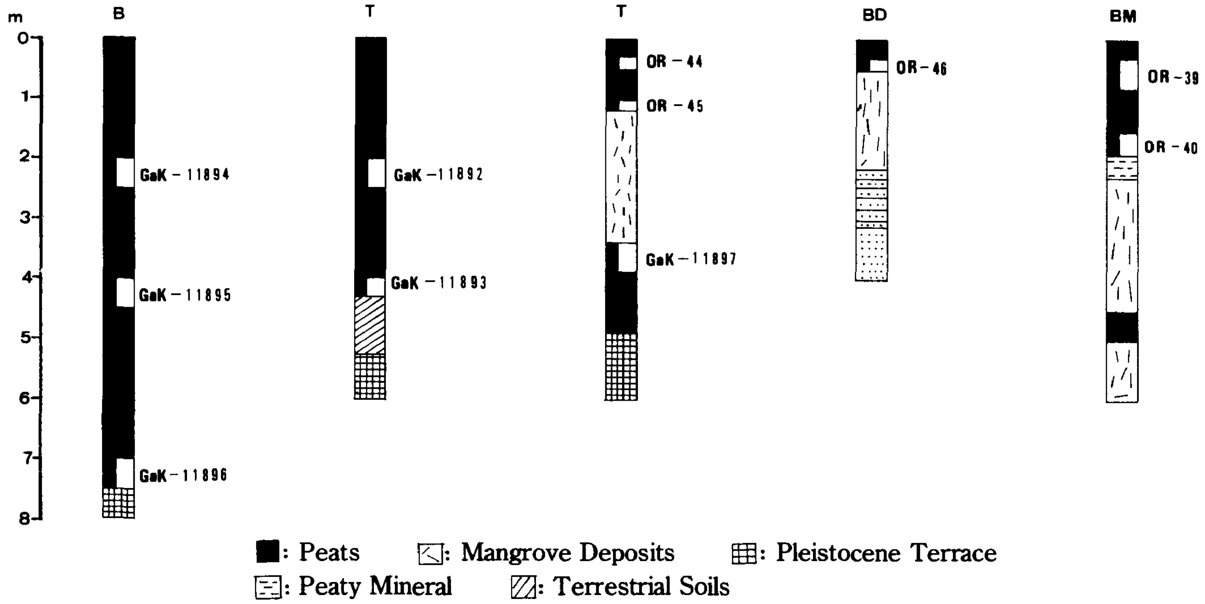
Table 5 The Results of ^{14}C-Dating of Peat Soil Samples

Sample No.	Depth (Av. in cm)	Age (Years BP)	Depth of Soil Sample (cm)*	Calculated Rate of Peat Accumulation (cm/100yr)	Material and Location
I. Jambi					
		Ombrogenous Peats Zone			
GaK-11894**	0-225	4040±180	200-250	6	Woody Peat; 7 km Northeast of Pulaumentaro
GaK-11895**	225-425	4360±130	400-450	63	Charred wood; 7 km Northeast of Pulaumentaro
GaK-11896**	425-725	5710±130	700-750	22	Charred wood; 7 km Northeast of Pulaumentaro
GaK-11892**	0-225	5890±190	200-250	4	Woody Peat; 3 km North of Rantaupanjang
GaK-11893**	225-425	6830±180	400-430	21	Woody Peat; 3 km North of Rantaupanjang
		Riverine to Brackish Deposits Zone			
OR-44	0- 40	1120± 55	30- 50	4	Woody Peat; SK-8 Unit II Dendang I
OR-45	40-110	1440± 55	100-120	22	Woody Peat; SK-8 Unit II Dendang I
GaK-11897**	110-363	5980±180	335-390	6***	Charcoal; SK-8 Unit II Dendang I
		Brackish to Marine Deposits Zone			
OR-46	0- 40	220± 40	30- 50	18	Peat; SK-19 Rantaurasau near to the Feeder Canal
II. South Kalimantan					
		Riverine to Brackish Deposits Zone			
OR-39	0- 50	1420± 70	25- 75	4	Peat; 5 km Northeast of Center of Anjir Sarapat
OR-40	50-172	2000± 50	150-194	21	Peat; 5 km Northeast of Center of Anjir Sarapat

* See Fig. 11

** After Supiandi and Furukawa [1986]

*** To show the rate of mangrove deposits accumulation



B, T, and BD are profiles taken from the Kumpeh, Tanjung and Berbak Delta areas of Jambi, respectively; and BM is from the Pulau Petak Delta area of South Kalimantan.

Fig. 11 Depth of Soil Samples Submitted to ^{14}C-Dating

ered by dense forest. The young mangrove deposits, on the other hand, are related to the present mangrove vegetation that now covers them, and are characterized by clayey texture, gray to greenish gray color, and softness.

The inland area was submerged seasonally by freshwater which was dammed up by natural levees. This retarded the decomposition of organic matter, and peat formation took place. These peat deposits started to accumulate during the Holocene period (Table 5).

In Jambi, two peat deposits were found, (i) deep peats deposited on Pleistocene terrace, and (ii) thin peats deposited on mangrove deposits. Peats covering the Pleistocene terrace started to accumulate approximately 5,700 years ago in the Kumpeh area, and approximately 6,800 years ago in the Tanjung area. During the first stage of peat accumulation on the terrace, organic matter were derived from grasses and ferns. After the vegetation changed to swamp forest, the organic matter production increased drastically and a thick peat dome was formed. In the center part of peat dome, the elevation was increased by peat development to about 7.0 m above MSL.

Later peat formations are also found. Peat on mangrove deposits near Telukbuan started to accumulate approximately 1,400 years ago. These peats are mostly less than 2.0 m thick and are derived from mangrove vegetation in the upper layers and grasses and ferns in the bottom layers.

In the brackish to marine deposit zone, thin peats on mangrove deposits started to accumulate approximately 200 years ago, and are mixed with mineral materials resulting in the peaty soils.

In South Kalimantan also, two peat deposits were found; (i) peats deposited on sand and gravel (Fig. 10-2), and (ii) peats deposited on mangrove deposits (Fig. 10- 1). Sand and gravel are related to a low terrace formation. Although I have no data about the age of the peats covering the sand and gravel, I believe that they probably developed during transgression period. When the sea level rose, the low terrace of sand and gravel would have started to be inundated, and peats would have accumulated. The floral composition of peats deposited here mostly derived from grasses in all layers. The thickness of peat deposits is not more than 1.6 m (see Fig. 8, BM-24).

Peats on mangrove deposits in the riverine to brackish deposit zone started to accumulate approximately 2,000 years ago. These peats probably started to accumulate later than those deposited on the sand and gravel.

The results of this investigation show that the sediments in the coastal plains of Jambi consist of (i) Pleistocene terrace underlying the thick peat-dome in the ombrogenous peats zone and mangrove deposits in the riverine to brackish deposits zone; and (ii) mangrove deposits underlying thin peats in the riverine to brackish deposits zone and overlying the tidal flats in the brackish to marine deposits zone. In the coastal plains of South Kalimantan, the sediments consist of (i) mangrove deposits underlying the peats in the riverine to brackish deposits zone and overlying the tidal flats in the brackish to marine deposits zone; and (ii) sand and gravel underlying the peats in the riverine to brackish deposits zone. In the riverine deposits zone, the sediments in both coastal plains are mostly fluviatile deposits. This clearly indicates that peat deposits in the coastal plains play an important role in the rise of topography, while mineral soil deposits are significant in the accretion of coastline and the formation of natural levees.

The rapid change of the coastline in Jambi and South Kalimantan was caused by sediment supply of riverine and marine origin, and by transgression and regression of the sea in the past.

Acknowledgments

I would like to express my deep gratitude to Prof. Y. Takaya and Dr. H. Furukawa of the Center for Southeast Asian Studies, Kyoto University who gave me extensive guidance in all phases of this research. I wish to thank Prof. O. Koswara of the Faculty of Agriculture, Bogor Agricultural University for his help during the preparation of the field study. This research was facilitated by a grant from the Center for Southeast Asian Studies, Kyoto University, Japan and the Team of P3S-IPB, Bogor Agricultural University, Indonesia.

References

Andriesse, J. P. 1974. Tropical lowland peats in South-East Asia. *Communication* 63. Amsterdam: Department of Agriculture Research, Royal Tropical Institute.

Brown, C. A. 1960. *Palynological Techniques*. Library of Congress Catalog Card Number 60-14297. Baton Rouge, La.

Furukawa, H. 1986. Shizen Chiri to Syokusei—Sunda Iki no Dojo, Seitai Menba [Natural Geography and Vegetation—Soil and Ecological Members in Sunda Land]. *Gaku Jutsu Geppoh* [Japanese Scientific Monthly] 30(10): 724-729.

Furukawa, H.; and Supiandi, S. 1985. Batan Hari Gawa Ryuiki Teishicchi no Nogyo Keikan. Sono 1. Chikei to Taisekisojo [Agricultural Landscape in the Lower Batang Hari, Sumatra. Part one: Stratigraphy and Geomorphology of Coastal Swampy Lands]. *Tonan Ajia Kenkyu* [Southeast Asian Studies] 23(1): 3-37.

Institut Pertanian Bogor Team. 1975. Pembentukan dan Klasifikasi Tanah. In *Laporan Survey dan Pemetaan Tanah Daerah Pasang Surut Muara Sabak, Delta Berbak, Jambi, Bab 2* [Genesis and Soil Calssification. In, Report of Soil Survey and Soil Mapping in the Tidal Swampy Land of Muara Sabak Area, Jambi, Chapter 2], pp. 2-39. Institut Pertanian Bogor [Bogor Agricultural University].

Kaila, A. 1956. Determination of the Degree of Humification in Peat Samples. *Journal of the Scientific Agricultural Society of Finland* 28 : 18–35.

Supiandi, S. ; and Furukawa, H. 1986. A study of Floral Composition of Peat Soil in the Lower Batang Hari River Basin of Jambi, Sumatra. *Tonan Ajia Kenkyu* [Southeast Asian Studies] 24(2) : 113–132.

Van Bemmelen, R. W. 1949. *The Geology of Indonesia.* I–A. Martinus Nijhoft.