INVESTIGATIONS ON THE CLASSIFICATION AND GENESIS OF SOILS, DERIVED FROM ACID TUFFS UNDER HUMID TROPICAL CONDITIONS [1]

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SUMMARY

Four profiles of soils developed over dacitic tuffaceous material at an altitude of 70 m above sea level under humid and hot conditions were investigated mineralogically and chemically. The soils belong to the Podzolized Latosolic and to the Red-Yellow Podzolic Soil Group, depending on the drainage conditions.

The higher clay content of the B-horizon was supposed to be realised by a breakdown of clay minerals in the upper horizons.

Attention was drawn to the possible importance of the C/N quotient in soil formation, especially to explain the different course of the clay's molar Al_2O_3/Fe_2O_3-ratios in latosolic soils and podzolic soils of the humid tropics.

INTRODUCTION

In an earlier investigation (v. SCHUYLENBORGH and v. RUMMELEN, 1955) a first attempt was made to classify soils of Indonesia, developed over liparitic, andesitic and basalto-andesitic tuffs at high altitudes (ranging from 1000 m to 2000 m above sea level) on the level of the Great Soil Groups.

It is the scope of this paper to classify soils at low altitudes (0—100 m), developed over dacitic tuffaceous material.

A considerable part of West-Java (region between the villages Serang, Rangkasbitung, Serpong and Tangerang) and of South Sumatra is covered by dacitic volcanic material (WHITE, 1925; SCHEIBENER, 1925), expelled by the now disappeared Danau-volcano of Pleistocene age in the extreme West of Java. This material is, at least partly, deposited in the sea and mixed to some extent with tertiary sediments. This peculiarity has therefore to be taken into account in the genetic considerations.

METHODS

The discussion of results is based on 1) the pH-values; 2) the mechanical composition; 3) the organic matter content; 4) the mineralogical composition of the sand and clay fractions; 5) the chemical composition of the clay fraction of all horizons of the morphologically described profiles; 6) the composition of the forest litter, covering the profiles and on 7) the C/N-values of some profiles.

The methods used in the determination of the pH-values, mechanical composition, org. matter and the mineralogical composition are entirely the same as reported by VAN SCHUYLENBORGH and VAN RUMMELEN (1955). As to the mechanical analysis it should be pointed out that all samples could be peptised with a 0.0006 molar solution of sodium pyrophosphate.

The analysis of the chemical composition of the clay was carried out as described by BILTZ and BILTZ (1947, p. 380 et seq.), using the sodium car-

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boonate fusion. The litter samples were ashed at 450° C in an electric furnace. In the solutions obtained after fusion and after ashing, iron was determined by titration with versenate solution (KUANG LU CHENG, R. H. BRAY and T. KURTZ, 1953) with sulphosalicylic acid as the indicator. Phosphorus, titanium and magnesium were determined spectrophotometrically, using the methods of SCHEEL (1936), of WEISLER (1945) and of YOUNG and GILL (1951), respectively.

Calcium was estimated by titration of the acid solution of calciumoxalate obtained by precipitation in weakly acid medium according to CHAPMAN (1928). Potassium and sodium were determined with the flame-photometer. The spectrophotometer and flame-photometer used, were the HILGER UVISPEK and LANGE-photometer respectively. The N-content of the soil was determined by the Kjeldahl method (see PIPER, 1947).

CLIMATE, TOPOGRAPHY AND DESCRIPTION OF THE PROFILES

The climate is hot and humid. The mean annual temperature ranges from 27—30° C and the rain fall is high, viz. about 3000 mm a year. The distribution of the rainfall at some meteorological stations is given in table 1.

Table 1 Monthly distribution of rainfall in the investigated region.

Station	Jan.	Febr.	March	April	Mai	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Yanlappa . . .	177	501	220	215	320	183	275	262	236	398	194	209	3190
Rangkasbitung	282	246	214	216	215	156	123	128	140	207	212	240	2379
Djasinga . . .	310	315	306	391	297	225	191	212	229	280	307	285	3348
Serpong . . .	256	267	274	255	203	130	98	104	99	200	222	269	2377

The topography is gently rolling. The permeability of the soil ranges from rather good on the top of the low hills to rather poor and poor in the valleys. This leads to the formation of red soils on the top of the hills and yellow soils in the valleys (see also: profile description).

Because cultivation was started a hundred years ago, severe erosion can be noticed at several places. It was therefore necessary to seek a part with a more or less natural vegetation. A fortunate circumstance was, that at *Yanlappa* (dessa Hadjere) a primary lowland tropical rainforest had been maintained, where it was possible to investigate the genesis and nature of the soils. The altitude was 70 m above sea level.

Several pits were dug and four profiles, one on the top of a low hill, one halfway the slope, and two in the valley, were sampled. The description is as follows.

I. Profile on the top of a low hill (samples Nrs. 404—410). Vegetation: dense tropical lowland rainforest. Drainage: rather good.

A_1 0—4 cm. Yellowish brown to dark brown (10YR5/4—10YR3/4 [2]) clay loam. Moderate fine subangular blocky to crumb structure.

B_1 4—25 cm. Reddish yellow to strong brown (7.5YR7/6—7.5YR5/6) clay. Moderate fine subangular blocky to crumb structure; clay coatings present.

[2]) The Munsell colour notation refers to the air-dry and field-wet soil respectively.

B_{21}	25—50 cm.	Reddish brown to yellowish red (5YR5/4—5YR4/6) clay. Weak fine subangular blocky to crumb structure. Clay and iron coatings present. Somewhat mottled.
B_{22}	50—90 cm.	Yellowish red (5YR5/6—5YR4/8) clay. Weak fine subangular blocky structure. Clay and iron coatings present. Somewhat mottled.
B_3	90—110 cm.	Yellowish red (5YR5/6) clay. Massive structure. Somewhat mottled.
B_3g	110—120 cm.	Reddish yellow to yellowish red (5YR6/6—5YR5/6) clay. Massive. Mottled. Black manganese-iron concretions occur.
C	+120 cm.	Pinkish grey (5YR7/2—5YR6/2) silty clay with reddish yellow (5YR7/6) spots. Massive.

The profile is well rooted to a depth of 100 cm. Conditions of alternating oxidation and reduction occur below 110 cm depth.

II. Profile half way the slope of low hill (sample Nrs. 353—358). Slope about 15%. Vegetation is the same as over profile I. Drainage poorer than in profile I.

A_1/A_2	0—10 cm.	Very pale brown to yellowish brown (10YR7/4—10YR5/6) silty clay loam. Moderate fine subangular blocky structure.
B_1	10—40 cm.	Reddish yellow to strong brown (7.5YR7/6—7.5YR5/6) clay. Moderate fine subangular blocky structure. Iron coatings occur.
B_{21}	40—58 cm.	Reddish yellow to strong brown (7.5YR7/6—7.5YR5/6) clay. Moderate medium subangular blocky structure. Iron coatings present.
B_{22}	58—80 cm.	Reddish yellow to yellowish red (5YR7/6—5YR5/8) clay. Moderate medium subangular blocky structure. Iron coatings to be noticed.
B_{23}	80—110 cm.	Reddish yellow to strong brown (5YR6/6—7.5YR5/8) clay. Massive structure.
C	+110 cm.	Pink to light grey (10YR6/2—10YR7/2) clay with yellowish red (5YR5/8) spots.

The profile rather well rooted to a depth of 90 cm.

III. Profile nearly in the valley (sample Nrs. 359—363). Vegetation: open tropical lowland rainforest. Drainage conditions are rather poor.

A_2	0—10 cm.	Very pale brown to yellowish brown (10YR7/4—10YR5/4) clay. Moderate fine subangular blocky structure.
B_1	10—25 cm.	Very pale brown to yellowish brown (10YR8/4—10YR5/6) clay. Moderate fine subangular blocky structure. Iron coatings occur.
B_2	25—65 cm.	Pinkish reddish yellow to strong brown (7.5YR7/4à7/6—7.5YR5/6) clay. Moderate medium subangular blocky structure. Iron coatings.
B_2g	65—115 cm.	Light yellowish brown to strong brown (7.5YR6/4à6/6—7.5YR5/8) clay loam. Massive structure. Dark brown manganese-iron concretions and gleying occur.
C	+115 cm.	Pink to light grey (7.5YR8/4—10YR7/2) clay with strong brown (7.5YR5/6) spots. Massive structure.

The roots penetrate to a depth of 60 cm.

IV. Profile in the valley (sample Nrs. 411—415). Vegetation: open tropical lowland rain forest. Drainage conditions are poor.

A_2	0—10 cm.	Very pale brown to pale brown (10YR7/4—10YR6/3) silty clay loam. Moderate fine subangular blocky structure.
B_1	10—24 cm.	Yellow to very pale brown (10YR8/6—10YR7/4) clay. Moderate fine subangular blocky structure. Iron coatings occur.
B_2	24—43 cm.	Very paly brown to light yellowish brown (10YR7/4à6/4—10YR6/4) clay. Moderate medium subangular blocky structure. Soft iron concretions (2.5YR4/8) occur.

B_{2g}	43–72	cm.	Very pale brown (10YR7/4–10YR7/3) silty clay. Massive structure. Gleying phenomena occur.
C	+72	cm.	Very pale brown to light grey (10YR7/3–10YR7/2) silty clay. Massive structure.

The groundwater level was found at a depth of 1–1.40 m. After rains the level is 50 cm. The roots penetrate to a depth of only 40 cm.

All profiles are covered by a layer of litter of only one leaf thickness, indicating a rapid decomposition of the leaves, probably completely into carbon dioxide and water. There is no intermingling of the organic matter with the soil, so that the organic matter in the soil is derived from the roots.

Results and classification

The analytical data of profile I are summarized in tables 2 and 3.

Table 2 Mean mineralogical composition of the sand fraction.

Horizon	Chief minerals in the total [1]) sand fraction									Composition of the heavy sand fraction									
											Content of non-opaque minerals (as percentages of total content non-opaque minerals)								
	quartz turbid	quartz clear	quartz sandstone	oligoclase	acid volcanic glass	sanidine	nontronite	iron concretions	miscellaneous	opaque	hypersthene	augite	zircon	rutile	anatase	green amphibole	brookite	olivine	diaspore
A_1	27	35	12	tr	1	2	1	12	10	77	68	6	13	2	6	1	1	–	2
B_1	24	36	13	tr	1	tr	–	11	13	91	44	7	33	6	10	–	tr	–	tr
B_{21}	27	37	12	2	1	2	tr	10	7	91	44	2	44	4	4	–	1	1	–
B_{22}	25	31	16	2	1	1	tr	7	16	91	24	1	47	8	20	–	tr	–	tr
B_3	25	19	11	1	tr	tr	1	15	28	91	12	3	50	8	24	–	–	–	3
B_{3g}	16	11	6	1	tr	1	4	16	44	94	11	2	64	6	15	–	1	–	–
C	26	10	16	tr	tr	1	3	17	27	98	10	3	54	4	23	–	1	–	4

[1]) For details see table 14 at the end of this paper.

The table shows that the parent material is a mixture of dacitic tuff and tertiary sand, thus highly acidic. The composition of the total sand is very uniform. In the heavy sand fraction an enrichment of hypersthene in the upper horizons can be noticed and of zircon and anatase in the lower horizons, possibly a consequence of the different sedimentation velocity. Hypersthene is present as prismatic and euhedral individuals, showing traces of iron oxide coatings. Augite has a very irregular shape with a marked ragged structure, suggesting a rather heavily weathered profile (see also: v. Baren and Kiel, 1950).

In spite of the differences in the composition of the heavy mineral fraction, the profile seems to be autochtonous enough to base a genetic examination on it.

Table 3 Physical and chemical composition.

Horizon	Mechanical composition			pH [1]	Organic matter % C	Composition of the clay fraction			
	$> 50\,\mu$ %	$50\text{–}2\,\mu$ %	$< 2\,\mu$ %			SiO_2/R_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3	Al_2O_3/Fe_2O_3
A_1	29.5	29.8	31.5	6.42–6.12	5.26	1.73	2.07	10.5	5.08
B_1	18.4	24.0	52.8	4.96–4.68	1.76	1.82	2.19	10.9	4.96
B_{21}	16.0	22.6	59.3	5.30–4.91	1.39	1.91	2.30	11.2	4.86
B_{22}	13.0	23.2	62.0	5.38–4.97	1.13	2.03	2.49	11.2	4.52
B_3	13.6	26.7	56.3	5.39–5.24	1.01	1.94	2.27	13.2	5.86
B_{3g}	17.4	33.3	45.2	5.56–5.11	0.85	1.85	2.15	13.0	6.10
C	6.2	42.6	48.7	5.68–5.09	0.59	2.12	2.40	18.1	7.53

[1] The first pH-value refers to that of the clear supernatant liquid after centrifugation of a suspension of 10 g of soil in 25 cc water. The second refers to the pH-value of the suspension. The first value must theoretically approach the true pH in the soil.

The most important conclusions from table 3 are: a) a marked increase of the clay content in the B_2-horizon, indicating a podzolization process; b) an increase in the molar SiO_2/R_2O_3, SiO_2/Al_2O_3 and SiO_2/Fe_2O_3 ratios, indicating a laterization process.

Combining these findings with the profile morphology (fine subangular blocky to crumb structure of the upper horizons), it is permissible to classify this soil as Podzolized Reddish-Brown Latosolic soil. Already DAMES (1955) used this name for soils derived from sandy limestones, sandstones and sandy clays of Neogene age and occurring from sea level up to 250 m altitude. He considers his profiles as equivalents of the Red-Yellow Podsolic soils.

A remarkable result is the decreasing molar Al_2O_3/Fe_2O_3 ratio in the A_1, B_1 and B_2 horizons, whereas this ratio decreases in all podzolic soils so far examined by the author in the humid tropics. This will be discussed later on.

Table 4 Mean mineralogical composition of the sand fraction.

Horizon	Chief minerals in the total [1] sand fraction								Composition of the heavy sand fraction												
										Content of non-opaque minerals (as percentages of the total content non-opaque minerals)											
	quartz turbid	quartz clear	quartz sandtone	oligoclase	andesine	volcanic glass	iron concretions	miscellaneous	opaque	hypersthene	augite	zircon	tourmaline	rutile	anatase	brookite	epidote	green amphibole	glaucophane	corundum	diaspore
A_1/A_2	12	47	14	tr	tr	6	9	11	73	74	7	4	—	8	6	—	—	tr	—	1	—
B_1	10	50	14	1	1	2	13	7	87	54	7	16	—	4	13	—	2	3	—	—	tr
B_{21}	13	46	17	tr	1	tr	9	12	82	48	6	17	tr	12	13	tr	—	tr	—	—	1
B_{22}	10	46	17	tr	tr	tr	15	14	90	39	6	16	2	7	18	1	—	4	—	—	4
B_{23}	4	35	18	—	tr	—	27	13	95	9	—	28	4	10	43	1	3	1	—	—	1
C	2	27	10	tr	tr	—	40	17	89	5	3	17	6	7	51	2	—	1	1	1	4

[1] For a detailed analysis see table 15 at the end of this paper.

The mineralogical analysis of the clay fraction indicates that in all horizons a montmorillonitic clay mineral, probably nontronite, is predominant followed by kaolinite, quartz and gibbsite in decreasing order.

Profile II shows the following analytical results (tables 4 and 5).

The parent material is the same as in profile I. An enrichment of hypersthene in the upper horizons and an increase, however less pronounced than in profile I, of zircon with depth can be noticed. The composition of the total sand fraction as well as that of the heavy mineral fraction indicates that the deeper horizons are different from the upper horizons. Genetic considerations therefore have to be restricted to the four upper horizons. Hypersthene occur mainly as prismatic grains, in the lower horizons more or less polluted by iron oxide. Augite is in the two upper horizons heavily corroded and has a very irregular and ragged appearance. In the B_2-horizons grains with a non-corroded appearance were encountered, whereas in the two lowest horizons almost uncorroded forms were found.

Table 5 Physical and chemical composition.

Horizon	Mechanical composition			pH [1]	Organic matter % C	Composition of the clay fraction			
	$> 50\ \mu$ %	$50–2\ \mu$ %	$< 2\ \mu$ %			SiO_2/R_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3	Al_2O_3/Fe_2O_3
A_1/A_2	15.0	43.4	36.8	5.56–5.39	1.48	1.88	2.23	11.8	5.28
B_1	11.1	39.1	47.5	5.34–4.24	0.98	1.82	2.17	11.5	5.32
B_{21}	9.53	33.8	55.2	5.09–4.32	0.80	1.80	2.14	11.4	5.33
B_{22}	8.20	29.8	60.5	5.91–4.61	0.77	1.81	2.11	13.4	5.37
C	8.12	27.7	63.9	5.76–4.56	0.51	1.96	2.21	16.9	7.61
B_{23}	18.3	33.5	48.0	5.48–4.79	0.24	1.92	2.14	19.0	8.90

[1]) See note table 3.

The increase of the clay content as well as the decrease of the molar silicic acid-sesquioxide ratios indicates a podzolization process. These data, combined with the profile characteristics, permit the conclusion that this profile belongs to Red-Yellow Podzolic Great Soil Group.

As in all podzolised soils in the humid tropics, examined by the author so far, the Al_2O_3/Fe_2O_3 ratio increases with depth.

The predominant clay mineral in all horizons is montmorillonitic, probably nontronite, followed by kaolinite and quartz in decreasing order.

The results of the analysis of profile III are given in tables 6 and 7.

The oligoclase content is higher than in the profiles I and II. The three upper horizons have a very uniform composition, whereas the two lowest horizons deviate strongly. A genitic discussion therefore has to be restricted to the three upper horizons. Oligoclase is more or less corroded, whereas andesine is so heavily weathered, that one can speak of a "mineral-skeleton". Hypersthene occurs mainly as idiomorphous crystals with ironoxide coatings in the lower horizons. Augite is strongly ragged in the two upper horizons whereas in the B_2 horizon corroded and uncorroded individuals are found in nearly equal quantities.

Remnants of the prismatic habitus however can be recognized, this in deviation from the profiles I and II.

Table 6 Mean mineralogical composition of the sand fraction.

Horizon	Chief minerals in the total[1] sand fraction								Composition of the heavy sand fraction													
										Content of non-opaque minerals (as percentages of the total content non-opaque minerals)												
	quartz turbid	quartz clear	rock fragments[2]	oligoclase	andesine	acid volcanic glass	iron concretions	miscellaneous	opaque	hypersthene	augite	zircon	tourmaline	granate	rutile	anatase	brookite	chloritoid	epidote	green amphibole	diaspore
A_2	33	19	11	9	3	3	8	10	85	63	14	16	1	1	2	—	2	—	—	1	—
B_1	30	16	12	16	1	1	12	9	71	71	14	5	—	—	1	—	6	1	1	1	—
B_2	23	19	13	10	1	1	16	13	90	61	15	15	—	—	3	—	3	—	1	2	sp
$B_{2}g$	4	13	6	7	tr	tr	17	52	92	16	6	55	tr	1	9	1	11	—	—	1	—
C	5	12	8	3	1	1	14	54	93	30	12	26	—	—	11	—	19	—	—	2	—

1) For a detailed analysis see table 16 at the end of this paper.
2) Mainly quartz-sandstone.

Table 7 Physical and chemical composition.

Horizon	Mechanical composition			pH[1]	Organic matter % C	Composition of the clay fraction			
	> 50 μ %	50—2 μ %	< 2 μ %			SiO_2/R_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3	Al_2O_3/Fe_2O_3
A_2	25.4	30.6	41.4	5.52—4.24	1.37	2.04	2.43	12.6	5.17
B_1	24.9	29.9	44.2	5.59—4.07	0.89	1.95	2.31	12.5	5.42
B_2	15.2	25.7	63.6	5.80—4.33	0.58	1.89	2.22	12.8	5.75
$B_{2}g$	32.1	25.2	35.9	6.04—5.02	0.18	2.03	2.37	13.9	5.84
C	3.7	37.4	61.0	5.54—5.22	0.09	2.41	2.71	21.6	8.00

1) See note table 3.

The increase of the clay content and the decrease of the molar SiO_2 sesquioxide ratios with depth again indicate a podzolic soil formation. Combining these data with the profile characteristics, the soil can be defined as a Yellow Podzolic Soil.

Here too, in all horizons nontronite is the predominant clay mineral followed by quartz and kaolinite in decreasing order.

Finally, the results of the analysis of profile IV are reported in tables 8 and 9.

The mineralogical composition and the shape of the minerals have a close resemblance to those of profile III. The four upper horizons have a very uniform composition.

From the profile description and these data it can be concluded, that this profile belongs to the Yellow Podzolic Soil groups too, just as profile III.

Table 8 Mean mineralogical composition of the sand fraction.

Horizon	Chief minerals of total[1]) sand fraction								Composition of the heavy clay fraction									
										Content of non-opaque minerals (as percentages of total content of non-opaque minerals)								
	quartz turbid	quartz clear	quartz sandstone	oligoclase	andesine	acid volcanic glass	iron concretions	miscellaneous	opaque	hypersthene	augite	zircon	rutile	anatase	green amphibole	corundum	diaspore	brookite
A_2	26	12	12	10	3	4	12	16	85	73	10	8	1	6	1	tr	tr	1
B_1	30	15	13	10	2	2	7	15	81	71	11	8	1	8	—	1	—	—
B_2	21	14	12	8	3	3	8	30	84	82	4	7	1	4	1	1	—	—
B_2g	14	7	12	8	2	2	10	45	85	73	7	9	1	7	—	3	—	—
C	16	6	22	2	tr	tr	10	42	79	22	7	11	10	48	1	—	1	—

[1]) For details see table 17 at the end of this paper.

Table 9 Physical and chemical composition.

Horizon	Mechanical composition			pH[1])	Organic matter % C	Composition of the clay fraction			
	> 50 μ %	50–2 μ %	< 2 μ %			SiO_2/R_2O_3	SiO_2/Al_2O_3	SiO_2/Fe_2O_3	Al_2O_3/Fe_2O_3
A_2	14.2	45.9	37.6	4.88–4.83	1.28	2.34	2.81	14.1	5.00
B_1	11.0	39.8	47.2	4.84–5.00	0.87	2.27	2.72	15.3	5.64
B_2	2.2	35.4	60.8	5.18–5.12	0.46	2.27	2.66	16.1	6.04
B_2g	1.3	39.7	57.8	4.92–5.08	0.40	2.48	2.89	17.6	6.13
C	2.9	47.6	53.2	5.14–5.35	0.15	2.54	3.04	15.6	5.00

[1]) See note table 3.

The predominant clay mineral in all horizons is nontronite, followed by kaolinite, quartz and gibbsite in decreasing order.

Summarizing the results, we can conclude that the region investigated can be characterized by the catena: Podzolised Reddish-Brown Latosolic Soils on the tops of the low hills, Red-Yellow Podzolic Soils on the slopes and Yellow-Podzolic Soils in the valleys. Furthermore, it seems reasonable to conclude that the soils, developed over acid parent material, under humid and hot climatic conditions and conditions of free drainage, belong normally to the Podzolized Latosolic soils. When the drainage is impeded, Red-Yellow Podzolic soils are formed. This conclusion is supported by the occurrence of Red-Yellow Podzolic soils in East-Borneo [3]) (not reported here) developed over acid parent material at an altitude of about 30 m.

[3]) Profile descriptions will be sent by the author upon application.

In a later paper it will be shown, that, on andesitic parent material red latosolic soils will be formed under the same climatic conditions, whereas the podzolized latosolic soils occur at greater altitudes.

On the genesis of the soils described

Considering the clay content of the horizons, it appears that the A_1/A_2-horizons are only 4—10 cm thick with a clay content of 31—41 %, whereas the B-horizons have a thickness of 60 to 100 cm with a clay content varying from 60 % to 65 %. It is therefore unlikely, that the amounts of clay in the B-horizons are illuviated from the A-horizon. This was already stated by Simonson (1950) for red-yellow podzolic soils in U.S.A. Pearson and Ensminger (1949) stated that the kaolinite content in the clay fractions of Alabama (Red-yellow Podzolic-) soils increased with depth, associated with a decreasing proportion of quartz, while the decreases in the amounts of quartz are smaller than the increases in amounts of kaolinite. Simonson (1950) postulated from these statements and his own observations, that kaolinite is formed in the C-horizon with subsequent breakdown in the A and B horizons. The increase in clay content could then be explained by assuming that the hydrolysis of the clay proceeds very rapidly in the A-horizon and less rapidly in the B-horizon.

Although the present author could not establish an increase in the montmorillonite or kaolinite content of the clay with depth, he agrees with Simonson, especially in the former's case and for the following reasons: 1. The arrangement and thickness of the A and B horizons do not agree with a mere mechanical illuviation of clay; 2. The SiO_2-content of the clay fraction of the profiles in the valley is higher than that of the profiles on the top of the low hills (see table 10). This can be explained by a lateral downward movement of silicic acid, formed by the hydrolysis of the clay minerals in the upper profiles. However, the impeded drainage of the lower profiles can also contribute to this phenomenon; 3. The augite grains have in the upper horizons the most ragged appearance, whereas this decreases in the lower horizons, where uncorroded individuals occur.

Table 10 SiO_2-percentage of the clay fraction of the profiles examined.

Profile	A-hor.	B-hor.	C-hor.
I	40.1	42.6	46.8
II	44.2	43.8	45.4
III	45.4	44.9	48.9
IV	46.1	47.7	48.9

The author proposes therefore the following hypothesis for the genesis of the soils of the investigated region. In the Pleistocene era dacitic material was ejected by the Danau-volcano, deposited in the sea and mixed to some extent with sand from tertiary formations. The conditions of weathering therefore will be uniform over a considerable depth of the sediment, leading to a uniform distribution of clay and to the formation of a montmorillonitic clay mineral. (It would be highly improbable that from this acid parent material montmorillonite would be formed under conditions of free drainage). After the gradual regression of the sea, soil forming processes started, introducing conditions, entirely different from the circumstances under which the clay had been synthesized. This leads to the breaking down of the clay minerals, originally formed, and the process will be most intensive in the upper horizons and less intensive in the deeper horizons.

This hypothesis does not rule out some mechanical illuviation, but the main process during soil formation will be the one mentioned above.

A rather intriguing fact is the different mobility of iron and aluminium, indicated by the molar ratio Al_2O_3/Fe_2O_3. All latosolic soils, examined so far (a number of 4), show a decreasing ratio, whereas in the podzolic soils of the humid tropics (15 profiles analysed) show an increase of this ratio with depth. Some results are summarized in table 11.

Table 11 Molar Al_2O_3/Fe_2O_3 ratio of the horizons of some tropical soils.

Podzolized Latosolic soil		Brown Latosolic soil [1]		Red-Yellow Podzolic soil		Tropical Gray- [2] Brown Podzolic soil	
Hor.	Al_2O_3/Fe_2O_3	Hor.	Al_2O_3/Fe_2O_3	Hor.	Al_2O_3/Fe_2O_3	Hor.	Al_2O_3/Fe_2O_3
A_1	5.08	A_{11}	5.50	A_1A_2	5.28	A_1	4.75
B_1	4.96	A_{12}	5.17	B_1	5.32	A_2	5.85
B_2	4.69	A_{13}	5.13	B_2	6.10	B_1	7.47
B_3	5.98	AC	5.09	C	8.90	B_2	8.26
C	7.53	C	5.39			C	11.50

1) To be published.
2) v. SCHUYLENBORGH and v. RUMMELEN (1955).

The author does not know yet, whether this reverse relationship in the soils of the humid tropics of Indonesia is generally true or not. So far, he did not obtain exceptions. It is therefore perhaps of value to look for an explanation or for correlations with soils of other climates.

There was a possibility that the composition of the leaf litter could throw some light on this matter, especially when an appreciable amount of Al_2O_3 would be present in the litter over profile I. The analysis of the leaf litter of profiles I and II is given in table 12.

Table 12 Composition of the leaf litter, expressed in percentages of absolute dry matter.

Litter of	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	P_2O_5
Profile I	8.02	0.33	0.14	2.03	1.50	0.31	0.05	0.15
Profile IV	9.48	0.27	0.15	2.15	1.58	0.47	0.06	0.13

The author does not believe that the somewhat higher Al_2O_3-content of the litter of profile I contributes to the higher Al_2O_3/Fe_2O_3-ratios in the upper horizons. It can only be recognized that the higher SiO_2-content of the litter of profile IV may contribute to a higher SiO_2-content of the profile.

Therefore it is necessary to draw the attention to another fact. In the previous paper, already mentioned (v. SCHUYLENBORGH and v. RUMMELEN, 1955), the possible importance of the C/N-ratio in soil formation was suggested. It was supposed that the constant C/N ratio in the soil profile might signify, that there is no humification of organic matter but rather a complete decomposition into carbon dioxide and water (see also: JOFFE, 1949, p. 177). The solubility of the decomposition products (Al_2O_3 and Fe_2O_3) of the primary minerals in water would then be a measure for the mobility. Because the solubility of aluminiumhydroxide is larger than that of ferric hydroxide, a reasonable explanation was obtained for the greater mobility of aluminium compared with that of iron in podzolic soils of the humid tropics. In temperate climates however, the C/N ratio decreases with depth. This might imply a humification or formation of organic acids and then the complex-forming capacity of these acids comes into play. The complex iron compounds are more soluble than the complex aluminium ones, with the consequence that then iron is more mobile than aluminium.

Now, if the C/N-ratio in the latosolic soils decreases with depth, a correlation would be obtained with the podzolic soils of the temperate climate zone. This appeared to be true as will be shown in table 13.

Table 13 C/N- and molar Al_2O_3/Fe_2O_3-ratios of some latosolic and podzolic soils.

Greenville sandy loam (latosolic soil) 1)		Podzolized Latosolic soil (Prof. I)			Yellow Podzolic soil (Prof. IV)			Tropical Grey-Brown Podzolic soil			Sassafras Series (Grey-Brown Podzolic) 1)		Miami silt loam (Grey-Brown Podzolic) 2)	
Hor.	C/N	Hor.	C/N	Al_2O_3/Fe_2O_3	Hor.	C/N	Al_2O_3/Fe_2O_3	Hor.	C/N	Al_2O_3/Fe_2O_3	Hor.	C/N	Hor.	Al_2O_3/Fe_2O_3
0–10″	15.2	A_1	13.9	5.08	A_2	9.7	5.00	A_1	21.2	4.75	A	11.8	A_1	4.68
10–15″	11.1	B_1	12.4	4.96	B_1	10.0	5.64	A_2	20.3	5.85	B	8.0	A_2	4.55
15–36″	7.4	B_{21}	10.6	4.86	B_2	9.5	6.04	B_1	21.6	7.47	C	6.1	B	3.19
		B_{22}	9.2	4.52	$B_{2}g$	9.1	6.13						C	3.38
		B_3	13.4	5.86	C	5.0	5.00							
		$B_{3}g$	13.0	6.10										

1) ANDERSON and BEYERS, 1934.
2) BEYERS, ALEXANDER and HOLMES, 1955.

It is possible to conclude, that, in the humid tropical region, the C/N quotient of the solum of podzolic soils is practically constant, while the molar Al_2O_3/Fe_2O_3-ratio of the clay fraction increases with depth. In latosolic soils the C/N quotient and the clay's Al_2O_3/Fe_2O_3-ratio decreases with depth, just as in podzolic soils of the temperate climatic zone.

Why the C/N value decreases with depth in latosolic soils and remains constant in the podzolic soils of the humid tropics is a matter of investigation in the department of the present author.

Considering the clay minerals of the soils it should be pointed out, that the predominant clay mineral is a montmorillonitic one, probably nontronite. Kaolinite, quartz and gibbsite follow in the order of decreasing importance. Whether the amorphous allophane occurs, as stated to be present in volcanic soils (FIELDES and WILLIAMSON, 1955; FIELDES, 1955; KANNO and collaborators, 1955), could not be established Reviewing the literature on the clay minerals in red-yellow podzolic soils it can be stated that the following minerals have been detected: montmorillonite, (COLEMAN and JACKSON, 1945); kaolinite, quartz, hydrated aluminium oxide, iron oxides (PEARSON and ENSMINGER, 1948); dioctahedral vermiculite and regularly and randomly interstratified illite-vermiculite (RICH and OBENHAIM, 1955). Such a diversity in the type of clay minerals of Red-yellow Podzolic Soils makes it impossible to classify these soils on the base of the mineralogical composition of the clay fraction (see also: SIMONSON, 1950).

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On request of the Experimental Station of the Forest Department, the Soil Research Institute at Bogor undertook the reconnaissance and soil survey of the forested area of Yanlappa. The survey group recognized the main soils of the area to belong to the Red-Yellow Podsolic group and established catenary relations between the different soil series and drainage conditions. Four profiles of this catena have been further analysed by us and are dealt with in this paper.

As it mainly stresses analytical research it does not affect the original results of the field party which are prepared for publication by the Soil Research Institute.

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Table 14 Mineral composition of the sand fraction of profile I.

Horizon	Fraction in μ	quartz turbid	quartz clear	quartz sandstone	oligoclase	andesine	volcanic glass	sanidine	nontronite	hypersthene	augite	zircon	magnetite	organogenous silicic acid	gibbsite	iron concretions	rock fragments	miscellaneous
A_1	500–250	30	46	7	1	tr	—	3	—	—	—	—	—	—	—	6	—	7
	250–105	22	37	16	tr	tr	tr	2	1	tr	—	—	tr	—	—	14	—	8
	105– 53	35	11	13	tr	—	2	tr	1	1	—	tr	2	1	—	19	—	15
	53– 50	24	7	16	—	1	7	1	1	tr	1	tr	2	3	1	21	—	15
B_1	500–250	20	58	7	—	—	—	1	—	tr	—	—	—	—	—	6	—	8
	250–105	24	31	16	tr	—	1	tr	—	2	1	—	tr	—	—	11	1	13
	105– 53	29	13	15	—	—	2	tr	—	1	—	tr	2	—	tr	16	1	20
	53– 50	30	9	12	—	tr	5	tr	—	tr	tr	tr	1	3	1	22	1	16
B_{21}	500–250	18	60	4	2	—	2	tr	—	—	—	—	—	—	—	11	—	3
	250–105	32	33	14	2	—	1	2	1	tr	—	—	1	—	1	8	—	5
	105– 53	29	6	22	1	—	1	2	tr	3	tr	tr	2	1	—	11	1	19
	53– 50	27	5	12	1	—	3	2	tr	1	1	tr	1	tr	tr	20	—	27
B_{22}	500–250	25	48	8	1	—	1	2	—	—	—	—	—	—	—	10	1	5
	250–105	23	27	20	2	—	tr	1	tr	—	—	—	1	—	—	5	tr	21
	105– 53	28	16	20	1	—	1	tr	1	tr	—	tr	5	—	—	10	1	18
	53– 50	29	9	17	—	tr	1	tr	3	—	tr	—	2	tr	tr	8	1	31
B_3	500–250	24	35	7	1	—	tr	tr	—	—	—	—	tr	—	—	15	—	18
	250–105	31	13	13	1	—	tr	tr	2	—	—	—	—	—	—	15	—	25
	105– 53	16	6	13	1	—	2	tr	2	—	—	tr	2	—	—	15	—	43
	53– 50	11	2	7	—	—	—	tr	1	—	—	—	—	1	—	12	—	66
B_3g	500–250	26	14	6	2	—	—	2	tr	—	—	—	—	—	—	20	—	30
	250–105	16	12	6	1	—	tr	—	5	—	—	—	tr	—	—	16	—	40
	105– 53	9	2	7	—	—	tr	—	3	—	—	tr	3	—	—	10	—	66
	53– 50	4	2	4	—	—	tr	—	6	—	—	—	—	—	—	15	—	68
C	500–250	38	23	10	—	—	—	1	tr	—	—	—	—	—	—	8	—	20
	250–105	29	8	19	1	—	—	1	2	—	—	—	—	—	—	15	—	25
	105– 53	15	6	13	tr	—	—	1	6	—	—	—	tr	—	—	27	—	35
	53– 50	9	—	16	—	—	—	—	3	—	—	1	—	—	tr	24	—	43

For description of hypersthene, augite, andesine and oligoclase, see text. The volcanic glass grains are colourless and possess vescicless, in most cases filled with a yellow to brown substance. Some grains show no vescicless and are yellow, indicating a less acid composition. The iron concretions are amorphous and very dark brown, mostly very irregularly shaped. Rock fragments consist of glassy grains with many occlusions, mostly of magnetite and hypersthene. Miscellaneous: not to be indentified weathering products, with yellow to brown colour; occlusions occur. The grains are rounded and isotrop.

Table 15 Mineral composition of the sand fraction of profile II.

Horizon	Fraction in μ	quartz turbid	quartz clear	quartz sandstone	oligoclase	andesine	volcanic glass	sanidine	nontronite	hypersthene	augite	zircon	biotite	muscovite	magnetite	organ-ogenous silicic acid	gibbsite	iron concretions	rock fragments	miscella-neous
A_1/A_2	500–250	13	11	tr	2	5	16	tr	—	tr	—	—	—	—	1	—	—	37	5	10
	250–105	20	13	19	—	1	3	1	1	1	tr	—	—	—	1	tr	—	25	3	12
	105– 53	56	11	14	—	tr	5	—	tr	tr	tr	tr	tr	tr	tr	tr	—	4	—	10
	53– 50	54	12	16	—	tr	6	—	tr	1	tr	—	—	—	1	1	—	1	—	8
B_1	500–250	15	22	3	2	—	—	tr	—	—	—	—	—	—	2	—	—	49	2	5
	250–105	30	14	10	—	tr	3	tr	—	1	tr	—	—	—	1	—	—	33	1	7
	105– 53	57	9	17	1	1	3	tr	—	tr	—	—	tr	tr	1	—	—	6	—	5
	53– 50	56	9	11	tr	tr	1	2	—	tr	tr	tr	tr	—	1	2	—	10	1	7
B_{21}	500–250	20	20	3	2	1	tr	—	—	—	—	—	—	—	—	—	tr	44	—	10
	250–105	31	10	24	—	1	2	—	tr	tr	—	—	tr	1	tr	—	—	22	1	8
	105– 53	47	14	17	tr	1	tr	—	—	tr	—	—	tr	—	1	—	1	5	—	14
	53– 50	59	10	17	—	—	1	—	tr	1	—	—	—	—	—	1	tr	5	—	6
B_{22}	500–250	10	21	4	3	3	—	tr	—	—	—	—	—	—	—	tr	—	50	—	9
	250–105	28	13	18	tr	tr	1	—	tr	—	—	—	tr	tr	tr	tr	—	26	—	14
	105– 53	52	9	19	—	—	—	tr	tr	tr	—	—	—	tr	tr	tr	tr	10	—	10
	53– 50	53	5	12	—	—	1	1	1	—	—	—	tr	1	2	tr	—	9	—	15
B_{23}	500–250	3	5	2	—	tr	—	—	—	—	—	—	tr	—	—	—	—	75	1	14
	250–105	18	4	12	—	—	—	—	1	—	—	—	—	tr	—	—	—	51	1	13
	105– 53	42	5	21	—	—	—	tr	1	—	—	tr	tr	1	1	tr	tr	14	—	12
	53– 50	45	tr	20	—	—	—	—	1	—	—	tr	1	tr	—	—	tr	21	—	10
C	500–250	tr	2	—	—	—	tr	1	—	—	—	—	—	tr	—	—	—	83	—	14
	250–105	13	1	9	tr	tr	—	—	—	—	—	—	—	2	—	—	—	63	—	12
	105– 53	38	2	14	—	—	—	2	1	—	—	—	1	tr	tr	—	1	24	—	17
	53– 50	36	1	10	—	—	—	—	tr	—	—	—	1	1	—	—	tr	26	—	24

For the description of the minerals: see text and table 14. Biotite is strongly weathered with irregular boundaries and yellow to yellow-brown.

Table 16 Mineralogical composition of the sand fraction of profile III.

Horizon	Fraction in μ	quartz turbid	quartz clear	quartz sandstone	oligoclase	andesine	volcanic glass	sanidine	nontronite	hypersthene	augite	zircon	magnetite	biotite	organ-ogenous silicic acid	gibbsite	iron concretions	miscella-neous
A_2	500–250	11	46	5	14	6	1	1	—	1	tr	—	—	—	—	—	8	7
	250–105	20	32	13	8	1	3	2	—	tr	1	—	1	tr	—	—	8	11
	105– 53	28	20	13	8	3	4	1	—	1	—	—	tr	—	tr	tr	10	12
	53– 50	22	16	14	2	tr	12	1	—	tr	—	—	1	—	7	1	9	15
B_1	500–250	13	42	6	17	3	tr	tr	—	—	—	—	—	1	—	—	13	5
	250–105	11	32	13	21	tr	1	1	1	tr	—	—	1	—	—	—	10	9
	105– 53	28	14	14	8	tr	3	2	2	1	tr	—	3	—	tr	tr	15	10
	53– 50	29	16	10	2	tr	4	1	2	1	tr	tr	1	—	3	—	16	15
B_2	500–250	11	53	4	12	1	tr	tr	—	—	—	tr	—	—	—	—	13	6
	250–105	24	16	14	10	1	tr	2	1	tr	tr	—	1	tr	—	tr	18	13
	105– 53	15	10	20	8	3	4	tr	3	2	—	—	2	tr	—	1	14	18
	53– 50	24	5	20	2	—	tr	tr	2	tr	tr	tr	4	—	—	—	16	27
B_2g	500–250	17	4	4	7	1	1	tr	tr	—	—	—	—	—	—	—	16	50
	250–105	11	3	8	8	—	—	tr	1	—	—	—	tr	1	—	—	19	49
	105– 53	6	5	6	6	tr	—	tr	tr	—	—	tr	tr	tr	—	—	15	62
	53– 50	25	9	8	2	tr	1	tr	2	tr	tr	—	2	tr	1	—	12	37
C	500–250	17	10	2	2	1	2	tr	—	—	—	—	—	—	—	—	19	47
	250–105	10	6	7	4	tr	tr	1	2	—	—	—	—	—	—	tr	13	57
	105– 53	12	3	10	3	1	1	2	tr	—	—	—	—	—	—	tr	15	53
	53– 50	15	2	9	1	—	1	1	—	—	—	—	—	tr	—	tr	5	66

For the description of the minerals see text and tables 14 and 15.

Table 17 Mineralogical composition of the sand fraction of profile IV.

Horizon	Fraction in μ	quartz turbid	quartz clear	quartz sandstone	oligoclase	andesine	volcanic glass	sanidine	nontronite	hypersthene	augite	biotite	muscovite	magnetite	organogenous silicic acid	gibbsite	iron concretions	rock fragments	miscellaneous
A_2	500–250	7	29	4	17	6	3	1	—	1	tr	—	—	—	—	—	12	6	14
	250–105	19	10	10	15	4	4	1	—	1	tr	tr	—	2	—	—	13	4	17
	105– 53	39	6	18	3	2	4	tr	1	2	tr	1	—	tr	tr	—	11	tr	13
	53– 50	36	5	22	2	1	9	1	tr	tr	—	tr	tr	1	2	—	5	—	17
B_1	500–250	13	28	7	22	3	2	2	—	1	—	—	—	—	—	—	9	1	12
	250–105	16	18	11	13	2	4	2	tr	2	1	—	—	1	1	1	12	tr	16
	105– 53	45	9	16	5	tr	1	3	tr	tr	1	tr	tr	2	sp	—	3	—	15
	53– 50	42	5	17	2	1	6	—	tr	1	—	tr	tr	—	3	—	5	1	17
B_2	500–250	11	29	6	14	3	tr	tr	—	tr	—	—	—	—	—	—	14	2	21
	250–105	11	13	9	14	3	5	tr	—	1	1	—	—	1	tr	1	11	tr	30
	105– 53	32	7	17	2	1	2	1	tr	tr	—	—	tr	2	1	—	4	—	31
	53– 50	38	2	12	1	tr	1	1	tr	tr	tr	—	1	—	tr	1	7	—	46
$B_{2}g$	500–250	2	9	3	14	1	tr	1	—	—	—	—	—	—	—	—	28	—	42
	250–105	7	4	7	10	2	1	tr	—	tr	1	—	—	1	—	—	11	—	56
	105– 53	22	9	17	5	3	1	tr	tr	tr	tr	tr	tr	1	—	tr	3	tr	38
	53– 50	29	1	27	4	1	1	—	1	—	—	—	1	—	—	tr	5	1	29
C	500–250	3	1	4	4	tr	—	1	—	—	—	—	—	—	—	—	27	—	60
	250–105	9	4	16	1	tr	—	—	tr	—	—	1	1	—	—	—	11	1	56
	105– 53	23	8	32	3	—	—	1	tr	—	tr	1	tr	tr	tr	1	4	—	27
	53– 50	18	6	16	2	—	tr	1	3	tr	tr	tr	tr	—	tr	tr	13	—	41

For the description of the minerals see text and tables 14 and 15.