Proc. 3d ASEAN Soil Conference
Kuala Lumpur, Malaysia, 1975

Govt. of Malaysia, Ministry of
Agriculture, Kuala Lumpur 1977

pp 121-131

RED-YELLOW PODZOLIC SOILS FROM THE LAMPUNG AND SOUTH SUMATRA PROVINCES (SUMATRA, INDONESIA)

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ABSTRACT

An integrated study of some Red-Yellow Podzolic Soils of Lampung and South Sumatra revealed that soil genesis is influenced by agricultural practices. In many profiles the process of clay illuviation is not dominating. Former textural B-horizons are either being homogenized by biological activity or are being broken down by pseudogley processes ("wet clay destruction"). It seems possible to distinguish between ameliorating and deteriorating profiles. This is of importance for future agricultural use of these soils.

INTRODUCTION

The Soil Research Institute in Bogor (Indonesia), started the study of Red-Yellow Podzolic Soils (RYP soils hereafter) within the frame work of its research programme on problem soils. Directives for this research programme were outlined at the Second ASEAN Soil Conference (Jakarta, 1972).

The objective of the present research is to differentiate the Group of the RYP soils and to measure the changes in these soils relative to different agricultural practices. Included are the changes in physical and chemical characteristics and related morphological properties.

Two areas selected for detailed study were the Lampung and South Sumatra provinces. Field work here was carried out during 1972 and 1973 under supervision of Dr P.M. Drieoren. The locations of the soil profiles studied are given in Gig. 1.

According to Dudal and Soepraptohardjo (1957) RYP soils are defined as follows:

– "Red-Yellow Podzolic Soils are highly leached, show a light grey to yellowish surface soil over a red yellow accumulation horizon of relatively heavy texture with blocky structure, low permeability and a low degree of stable aggregation. Organic matter content, base saturation and pH are low, the latter commonly between pH 4.2 and 4.8. The development of the leached surface horizon may not always be well expressed. Parent material frequently mottled yellow, red and grey appears at no great depth" –

This rather broad description leaves room for further differentiation of RYP soils, e.g. on the basis of their genetic properties which are still poorly understood. This paper discusses genesis and properties of a number of representative RYP soils. It is intended as a first step towards a sound theoretical basis for the agricultural evaluation of this widespread group of soils.

1. ENVIRONMENTAL CONDITIONS

Geology and geomorphology

The Spine of Sumatra is the Barisan mountain range, a geanticline which extends in a NW–SE direction along its western coast. The Barisan range consists mainly of old quartzites and schists, covered with young andesitic material. Peaks in the Barisan range may reach heights of well over 3000 metres. In the northern province of South Sumatra surfacing older formations form a transition to the Triassic, Jurassic and Cretaceous formations of Jambi. Towards the northeast, these formations are covered by the acid Tertiary Palembang Beds, which cover the greater part of the area, and the Quaternary andesitic tuffs of Lampung. (Fig. 2)

Soil formation in the area is mainly determined by the age and kind of parent material. Young andesitic material from the Barisan Range yield relatively fertile Regosols, Andosols and Latosols. On the basaltic Sukadana Plateau excellent Latosols are found. The majority of the area, however, consists of dacitic quarternary tuffs overlying the Tertiary Palembang Beds. On the latter tuff deposits, RYP soils are formed (Driessen and Soepraptohardjo, 1974).

The elevated mountain belt (zone A) has a pronounced relief and is incised by many rivers. The transition to the middle zone (B) with Tertiary Middle and Upper Palembang Beds and Quaternary tuffs is gradual. In Lampung particularly the landscape in zone B is level to slightly sloping.

Belt C occupies the lower part of the area, where the rivers grade into extensive flats, which are still partly under tidal influence (Fig. 3).

Rainfall

The greater part of the area features rainfall type B of Schmidt and Ferguson (1951), which has a ratio of 0.14 to 0.33 between the average number of dry and wet months. The annual precipitation data are grouped into four isohyetal belts (Fig. 4). Rainfall increases from the east, where it is less than 2000 mm per year towards the Barisan Range, exceeding 3000 mm per year. The climate belongs to Köppen's *Afa* type.

Hydrology

Hydrological conditions differ in the belts outlined above. Most of the rivers flow in an easterly direction and debouch in the Java Sea. Their upper courses in the Barisan Range form an intricate pattern of deep valleys and gorges. The Seputih dam is situated in this belt. In the middle courses, dendritic drainage patterns occur in zone A and parallel patterns occur in zone B.

In the lower courses (zone C), wider valleys grade into swamps and tidal creeks. The approximate boundaries of the zones are shown in Fig. 5.

Vegetation and land use

In most of the area, the original vegetation has been destroyed by shifting cultivation. The primary vegetation, preserved in some drier parts of the lowland includes the following valuable species: meranti (Shorea leprosula), merawan (Shorea mengerawan), kapu (Dyobalanops sp.), kayu kembang (Cenaga odorata), seru (Schima bancana), Oaks (Quercus), chestnuts (Castanea), lauraceae and rattan. Most secondary forests have a poor stand.

As a result of improper land use, considerable parts of the area are now covered with alang-alang (speargrass, Imperata cylindrica) and shrubs (e.g. Lantana camara and Eupatorium ssp.).

Shifting cultivation is still practiced, and upland crops are grown in areas where water is insufficient. Rubber is the only common perennial crop. In irrigatable areas, e.g. in the Seputih project, rice is grown, followed by a second crop.

2. MATERIALS AND METHODS

Profile descriptions were made in the field using the methods described in the Soil Survey Manual (1962), supplemented according to the system used at the Netherlands Soil Survey Institute. The Soils were classified according to Soil Taxonomy (1974).

Laboratory analyses included the determinations of the particle size distribution (pipette method), total SiO_2, Al_2O_3 and Fe_2O_3 in the clay fraction, pH-H_2O and pH-KCl in various dilutions, organic carbon (wet destruction) and total nitrogen (Kjeldahl). In addition, cation exchange capacities and base saturation values were determined according to the procedures outlined in the SRI-Laboratory Manual (1972). The soil-physical data include soil permeability, water retention at various pF-levels, bulk density and aggregate stability (SRI-Laboratory Manual, 1974).

The clay mineralogical composition was determined with the aid of X-ray diffraction*) and Differential Thermal Analysis. Clay samples for X-ray diffraction were K- and Mg-saturated at 50 % relative moisture, glycerolated and heated.

Thin sections for micromorphological investigations were prepared after the methods used at the Department of Soil Science and Geology, Agricultural University, Wageningen.

The mineralogical composition of the sand fraction was determined by line-counting in the 100–200 m fractions.

3. SOILS

A number of representative profiles from the zones A, B and C have been described in detail. For a selection of these profiles the reader is referred to the appendix.

4. EXPERIMENTAL RESULTS

4.1. *Micromorphology*

The results of our observations on thin sections are summarized below. In general, the terminology of Brewer (1964) was adopted. For the description of regrouping phenomena the terminology of Jongerius (1970) was applied.

SAMPLES FROM LAMPUNG:

L/JD4 (Zone B)

S-matrix: porphyroskelic throughout the profile, in places also agglomeroplasmic.

Plasma: isotic and undulic in the A1.1, asepic to very faint skelsepic in the A1.2g, skelsepic in the A2, and undulic to masepic in the B2t.

x) For qualitative determination the criteria of Quakernaat (1968) were adopted.

Voids: many compound packing voids, number decreasing with depth.
Special features: ferriargillans in the B2t; ferriargillans in the A2 have deteriorated. In places along voids in the B2t neoferrans of red hematite and yellowish red goethite occur. Aggrotubules are common, particularly so in the upper layers. Pedotubules with strongly welded pellets occur in the A1.2g.

L.JD12 (zone B)
S-matrix: porphyroskelic throughout.
Plasma: isotic and undulic in the A1, insepic to lattisepic and faintly skelsepic plasmic fabric in the B2t.
Voids: many channels and compound packing voids in the upper part of the profile.
Special features: neoferrans along voids in the B2.2t. Aggrotubules with pellets of matrix material are common in the upper layers but are also present in the B2.2t.

L.JD2 (zone C)
S-matrix: porphyroskelic throughout.
Plasma: isotic in the A1, undulic in the A1 and B2.2t, skelsepic and vosepic in the B1 and B2.1t, and undulic, inseptic and masepic in the B2.2t.
Voids: many compound packing voids throughout.
Special features: faint free grain argillans in the B1 and B2.1t; faint free grain ferriargillans in the B2.2t. void argillans in the B1 and B2.1t. Aggrotubules are common, particularly so in the upper layers. Lignified wood was found in the B1.

L.JD9 (zone C)
S-matrix: porphyroskelic throughout.
Plasma: isotic, undulic and faintly lattisepic in the A1, insepic and increasingly skelsepic in the B2t and masepic here and there in the B2.2t and B2.3t.
Voids: many compound packing voids throughout.
Special features: in the B2.4t and B2.5t sone neoferrans and iron nodules do occur; in the B2.6t the development of iron nodules is pronounced. Aggrotubules are common in the upper four horizons.

Samples From South Sumatra:
SS/JD12 (zone B)
S-matrix: porphyroskelic throughout.
Plasma: isotic and undulic in the A1.1, faintly skelsepic in the IIA1.2 and IIA1.3, faintly masepic in the IIA2, IIB2.1t and IIB2.2t(g).
Voids: many compound packing voids; number decreasing with depth.
Special features: neoferrans of red hematite and yellowish red goethite in the IIB2.1t and IIB2.2t(g). Aggrotubules common above IIB2.2t(g), particularly so in the A1.1. Fresh and lignified wood in A1.

SS/JD1 (zone C)
S-matrix: porphyroskelic throughout.
Plasma: isolic to undulic in A1, Silasepic and faintly skelsepic in B1, B2.1t and B2.2t.
Voids: many compound packing voids; number decreasing with depth.
Special features: Aggrotubules throughout the horizons above the plinthite horizons (B2.3t + pl). Dignified wood in B1.
Note: Thin sections of the plinthite horizon were not available.

4.2. *Physical and chemical characteristics*

The surface textures of the profiles studied are loams, clayloams and sandy clayloams as illustrated in Fig. 6; B-horizons consist of clay or sandy clay. Table 1 presents some additional physical soil characteristics. Bulk densities vary from 1.10 to 1.45 and increase with depth. The drainage pores are classified in pores for quick (volume air at pF 2) and slow drainage (volume water between pF2 and 2.5). Some profiles have a higher percentage of quickly draining pores than others but both pore volumes decrease markedly with depth, viz. from 37% to 6% (Q.D.P.) and from 13% to 3% (S.D.P.). This is accompanied by a decrease in water permeability from 5.5–14 cm/24 hours to 0.2–4.0 cm/24 hours.

The water retention at pF levels are shown in Fig. 7. The available moisture (between pF 2.5 and 4.2) varies from 4 to 9%.

The quantities of total carbon and nitrogen, the cation exchange capacity values, the base saturation values and the pH are given in Fig. 8 and 9. The organic carbon and nitrogen contents decrease with depth as expected.

Exchangeable bases occur in the usual order of abundance: Ca > Mg > K > Na. Ca tends to decrease with depth. The base saturation is variable but the values tend to decrease with depth. The pattern of profile SS/JD1 is inconclusive but profile L/JD12 has values which do increase with depth and are above 30%; pH-H_2O is generally near 5.0 or below; only profile L/JD12 has higher values in its upper horizons.

4.3. *Mineralogical properties*

Figure 10 presents the mineral assemblages of the total sand fractions as well as the heavy fractions. Turbid quartz is the dominant mineral of the sand. In the heavy mineral fraction, zircon, tourmaline, anatase and rutile are dominant over the volcanic minerals hyperstene and augite. The latter minerals are found in the (colluvial) upper layers of most profiles. An exception is the profile L/JD9 which contains approximately 50% of hyperstene in the heavy fraction of the B2.4t (gravel)-horizon. X-ray diffraction patterns of the fraction smaller than 2 microns are shown in Figure 11. As expected, kaolinite is the dominant clay mineral and forms up to 90% of the total clay; the accessory clay mineral is identified as "soil chlorite". Other minerals, which were present in portions of less than 5% only, were cristobalite, quartz and goethite. Silica/sesquioxide-ratios in the clay fractions are presented in Table 2. Silica minerals in the clay fractions obscure the trends in sheet silicates particularly in the upper horizons. DTA-curves confirmed the occurrence of kaolinite and iron oxides.

5. **Discussion**

The differentiation of "Red-Yellow Podzolic Soils" from the original "Red Soils" has been based on morphological characteristics (Dudal and Soepraptohardjo, 1957). The genetic formation of these soils has been the subject an intergrated study of field characteristics, micromorphological properties and analytical data. Until recently, Indonesian Red-Yellow Podzolic Soils were considered relatively young soils and are still being formed. Some important new aspects of the formation of these soils will be discussed and conclusions will be drawn with regard to the practical implications of our results.

5.1. *Profile formation*

PROFILE L/JD2

Occasional argillans occur along voids and are thought to be fossil in most of the profile. Argillans in the upper layers are devoid of iron. This hints at hydromorphism. Lignified wood in the upper part of the profile points in the same direction. The textural B-horizon is being removed by both bioturbation (aggrotubules occur in the lower part of the B-horizon) and pseudogley (Brinkman et al., 1973). Hydromorphism in the upper part of the profile is due to periodic stagnation of water on the fairly impermeable B-horizon, which has one of the lowest permeability values measured. Most of the void argillans occur in the lower part of the profile.

PROFILE L/JD4

This profile shows homogeneization of a former B-horizon in the upper part of the profile. Oriented clays in these parts from pellets in the matrix. Void argillans are very scarce and occur in the lowest horizon exclusively; they are covered with neoferrans. This suggests that since the development of the B2t-horizon the groundwater has risen. Two processes play a major role in this profile: bioturbation of the upper horizons and plinthization in the B2t. Above the B2t hydromorphic destruction of clay skins is evident.

PROFILE L/JD9

This profile is very much like the preceding one. Argillans or ferriargillans along voids are very scarce; bioturbation is important down to the stoneline. Deeper in the profile, neoferrans and iron nodules indicate plinthization.

PROFILE L/JD12

Oriented clay does not occur along recent voids and is therefore considered fossil. The A-horizon is probably formed in the former B-horizon as is apparent from the abundance of sepic structure in the former. In the B2.2t-horizon the large number of neoferrans indicates plinthization, though the evidence of bioturbation in the B2.2t may point to a lowering in the groundwater table since.

PROFILES SS/JD1 AND SS/JD12 (South Sumatra)

These profiles feature bioturbation of the horizons above the zone with hydromorphic characteristics and iron segregation in the lower horizons.

SiO_2/Al_2O_3 – and SiO_2/R_2O_3 – ratios of the clay fractions suggest downward movement or Al_2O_3 and Fe_2O_3 in the profiles from Lampung (L/JD4, L/JD9 and L/JD12). (See table 2). Profile L/JD2, where clay destruction was found in the upper part of the profile, seems depleted of alumina in its upper layers.

In the soil profiles studied four processes are important:

1. bioturbation
2. wet clay destruction
3. clay eluviation and illuviation
4. plinthization

Bioturbation is most pronounced in the surface soils and decreases in intensity with depth. Where clay movement occurs its effect may be compensated by this bioturbation. Where bioturbation is hindered, e.g. by fluctuating ground water or by extreme oligotrophy, the effect of clay movement become perceptible and distinct eluviation and iluviation horizons develop.

Wet clay destruction enhances the contrast between horizons with stagnating water and overlying horizons. Directly above the "impermeable" layer clay is destroyed and planosol-like sharp textural changes may develop. This is favoured by the reduced biological activity due to temporary water saturation.

Plinthization develops very distinct horizons and depends also on the water regime. Where ground water is lowered, plinthization stops in the higher parts of the profile and the plinthite-horizon may eventually be homogenized by biological activity.

CONCLUSIONS

In the foregoing, it has been pointed out that through an integrated study of soil micromorphology, clay mineral analysis, and physical and chemical analysis, so-called "Red-Yellow Podzolic Soils" from Lampung and South Sumatra can be distinguished into soils which are ameliorating and soils that deteriorate.

Soils that show an increase in biological activity, and homogeneization of textural B horizons under relatively dry conditions are considered ameliorating. Those that show hydromorphic clay destruction above an impermeable B-horizon, or that show plinthization on high in the profile, are considered deteriorating.

Lowering the ground water will apparently stop plinthization and will favour biological homogeneization in some soils. Soils with water-stagnating B-horizons are not easily improved.

As all profiles have very low water holding capacities, either an even distribution of precipitation, or irrigation are necessary for continuous cropping. The very low aggregate stability of most topsoils (that of SS/JD 1 excepted) indicates that to prevent erosion the land should not lie fallow.

Measures should be taken to prevent surface run-off.

Wet rice cultivation will probably not be suitable for soils with pseudogey phenomena. In these soils, the possibility of aliminum toxicity may exist as a result of clay destruction.

Thus, when classifying "Red-Yellow Podzolic Soils" for agricultural purposes, it seems important to include forecasts with respect to changes in the soil that can be expected in connection with the cultivation system.

ACKNOWLEDGEMENTS

The authors are much indebted to Dr. D. Muljadi, Director of the Soil Research Institute Bogor, for permission to present the paper at the Third ASEAN Soil Conference. They also thank Mr M. Soepraptohardjo, Head of the Pedology Division for his cooperation.

The authors wish to express their gratitude to the Head and staff of the Department of Soil Science and Geology in the Agricultural University of Wageningen, The Netherlands, and the Soils Laboratory of the Royal Tropical Institute in Amsterdam for the facilities and cooperation received. In particular the kind assistance received in the fields of X-ray diffaction, DTA and the preparation of thin sections is gratefully mentioned.

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APPENDIX

Profile descriptions

Profile L/JD4 (zone B)

Location: Seputih Raman, *Lampung*
Classification: Yellow Podzolic soil (Plinthudult)
Geomorphology: Undulating to sloping peneplain
Parent material: Quaternary acid tuff
Elevation: 44 m above sea level
Precipitation: 2500–3000 mm per annum
Vegetation/landuse: Dry farming, various annual crops + rice

A1.1	0–14 cm	Dark brown (10 YR 3/3) loam, moderate very fine subangular blocky, slightly hard (d), slightly sticky plastic, few macro- and mesopores, common micropores, abrupt and smooth boundary to:
A1.2	14–65 cm	Yellow (10 YR 7/6) loam, moderate very fine subangular blocky, friable (m), slightly sticky-slightly plastic, many pores, common faint medium iron mottles, one medium krotovina, gradual and smooth boundary to:
A2	65–80 cm	Brownish yellow (10 YR 6/6) clay loam, moderate very fine angular blocky, firm (m), sticky and plastic, common macro- and mesopores, many micropores, many prominent medium regular red (2.5 YR 4/8) iron mottles, few medium gravel, clear and smooth boundary to:
B2t	80+ cm	Light grey to grey (10 YR 6/1) clay, moderate very fine subangular blocky, firm (m), slightly sticky-plastic, few pores, abundant prominent regular medium red (2.5 YR 4/8) iron mottles, many prominent fragments of cutans, abundant plinthite.

Profile L/JD12 (zone B)

Location: Gunungbatin Baru, *Lampung*
Classification: Red-Yellow Podzolic soil (Ultic Plinthic Tropudalf)
Geomorphology: Undulating to sloping peneplain
Parent material: Quaternary acid tuff
Elevation: 55 m above sea level
Precipitation: 2500–3000 mm per annum
Vegetation/landuse: Secondary forest (*Schima bancana)*, alang-alang

A1	0–18 cm	Very dark brown (10 YR 2/2) sandy clay loam, moderate coarse subangular blocky, slightly hard (d), slightly sticky-slightly plastic, common meso- and macropores, many macropores, many micropores, clear and smooth boundary to:
B2.1t	18–38 cm	Yellowish brown (10 YR 5/6) sandy clay, moderate, coarse subangular blocky, friable (m), sticky non-plastic, many pores, distinct cutans, few fine and medium root prints, one medium krotovina, diffuse and smooth boundary to:
B2.2tpl	38–49 cm	Yellowish brown (10 YR 5/6) sandy clay, moderate coarse angular blocky, friable (m), slightly sticky-slightly plastic, common micro- and macropores, few mesopores, distinct cutans, few fine root prints, few faint medium plinthite nodules, abrupt and smooth boundary to:
B2.3tpl	49–67 cm	Yellowish brown (10 YR 5/6) clay, concretionary, moderate fine subangular blocky, common macropores few meso- and micropores, abundant distinct regular fine and medium yellowish red (5 YR 3/8) iron mottles, distinct cutans, abrupt and smooth boundary to:
B2.4tpl	67+ cm	Yellowish brown (10 YR 5/6) clay, concretionary, moderate fine subangular blocky, common macropores, few meso–and micropores, abundant distinct fine and medium regular reddish (2.5 YR 5/8) iron segregation, prominent cutans.

Profile L/JD2 (zone C)
Location: Buminabung, *Lampung*
Classification: Red-Yellow Podzolic soil (Plinthic orthoxic Paleudult)
Geomorphology: Undulating to rolling peneplain
Parent material: Quaternary acid tuff
Elevation: 24 m above sea level
Precipitation: 2500–3000 mm per annum
Vegetation/landuse: Rubber, alang-alang, shrubs

A1	0–12 cm	Dark brown (10 Yr 3/3) sandy clay loam, moderate fine subangular blocky, slightly hard (d), slightly sticky-slightly plastic, common macropores, gradual and smooth boundary to:
B1	12–40 cm	Reddish brown (5 YR 5/4) clay, weak fine and medium subangular blocky, friable (m), slightly sticky-slightly plastic, common macropores, many mesopores, weak fragments of cutans, diffuse and smooth boundary to:
B2.1t	40–68 cm	Strong brown (7.5 YR 5/6) gravelly clay, medium to coarse angular blocky, friable (m), sticky-slightly plastic, common macropores many meso–and micropores, weak fragments of clear and smooth boundary to:
B2.2t	68–94 cm	Reddish yellow (7.5 YR 6/6) clay, massive, firm (m) sticky-slightly plastic, common macropores, many meso- and micropores, weak fragments of cutans, common fine root prints, abrupt and smooth boundary to:
B2.3t	94+ cm	Reddish yellow (7.5 YR 6/6) clay, massive, firm, common pores, abundant medium and coarse limonitic concretions, few fragments of cutans.

Profile L/JD9(zone C)
Location: Umbul Gunung, *Lampung*
Classification: Red-Yellow Podzolic soil (Typic Tropudult)
Gemorphology: Undulating peneplain
Parent material: Quaternary acid tuff
Elevation: 30 m above sea level
Precipitation: 2500–3000 mm per annum
Vegetation/landuse: Secondary forest and shrubs.

A1	0–10 cm	Brown to dark brown (10 YR 4/3) sandy clay loam, moderate medium subangular blocky, friable (m), slightly sticky-slightly plastic, common macro- and mesopores, many micropores, clear and smooth boundary to:
B2.1t	10–28 cm	Yellowish brown (10 YR 5/6) clay, moderate coarse angular blocky, friable (m), slightly sticky-slightly plastic, many macropores and micropores, common mesopores, few slickensides, few very faint fragments of cutans, few medium krotovinas, gradual and smooth boundary to:
B2.2t	28–85 cm	Strong brown (7.5 YR 5/6) sandy clay, moderate coarse angular blocky, friable (m), sticky-slightly plastic, common macro- and mesopores, many micropores, common faint cutans, few medium krotovinas, gradual to diffuse and smooth boundary to:
B2.3t	85–118 cm	Identical with B2.2t, except for denser packing. Clay.
B2.4tgr	118–141 cm	Reddish yellow (5 YR 6/6) clay, moderate medium subangular blocky, friable (m), slightly sticky-slightly plastic, common pores, many fine and medium distinct reddish (2.5 YR 5/6) iron mottles, common cutans, abrupt and smooth boundary to:
B2.5tgr	141–162 cm	Reddish yellow (5 YR 6/8) clay, moderate coarse subangular blocky, friable (m), sticky-slightly plastic, few macro- and mesopores, common micropores, many distinct medium regular iron mottles, abrupt and smooth boundary to:
B2.6tpl	162+ cm	Plinthic

Profile SS/JD12 (zone B)
Location: Between Prabumulih and Baturaja, *South Sumatra*
Classification: Yellowish Brown Podzolic (Plinthic Paleudult)
Gemorphology: Dissected peneplain
Parent material: Tertiary acid tuff

Elevation: 20 m above sea level (estimate)
Precipitation: 2500–3000 mm per annum
Vegetation/landuse: Secondary forest

A1.1	0–10 cm	Dark brown (10 YR 3/3) sandy clay loam, weak fine subangular, sticky-slightly plastic, many pores, clear and smooth boundary to:
IIA1.2	10–13 cm	Strong brown (7.5 YR 5/6) sandy clay loam to clay loam, massive to weak medium angular blocky, very firm, slightly sticky-slightly plastic, many pores, fragments of clayskins from degraded former B2t, gradual and smooth boundary to:
IIA1.3	13–38 cm	Yellowish red (5 YR 5/6) clay loam, massive to weak medium angular blocky, firm (m), slightly sticky-slightly plastic, common macropores, few meso- and micropores, fragments of cutans from degraded former B2t, gradual and smooth boundary to:
IIA2	38–85 cm	Yellowish brown (10 YR 5/6) clay, massive to weak compound very fine and medium subangular blocky, friable (m), slightly sticky-slightly plastic, many pores, few prominent medium black charcoal fragments, few distinct fragments of cutans, clear and smooth boundary to:
IIB2.1t	85–104 cm	Yellowish brown to light yellowish brown (10 YR 5.5/4) clay, strong compound fine and medium subangular blocky, slightly hard (m), slightly sticky-slightly plastic, few pores, many faint irregular red (2.5 YR 4/6) medium iron mottles, prominent cutans, clear and smooth boundary to:
IIB2.3t(g) (plinthic)	104+ cm	Yellowish brown to light yellowish brown (10 YR 5.5/4) clay, compound strong fine and medium subangular blocky, slightly hard (m), slightly sticky-slightly plastic, few pores many faint irregular red (2.5 YR 4/6) medium iron mottles, common prominent medium spherical red (10 YR 4/8) hard and soft plinthite, prominent cutans.

Profile SS/JD1 (zone C)
Location: Gelumbang, *South Sumatra*
Classification: Yellowish Brown Podzolic (Plinthudult)
Geomorphology: Level to undulating peneplain, folded and eroded strata
Parent material: Tertiary acid tuff (Palembang bed)
Elevation: 19 m above sea level (estimate)
Precipitation: 2500–3000 mm per annum
Vegetation/landuse: Secondary forest (*Schima bancana*) and shrubs

A1	0–13 cm	Dark brown (10 YR 3/3) sandy clay loam, massive, friable (m), slightly sticky-slightly plastic, common pores, clear and smooth boundary to:
B1	13–32 cm	Yellowish brown (10 YR 5/6) sandy clay, massive, firm (m), slightly sticky-slightly plastic, common macropores, many meso- and micropores, gradual and smooth boundary to:
B2.1t	32–52 cm	Reddish yellow (7.5 YR 6/6) sandy clay, massive, firm (m), sticky-plastic, many macropores, common meso- and micropores, gradual and smooth boundary to:
B2.t	52–100 cm	Brownish yellow (10 YR 6/6) sandy clay, massive, friable to slightly firm (m), slightly sticky-slightly plastic, many pores, abrupt and smooth boundary to:
B2.3tpl	100+ cm	Brownish yellow (10 YR 6/6) pisolithic sandy clay, abundant pisolites, ranging from dark red (10 R 3/6) to strong brown (7.5 YR 5/8).

TABLE 1

Some physical characteristics of R.Y.P.-soils from Lampung and South Sumatra

Zone	Horizon	Depth (cm)	Bulk dens.	Drainage pores % Quick	Slow	Water perm. (cm 24th)	Agr. (%)	Instability Index	Swell factor
LAMPUNG									
B	L/JD4								
	A1.1	not analysed							
	A1.2(g)	14–65	1.4	8.4	13.8	1.7	43.0	2.8	1.1
	A2	65–80	1.5	11.8	9.0	1.3	65.2	1.9	1.2
	B2tpl*	not analysed							
C	L/JD2								
	A1	0–12	1.1	22.1	8.8	9.9	60.6	0.2	1.1
	B1	12–40	1.3	12.6	7.2	2.5	55.1	0.8	1.2
	B2.1t	40–68	1.3	23.0	6.8	1.0	48.5	1.9	1.3
	deeper horizons have not been analysed								
SOUTH SUMATRA									
B	SS/JD12								
	A1.1	0–10	1.1	36.7	3.0	7.7	70.1	0.3	nd
	IIA1.2	10–13	1.4	23.1	3.7	4.3	51.2	1.3	nd
	deeper horizons have not been analysed								
C	SS/JD1								
	A1	0–13	1.1	19.3	10.3	14.3	79.0	1.9	nd
	B1	13–32	1.3	12.4	9.1	2.1	84.4	1.5	nd
	B2.1t	32–52	nd	nd	nd	nd	68.8	2.9	nd
	B2.2t	32–100	nd	nd	nd	nd	77.5	2.2	nd
	B2.3tpl*	100+	not analysed						

NOTE: nd = not derermined
* pl = plinthite

TABLE 2

Clay mineral assemblages of R.Y.P.-soils from Lampung and South Sumatra

Zone Horizon	Depth (cm)	Composition	SiO_2	Fe_2O_3 (weight %)	Al_2O_3	SiO2 / Al_2O_3 (molar ratio)	SiO2 / R_2O_3 (molar ratio)
LAMPUNG							
B L/JD4							
A1.1	0–14	Kaolinite (Ch, G)	45.7	5.6	17.7	4.39	3.65
A1.2g	14–65	nd	46.2	7.2	25.9	3.03	2.56
A2	65–80	nd	36.5	15.6	22.2	2.79	1.93
B2t	80+	Kaolinite (Ch, G)	44.3	6.1	31.6	2.38	2.12
B L/JD12							
A1	0–18	Kaolinite (Ch, G)	42.3	7.0	32.7	2.20	1.93
B2.1t	18–38	nd	33.2	7.1	34.0	1.68	1.48
B2.2tpl	38–49	nd	20.8	5.5	33.8	1.05	0.95
B2.3tpl	49–67	nd	27.0	5.8	36.1	1.27	1.15
B2.4tpl	67+	Kaolinite (Ch, G)	35.2	6.1	24.9	2.40	2.08
C L/JD2							
A1	0–12	Kaolinite (Ch, G)	41.5	4.5	31.7	2.22	2.04
B2.1t	12–28	nd	38.8	7.4	26.8	2.46	2.09
B2.2t	28–78	nd	41.9	7.5	36.8	1.99	1.75
B2.3t	78–148	nd	39.6	5.8	31.6	1.86	1.67
B2.4tgr	148–160	nd	36.5	5.1	34.8	1.78	1.63
B2.5tgr	160–162	nd	33.7	5.4	39.2	1.46	1.34
B2.6tpl	162+	Kaolinite (G)	40.3	4.5	27.1	2.53	2.28
SOUTH SUMATRA							
B SS/JD12							
A1.1	0–10	Kaolinite (Ch, G, Q, C)	38.5	8.2	32.5	1.59	1.37
IIA1.2	10–13	Kaolinite (Ch, G, Q, C)	22.4	6.0	15.0	2.54	2.02
IIA1.3	13–38	Kaolinite (Ch, G, Q, C)	31.3	9.5	19.9	2.68	2.14
IIA2	38–85	Kaolinite (Ch, G, Q)	49.0	10.4	33.7	2.47	2.06
IIB2.1t	85–104	Kaolinite (Ch, G)	38.4	9.6	35.3	1.85	1.62
IIB2.2t (g)	104+	Kaolinite (Ch, G)	38.9	10.4	32.5	2.04	1.69
C SS/JD1							
A1	0–13	Kaolinite (Ch, G, C)	42.3	7.4	40.3	1.78	1.60
B1	13–32	Kaolinite (Ch, G, C)	41.7	6.7	37.2	1.91	1.71
B2.1t	32–52	Kaolinite (Ch, G, C)	37.7	7.5	37.1	1.73	1:53
B2.2t	52–100	Kaolinite (Ch, G)	43.3	7.3	39.9	1.85	1.66
B2.3tpl	100+	nd	nd	nd	nd	nd	nd

NOTE: Ch = Soil Chlorite
G = Goethite
Q = Quartz
C = Cristoballite
nd = not determined