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Descriptions and Analytical Data of Some Volcanic Ash Soils from East New Britain, Papua New Guinea

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Introduction

Volcanic ash soils in the tropics have now recieved great interest because of their relatively high fertility and also their intensive use for agriculture, as it is the case for the south Pacific regions.

On an occasion of the third scientific survey of the south Pacific (October to December, 1983), conducted by Research Center for the South Pacific, Kagoshima University, Japan, some soil samples derived from volcanic ashes near Rabaul, East New Britain Province, Papua New Guinea, were collected and described. According to Bleeker (1983) four different types of volcanic ash soils were recognized in Papua New Guinea, namely Hydrandepts, Dystrandepts, Eutrandepts and Vitrandepts (including Durandepts) by the use of Soil Taxonomy (Soil Survey Staff, 1975). Hydrandepts are those formed on andesitic ashes deposited during Pleistocene and typically occur in the highlands with a relatively cool and wet climate. These soils were recently studied in more detail on their mineralogy by Chartres and Pain (1984). While other three andepts are found near active volcanoes in lowland areas, especially in the Northern Province and the New Britain island. They have been developed from volcanic ashes of more recent ages. Some of these soils were studied by Parfitt (1975). However, no comparative studies seem to have been conducted on volcanic ash soils in the tropics and the temperate regions with special reference to the difference in their chemical fertility. This paper is a preliminary study which aim to investigate volcanic ash soils from the viewpoint mentioned above.

Descriptions of soils

Two profiles developed from volcanic ashes at Namanula and Rakunai near

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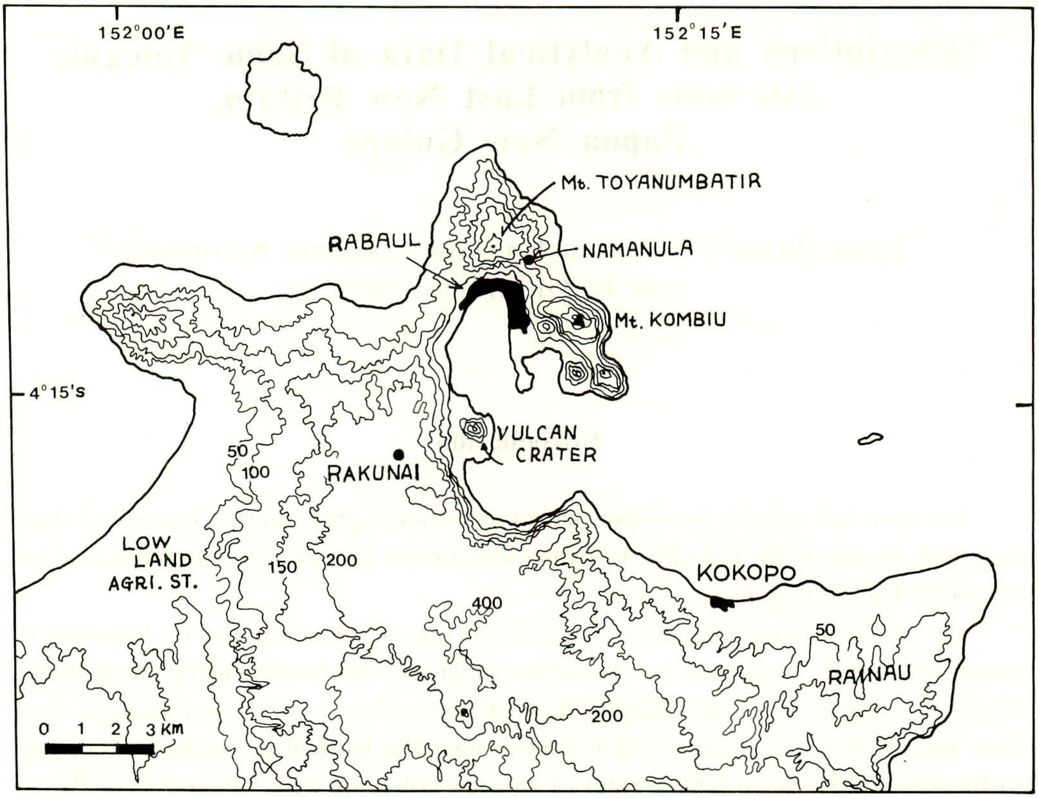

Fig. 1. Location of sample sites (closed circle) near Rabaul, East New Britain, PNG.

Rabaul, East New Britain, are described. Location of sample sites are shown in Fig. 1. The climate of this area is humid and hyperthermic (annual rainfall of 2000 to 3500 mm, and mean annual temperature of 26 to 27°C) with moderate seasonality (Bleeker and Freyne, 1981).

1. Profile at Namanula

The pedon is located at the footslope of Mt. Toyanumbatier (North Daughter) with the elevation of about 150 m above sea level (152°11′20″E, 4°11′30″S). Slope is flat to gently sloping and the vegetation is natural grass. Parent materials are recent andesitic volcanic ashes of different textures and ages overlying older dacitic to rhyolitic ashes of finer textures. Drainage is well drained and human influence would be very little, if present. Date of description and sampling was November 13, 1983.

A1 0-55 cm	: Brownish black (10 YR 2/2, moist); silt loam; weak fine to coarse subangular blocky; friable; frequent fine to coarse roots; clear smooth boundary. This layer was divided into two parts acoording to the hardness checked by hands and named as All and A12, and sampled. Some rock fragments (less than 2 cm in diameter) are present in the lower part of this horizon.
II(B)	: Dull yellowish brown (10 YR 5/4, moist); loamy sand; weak fine to

55-65 cm coarse subangular blocky plus structureless; friable and loose; frequent fine to medium roots; abrupt smooth boundary.

IIIC1 : Brownish black (7.5 YR 3/1, moist); loamy sand; weak coarse suban-
66-106 cm gular blocky; very friable; frequent medium roots; diffuse smooth boundary. Upper part is more yellowish and a thin cemented pan is present at the upper limit of this layer. Two samples were taken from upper and lower part of this layer, namely C11 and C12, respectively.

IIIC2 : Brownish gray (10 YR 4/1, moist); loamy sand; weak coarse suban-
106-123 cm gular blocky plus structureless; very friable and loose; frequent fine to coarse roots; abrupt smooth boundary.

IVA : Brownish black (10 YR 3/2, moist); silt loam; moderate fine to
123-133 cm medium subangular blocky; friable; freguent fine to medium roots; clear smooth boundary.

IVB : Yellowish brown (10 YR 5/6, moist); silt loam; moderate fine to
133-147 cm medium subangular blocky; friable; frequent fine to coarse roots; clear smooth boundary.

IVBC : Dark grayish yellow (2.5 Y 5/2, moist); silt; weak fine to medium
147-157 cm subangular blocky; very friable; few fine roots. Many pumice gravels (less than 5 cm in diameter) are present.

2. Profile at Rakunai

The pedon is situated at upland of about 250 m above sea level (152°06′30″E, 4° 16′30″S). Land from of the area might be formed by the deposition of volcanic ashes in the forms of pyroclastic flows of unknown age. Slope is gently sloping and human influence would be great due to the location of sample site very near a private house, and, in addition, the area seemed to have been formerly under coconut plantation. By field observation parent materials are volcanic ashes of dacitic to rhyolitic composition, probably corresponding to the deposits found at lower part of the pedon at Namanula. Drainage is also well drained and the date of description and sampling was November 14, 1983.

A11 : Brownish black (10 YR 3/2, moist); silt loam; fine to coarse blocky;
0-30 cm friable to very friable; frequent fine to medium roots; clear smooth boundary. Many rock fragments (less than 2 cm in diameter) are present.

A12 : Black (10 YR 1.7/1, moist); silty clay loam; weak fine to coarse suban-
30-47 cm gular blocky; friable; frequent fine to medium roots; abrupt smooth boundary.

B21 : Brown (10 YR 3.5/4, moist); silt loam; weak fine to very coarse
47-68 cm angularblocky; friable; common fine to medium roots; clear smooth boundary.

B22 : Yellowish brown (10 YR 4.5/6, moist) silt loam; weak fine to coarse
68-90 cm subangular blocky; very friable; common fine to medium roots; clear smooth boundary.

B23 : Brownish gray (10 YR 5/1, moist); loamy sand; weak fine to coarse

90-110 cm subangular blocky plus strutureless; very friable and loose; few fine roots.

Analytical methods

Analytical data were obtained according to the following methods: particle size distribution by repeating dispersion and sedimentaion method with intermittent sonification at pH 4 for the separation of clay and silt fractions, and by sieving of fine and coarse sand fractions; pH (H_2O) and pH (KCl) with a glass electrode pH meter in water (1:2.5) and 1 N KCl (1:2.5), and also pH (NaF) after 2 min of reaction (1 g soil/50 ml NaF); total nitrogen and carbon by the method of Kjeldahl and wet combusion with potassium dichromate, respectively; exchangeable bases by 1 M ammonium acetate extraction followed by atomic absorption spectrophotometry determination of Ca, Mg, K and Na; phosphorus retention (%) and phosphorus sorption by the method of Blakemore (1978) and H_3PO_4 (1:20), respectively; CEC by measuring Ca^{2+} retention by repeating washing with 1 N Ca $(CH_3COO)_2$, pH 7.0, followed by repeated washing with 0.05 N Ca $(CH_3COO)_2$, pH 7.0, and then replaced with N NaCl, where excess of Ca^{2+} in remaining solution were substracted from Ca^{2+} in NaCl by weighning for CEC caluclation.

Results and discussions

General characteristics and classification of soils

Volcanic ashes deposited at Namanula above IIIC2 horizon are very recent ones, as indicated high percentage of fine and coarse sand fractions (Table 1b), while below IVA horizon from the pedon at Namanula and for all horizons from Rakunai clay contents were relatively high. As mentioned earlier the parent materials of the lower part of the profile at Namanula seemed to be identical with those of Rakunai.

For Rakunai soils the following general characteristics would be pointed out (Table 1a). Total C was not so high, namely only 2.26 and 5.6% for A11 and A12 horizon, respectively, although the color was as black as many A1 horizons in Japan under humid temperate climate. Less organic matter content in A11 compared with that of A12 horizon is probably resulted from the decomposition of organic matter by human activity, since the area seemed to have been under coconut plantation. pH (H_2O) increased gradually with depth, from 6.33 to 7.22, but difference in pH between pH (H_2O) and pH (KCl) was notably high for B22 andB23 horizons, although exchange-able complexes were saturated with exchangeable bases. Very strong acidic character at exchange sites of the complexes would be plausible. This tendency was also found for IVB and IVBC horizons from Namanula. CEC varied from 13.50 to 24.12. Among exchangeable bases Ca was notably high compared with other bases and Mg and K

Table 1a. Chemical and physical properties of soils from Rakunai

Soil No.	Horizon (depth, cm)	Total C (%)	Total N (%)	C/N	pH			Particle size distribution (%)			
					H_2O	KCl	NaF	coarse sand	Fine sand	Silt	Clay
1	All (0-30)	2.26	-	-	6.33	5.09	9.60	30.0	34.8	27.0	8.2
2	A12 (30-47)	5.10	0.42	12.1	6.65	5.39	10.21	25.3	26.2	29.7	18.8
3	B21 (47-68)	1.27	-	-	6.66	5.17	10.15	35.9	30.2	26.1	7.8
4	B22 (68-90)	0.11	-	-	7.09	4.35	8.84	-	-	-	-
5	B23 (90-110)	-	-	-	7.22	4.57	8.12	42.9	32.9	20.0	4.2

Soil No.	Horizon (depth, cm)	Exchange acidity	Exchangeable bases					CEC	Base satu.	P reten- tion	P sorp- tion
			Ca	Mg	K	Na	sum				
		me/100 g soil							(%)	(%)	(mg/100 g)
1	All (0-30)	0.07	7.12	1.29	0.78	0.22	9.41	13.50	69.7	56.8	884
2	A12 (30-47)	0.10	13.18	1.80	0.44	0.38	15.80	24.14	65.5	91.7	1482
3	B21 (47-68)	0.18	5.62	1.68	0.91	0.38	8.59	13.70	62.7	82.9	1679
4	B22 (68-90)	0.30	6.94	4.24	5.29	0.52	16.99	17.13	99.2	32.1	754
5	B23 (90-110)	0.11	4.39	1.17	2.91	0.21	8.68	7.06	100.0	-	621

were also high for lower part of this profile. It is worth to mention here that base saturation was high through profile, even exceeding 100% in the lower part of this pedon from Rakunai. This phenomena is in contrast to the soils in Japan and also found for the samples from Namanula (Table 1b). The presence of dry season resulting in the change in water movement together with high weatherable minerals content would be one of reasons for this tendency, although high rainfall is recorded in the areas studied.

For Namanula soils clay content, CEC, and total carbon were so low for the samples above IIIC2 horizons (Table 1b), indicating to be unweathered materials, which are probably from the eruption of Vulcan Crater in 1937. General characteristics for IVA,IVB and IVBC horizons were the same as for those of Rakunai soils. Classification of the soils studied is tentatively named as Typic Troporthents and Typic Eutrandepts for Namanula and Rakunai soils, respectively, according to Soil Taxonomy. Recently so-called "Andisol" proposal has recieved much attention, an attempt to create a new order in Soil Taxonomy. The soils from Rakunai are hardly to fulfill the reguirements of diagnostic properties of ECDAM (Blakemore, 1978), except for pH (NaF) of major part of the pedon up to 68 cm from the surface being more than 9.4 and for P-retention (%) of A12 being more than 90%. Moreoever, variable charge is far from the reguirement. Of course the soils from Namanula did not fulfill any reguirements of ECDAM, except pH (NaF) for some samples.

Chemical fertility of volcanic ash soils

Although a term fertility is difficult to define, nutritional status of soils could be taken as chemical fertility which is shown by such analyes as CEC, total exchangeable bases (TEB), degree of base saturation (BS), exchangeable potassium, available phosphorus and content of total nitrogen. Bleeker (1983) proposed three classes for each analytical item (Table 2). In Table 3, results of chemical fertility of the volcanic ash soils, andepts, in Papua New Guinea (Bleeker, 1983) and also of those from Japan (Wada, 1983) are shown together for a comparison. It is evident that high total nitrogen, and moderate to high CEC and exchengeable potassium are characteristic of the andepts in both countries. As for TEB and BS the andepts in Japan seem to be in the middle position between Hydrandepts and other andepts in papua New Guinea. A relatively poor base content in the andepts from Japan compared with Dystrandepts and Eutrandepts in Papua New Guinea may be resulted from the difference in climate conditions and also in the composition of amorphous inorganic constituents which are closely related to the development of negatively charged surfaces for the retention of bases. The soils from Namnanula and Rakunai showed moderate to high fertility level for each item, although CEC from Namanula was in low level. However, in general, volcanic ash soils are relatively rich in chemical fertility. It is interesting to mention here that most of the areas of andepts in Papua New Guinea are mapped as no limitation lands in the land limitation map produced by Bleeker (1975) and are most suitable for cocoa production (Bleeker and Freyne, 1981).

Table 1b. Chemical and physical properties of soils from Namanula

Soil No.	Horizon (depth, cm)	Total C (%)	Total N (%)	C/N	pH			Particle size distribution (%)			
					H_2O	KCl	NaF	coarse sand	Fine sand	Silt	Clay
1	All (0–28)	1.49	0.12	12.4	7.47	5.92	9.65	11.8	73.8	11.6	2.8
2	Al2 (28–55)	0.45	0.04	11.3	6.72	5.40	9.45	12.8	74.4	10.5	2.3
3	II (B) C (55–66)	0.40	0.04	10.0	6.72	5.36	9.51	25.2	59.8	12.4	2.6
4	IIICll (66–86)	0.19	-	-	6.72	5.29	9.23	26.0	60.4	11.8	1.8
5	IIIC12 (86–106)	0.07	-	-	6.72	5.14	8.88	27.1	60.6	10.9	1.4
6	IIIC2 (106–123)	-	-	-	6.70	5.17	8.85	26.8	56.5	15.1	1.6
7	IVA (123–133)	2.58	0.19	13.6	6.31	4.68	9.98	18.1	45.0	23.0	13.9
8	IVB (133–147)	0.76	-	-	6.69	4.37	9.32	19.1	39.2	34.6	7.1
9	IVBC (147–167)	0.06	-	-	7.10	4.40	8.08	23.2	46.3	24.0	6.5

Soil No.	Horizon (depth, cm)	Exchange acidity	Exchangeable bases					CEC	Base satu. (%)	P reten-tion (%)	P sorp-tion (mg/100 g)
			Ca	Mg	K	Na	sum				
		me/100 g									
1	All (0–28)	0.06	3.15	0.61	0.37	0.03	4.16	4.89	85.1	24.6	384
2	Al2 (28–55)	0.06	1.45	0.12	0.25	0.06	1.88	2.92	64.4	22.3	536
3	II (B) C (55–66)	0.06	1.32	0.12	0.20	0.07	1.71	3.04	56.3	28.5	435
4	IIICll (66–86)	0.07	1.22	0.06	0.15	0.10	1.53	1.41	100.0	14.2	194
5	IIIC12 (86–106)	0.06	0.40	0.04	0.08	0.10	0.62	0.83	74.7	2.2	72
6	IIIC2 (106–123)	0.08	0.64	0.07	0.18	0.09	0.98	1.13	86.7	3.1	72
7	IVA (123–133)	0.31	7.43	1.12	2.33	0.83	11.71	18.80	62.3	69.9	1402
8	IVB (133–147)	0.61	5.04	1.70	2.26	1.78	10.78	16.65	64.8	46.6	914
9	IVBC (147–167)	0.15	7.01	2.70	1.46	1.26	12.43	12.28	100.0	-	223

Table 2. Analytical parameters used for assesment of chemical fertility

Fertility class	Total N (%)	Available P (ppm)	Exchangeable potassium	CEC	TEB	BS (%)
			me/100 g			
High	0.50	50	0.6	25	25	60
Moderate	0.10-0.50	10-50	0.2-0.6	6-25	3-25	20-60
Low	0.10	10	0.2	6	3	20

Table 3. Chemical fertility data (top soil, normally 0-50 cm)

	Fertility class	Total N	Av. P	Ex. K	CEC	TEB	BS
Hydrandepts	High	77	9	39	95	-	-
	Moderate	23	27	39	5	26	5
	Low	-	64	22	-	74	95
Dystrandepts	A High	65	-	23	50	14	38
and	Moderate	35	-	59	50	59	24
Eutrandepts	Low	-	-	18	-	27	38
Andepts in	High	47	-	12	59	6	6
Japan #	Moderate	53	-	76	41	71	41
	Low	-	-	12	-	24	53

Figures are the percentage of the number of samples belong to respective classes.

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