Melanic and Fulvic Andisols in Volcanic Soils derived from some Volcanoes in West Java

Andisol Melanik dan Fulvik pada Tanah Vulkanis, yang berasal dari beberapa gunung api di Jawa Barat

Rina Devnita

Department of Soil Science, Faculty of Agriculture, Padjadjaran University
Jln. Raya Bandung-Sumedang Km 21, Jatinangor 40600

Abstract

Melanic and fulvic Andisols are the great groups in the classification of volcanic soils Andisols, which describe the soils with high organic carbon content in the epipedon. The organic C must be more than 6% in the upper 30 cm with the value and chroma are 2 or less for melanic and more than 2 for fulvic. Melanic epipedon also has to have the melanic index that is 1.70 or less. The objective of this study is to investigate the melanic and fulvic Andisols in volcanic soils that developed under pine forest vegetation (*Pinus merkusii*) from different parent materials and ages of Mount Tangkuban Parahu (andesitic, Holocene) and Mount Tilu (basaltic, Pleistocene). The method used was a descriptive comparative survey of three profiles in Mount Tangkuban Parahu and three profiles in Mount Tilu. Analyses were done for each horizon in the profiles comprising the investigation of andic soil properties through the analyses of organic C, bulk density, Al + ½ Fe (ammonium oxalate), and P-retention. The investigations were continued by further calculation of organic C content and by investigation of soil colour with Munsell Soil Colour Chart. The results showed that the two profiles in Mount Tangkuban Parahu and two profiles in Mount Tilu are fulvic Andisol. No melanic Andisols were found in both locations. Pine forest vegetation encourages the formation of fulvic Andisols were derived from andesitic-Holocene parent materials or basaltic-Pleistocene parent materials.

Keywords: andesitic, basaltic, Holocene, Pleistocene, *Pinus merkusii*

Sari

Andisols melanik dan Andisols fulvik merupakan jenis pada klasifikasi tanah vulkanik Andisols, yang menggambarkan tanah dengan kandungan C-organik yang tinggi pada epipedonnya. Kandungan C-organik tersebut harus lebih besar daripada 6% pada lapisan 30 cm teratas, dengan value dan khroma 2 atau kurang untuk melanik dan lebih dari 2 untuk fulvik. Epipedon melanik juga harus mempunyai indeks melanik 1,70 atau lebih kecil. Tujuan penelitian ini adalah untuk menyelidiki Andisols melanik dan Andisols fulvik pada tanah vulkanis yang berkembang di bawah vegetasi hutan pinus (Pinus merkusii) yang berasal dari bahan induk berbeda, yaitu Gunung Tangkuban Parahu (andesitis, Holosen) dan Gunung Tilu (basaltis, Plistosen). Metode yang digunakan adalah survei deskriptif komparatif terhadap tiga profil di Gunung Tangkuban Parahu dan tiga profil di Gunung Tilu. Analisis tanah yang dilakukan terhadap setiap horizon pada profil dimulai dengan investigasi sifat-sifat tanah andik yang terdiri atas analisis C-organik, berat volume, Al + ½ Fe (dengan amonium oksalat) dan retensi P. Investigasi dilanjutkan dengan penghitungan kandungan C-organik dan pengamatan terhadap warna tanah yang berpedoman pada warna dalam Munsell Soil Colour Chart. Hasil penelitian menunjukkan bahwa terdapat dua profil di Gunung Tangkuban Parahu dan dua profil di Gunung Tilu yang merupakan Andisols fulvik. Tidak terdapat Andisols melanik pada kedua lokasi tersebut. Vegetasi hutan pinus mendukung terbentuknya Andisols fulvik, baik pada tanah yang berkembang dari bahan induk andesitis Holosen maupun basaltis Plistosen.

Kata kunci: *andesitis, basaltis, Holosen, Plistosen, Pinus merkusii*

Manuscript received: January 16, 2012, final acceptance: November 30, 2012
Corresponding Author: +6281394888163/*rinabursi@yahoo.com*

INTRODUCTION

The term of volcanic soils is used to designate soils formed from tephras or pyroclastic materials which are weathered rapidly. These soils can be classified as Andisols (Soil Survey Staff, 1990) or Andosol (World Reference Base, 2006). The name of Andisols or Andosols originated fromAndo-soils in Japan. Ando in Japanese coined from the term of *"an";* dark, and *"do";* soil. Ando is an uncommon Japanese word literally translated as dark soil (Shoji *et al.*, 1993).

The central concept of volcanic soils according to The Third Division of Soils (1973) including the parent material is volcanic ejecta. The horizon sequence commonly shows dark-coloured A horizons over brown to yellowish B horizons, the soil material is vitric and/or rich in allophane, having a low bulk density, high exchange capacity, and high phosphate retention. Meanwhile, the central concept of Andisols (Smith, 1978) is that of a soil developing in volcanic ash, pumice, cinders, and other volcanic ejecta or in volcanoclastic materials. These soils have an exchange complex that is dominated by X-ray amorphous compounds of Al, Si, and humus, or a matrix dominated by glass, and having one or more diagnostic horizons other than ochric epipedon.

This central concept consists of two important items: the parent materials are of volcanic origin and the soils are dominated by noncrystalline materials. However, it does not include the presence of large amounts of dark-coloured organic matter that is an essential characteristics for the central concept of Andosol in Japan. It also makes no mention of All Fe humus complexes that are the major form of active Al and Fe in nonallophanic Andisols (Shoji *et al.*, 1985).

Furthermore, ICOMAND (International Committee on the Classification of Andisols) introduced into the Keys of Soil Taxonomy (Soil Survey Staff, 1990) the criteria of andic soil properties for soils to be classified as Andisols. Those criteria state that the organic carbon is less than 25%, Al + *'ii* Fe with ammonium oxalate is more than 2%, bulk density is less than 0.9 gcm^{-3}, and phosphate retention is more than 85%. However, the criteria do not mentioned explicitly the presence of dark-coloured organic matter, and they more emphasize to the organic matter percentage without mentioning about colour.

The dark color of some Andisols come from such amount of high content of organic matter from certain vegetation. The darkest form of these top soils is called melanic epipedon (Soil Survey Staff, 1990). Such dark topsoils appear to be formed under grass vegetation that is frequently burned. The dark color is reflected in the value and chroma (moist) with Munsell Soil Colour Chart that are 2 or less, with the average of organic carbon content is 6% or more and 4% or more in every horizon. The lower limit for the thickness of melanic horizon was 30 em, but it has been revised to a cumulative thickness of 30 em or more within a total thickness of 40 em. Melanic Andisols proposed by Smith (1978) originated from a humus horizon. The definition of melanic epipedon is centred around the thickness, color, and melanic index to describe humus characteristics, organic carbon content, and the depth of melanic epipedon within the profile.

Melanic Andisols appear as the great group in Andisols ordo. Another great group with similar characteristics with melanic is fulvic. Fulvic great group was first proposed by Ottawa (1985) to classifY Andisols having a thick humus similar to melanic epipedon, but having lighter colours than melanic. The lighter colours were reflected in the value and chroma (moist) with Munsell Soil Colour Charts that more than 2. The different colour with Munsell between melanic and fulvic are due to the source of organic materials formed such epipedons. Shoji *et al.* (1988) informed that in Japan, melanic was formed by humus accumulation under Japanese pampas grass *(Miscanthus sinensis)*, meanwhile fulvic was formed by humus accumulation under beech forest (Fagus crenata). Melanic Andisols have high humic acid to fulvic acid ratios and contain the A type humic acid characterized by the highest degree of humification (Shoji, 1988). The melanic index must be 1.70 or less throughout (Soil Survey Staff, 2010). On the other hand, fulvic Andisols show low humic acid to fulvic acid ratios with a low degree of humification (Honna *et al.*, 1988). The different colour between melanic and humic Andisols is due to differences in the humus characteristics (Shoji *et al.*, 1988).

There is a scarcity of information on melanic and fulvic Andisols on volcanic soils found in tropical regions, especially in Indonesia. This article reports and discusses the results of a study conducted on the volcanic soils derived from Mount Tangkuban Parahu and Mount Tilu in West Java. The purpose of this study is to investigate the presence of those great groups related to the vegetation, nature, and age of parent materials from both volcanoes. The data obtained provide a picture of the characteristics of parent materials from volcanoes and the vegetation that form the soil.

This paper is to discuss the presence of melanic and fulvic Andisols on the volcanic soils derived from some volcanoes in West Java.

GEOLOGICAL SETTING AND PHYSIOGRAPIDCAL ENVIRONMENT

The study areas are located in the vicinity of two volcanoes, Mount Tangkuban Parahu and Mount Tilu. As the parent materials, Mount Tangkuban Parahu was andesitic from the Holocene age and Mount Tilu is basaltic from the Pleistocene age (Table 1). Mount Tangkuban Parahu is located at 107°38'57.0" S - 06°47'07.7" E, with a summit reaches 1400 m above sea level. It is situated about 50 km from the city of Bandung to the north. Soil samples and profile description of the Tangkuban Parahu were taken from the eastern upper slope, namely as TP 1, TP 2, and TP 3 (Table 2). Mount Tilu located at 107°32'31.4" S- 07°10'49.7" E, with a summit reaches 1500 m above sea level is situated about 98 km from the city of Bandung to the south. Soil samples and profile descriptions of this mount were taken from the eastern upper slope, namely as TL 1, TL 2 and TL 3 (Table 2). The complete information oflocation, parent material, age, vegetation, and geographical position are presented in Tables 1 and 2. The geological maps of both locations and the site of soil profiles are shown in Figures 1 and 2.

The soil profiles from both volcanoes were located under the pine forest vegetation (Figure 3). All profiles were made in the slope of 8 - 15%. Historically, the eruptions of both volcanoes occurred intermittently over the years varying from flank vents to eruption of mostly moderate in sizes.

MATERIALS AND NJETHODS

Andisols of the research were determined following the Soil Survey Staff(1990 and 2010). In the field, the profiles were described guided by National Soil Survey Center/NSSC (2002). Laboratory analyses were P-retention (Blakemore *et al.*, 1987), pH Hp, and pH KCl with glass electrode (Van Reeu-

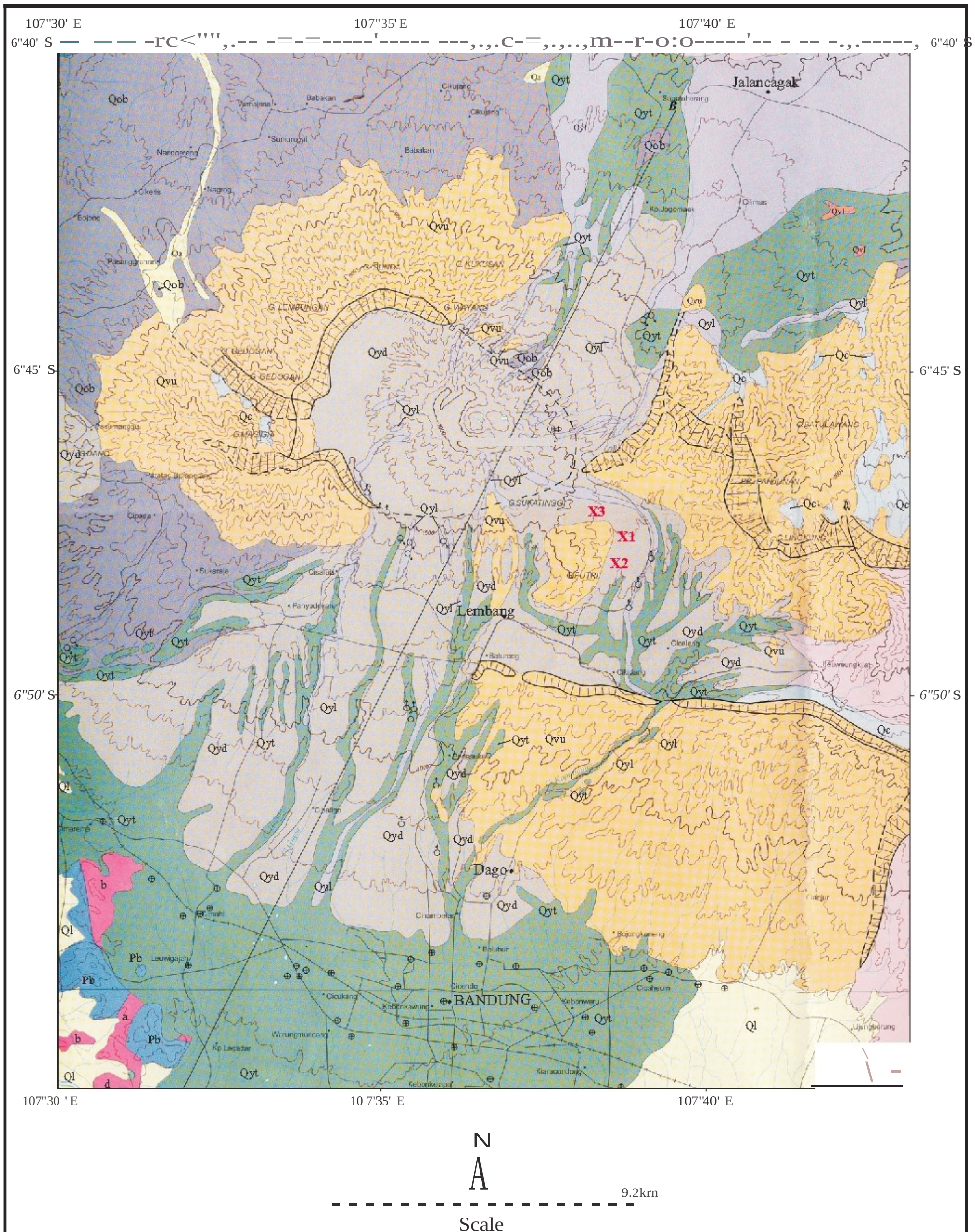
Table 1. Location, Source of Eruption, Nature, and Age ofPa ent Matcrials of the Study Site

District	Source of eruption	Nature of parent materials	Age	Vegetation
Cikole District	Mt Tangkuban Parahu (TPR)	Andesitic[1]	Holocene [1]	Pine forest *(Pinus mercusii)*
Pulosari District	Mt. Tilu (TLU)	Basaltic[2]	Pleistocene [2]	Pine forest *(Pinus mercusii)*

Source: [1])Silitonga, 2003; [2])*AJzwaretal.,* 1976

Table 2. Geographical Position of Studied Areas

Location	Profile	Coordinate	Elevation (m asl)
TPR	TP 1	107°38'57.0"- 06°47'07.7"	1300
	TP2	107°38'51.9"- 06°47'12.5"	1390
	TP3	107°38'54.9"- 06°47'11.6"	1405
TLU	TL 1	107°32'31.4"- 07°10'49.7"	1484
	TL 2	107°32'27.5"- 07°10'58.3"	1482
	TL 3	107°32'34.8"- 07°11'01.8"	1492



LEGEND:

e Town

X Profile Site

DESCRIPTION of MAP UNITS

Qyd SANDY TUFF: Sandy tuff from Mt. Dano and Mt. Tangkuban Parahu (eruptwn C of Van Bemmclcn, 1934). Browmsh sandy tuffs, very coarse hornblende crystals. Also red-weathered lahar, lapilh layers, and breccia.

PUMICEOUS TUFF: Tuffaccous sands, lap1h bombs, sconaccous lava, angular fragments of of dense andes1tc-basalt, many pumtce fragments, mostly from Mt. Tangkuban Parahu (eruphon A of Van Bemmclen, 1934) and Mt. Tampomas.

UNDIFFERENTIATED OLD VOLCANIC PRODUCTS: Volcantc breccta, lahar and lava repatedly.

OLDER VOLCANIC PRODUCTS: Breccta, lahar, and sandy tuff; bedded wtth low angle mthal dtp.

Figure 1. Geological map of Mt. Tangkuban Parahu. Source: Geological Map of the Bandung Quadrangle (Silitonga, 2003).

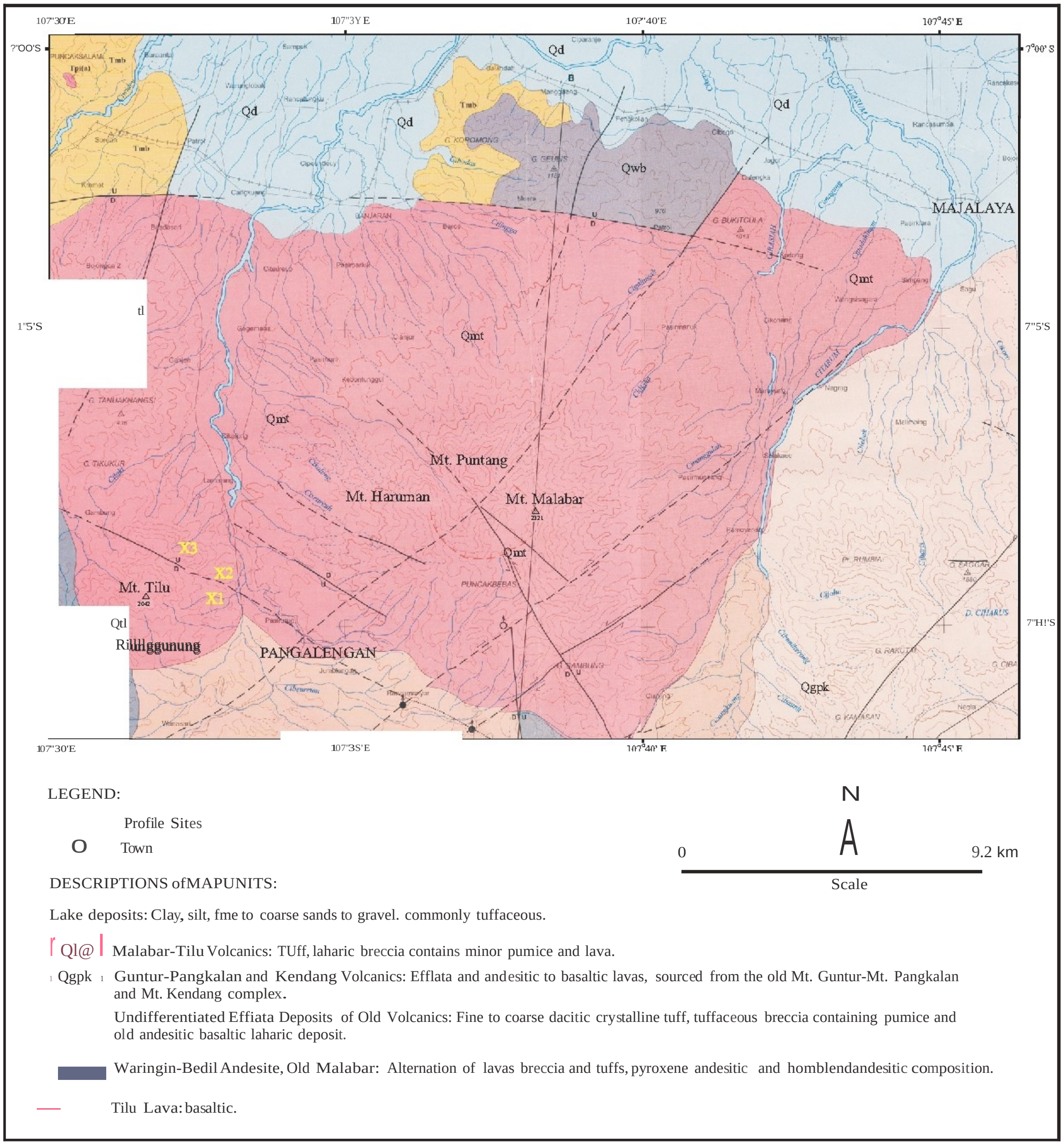


Figure 2. Geological map ofMt. Tilu. Source: Systematic Geological Map ofGarut and Pameungpeuk Quadrangle (Azwar *eta!.* , 1976).

wijk, 1992), organic carbon in Walkley & Black (Van Reeuwijk, 1992), extractable Fe, Aland Si with acid oxalate (Blakemore *et al.*, 1987), and bulk density (Blake and Hartge, 1986). The analysis of melanic index was done to the soils with with the value and chroma (moist) were 2 or less, in this case to the horizons 2 Ab 1 and 2 Ab 2 in TP 1; and horizons 2 Ab 2 and 2 Ab 3 in TP 2. The analysis of melanic index was based on Honna *et al.* (1988) by measuring the absorbances at wavelength 450 nm (K 450) and 520 nm (K 520) with the spectrophotometer. The value of K 450 divided by K 520 (K 450/K 520) of 1. 70 or less is the indication of the presence of melanic horizon. Soils with the value and chroma (moist) of

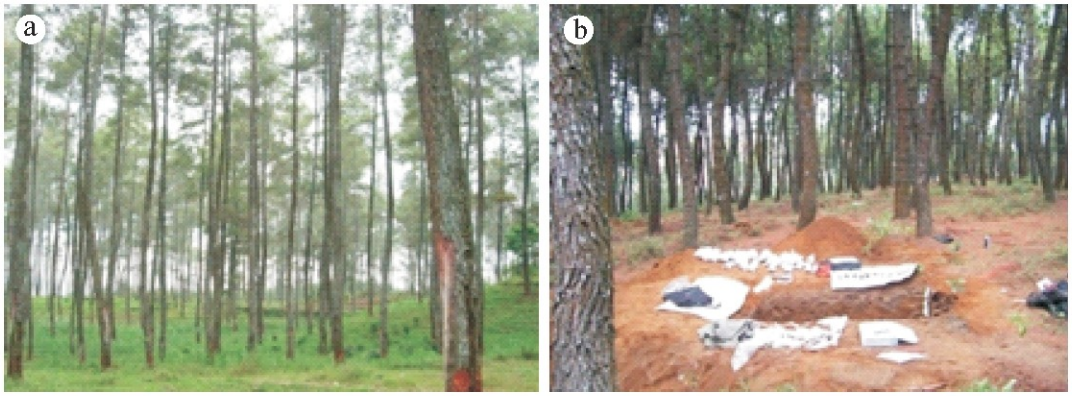


Figure 3. The sites of soil profiles in Mt. Tangkuban Parahu (a) and Mt. Tilu (b).

more than 2 were not necessary to be checked their melanic index since the prerequisite for colours were not fulfilled (Shoji, 1988). The analyses of P-retention, organic carbon, pH, extractable Fe, Al, and Si with acid oxalate were done in the Laboratory of Soil Science in Ghent University, Belgium. The analyses of bulk density was done in the Laboratory of Soil Physics, Faculty of Agriculture, Padjadjaran University, Indonesia.

REsuLT AND DiscussiON

Soils derived from Mount Tangkuban Parahu

The investigation of melanic and fulvic Andisols were started first with the investigation to classify the soil as Andisols through the andie soil properties (Soil Survey Staff, 2010). The result of analyses for andic soil properties for every horizon are presented in Table 3. The result until the depth of 60 em shows that the organic carbon is less than 25 %; bulk density is less than 0.9 g cm^{-3}, Al + Yz Fe is more than 2 %; and Pretention is more than 85%. Table 3 shows that these criteria were fully fulfilled for the whole depth, not only until the depth of 60 em. Therefore, there were no doubt for classifying these soils as Andisols, as found as well in some others volcanic area in West Java (Devnita *et al.*, 2010).

Andie criteria refered to the existence ofthe short range order minerals or noncrystalline minerals like allophane, imogolite, ferrihydrite, and metal-humus complex in Andisols as proposed by ICOMAND/ International Commitee on the Classification of Andisols (Leamy, 1988), even though the presence of those minerals is not mentioned explicitly. The organic carbon content must be high, but not more than 25%, for it will not be classified as Histosols, an order of organic soil. Accumulation of organic matter is stabilized by active Al and Fe, carbonic acid weathering (allophanic) and formation of laminar opaline silica. Therefore, preferential formation of noncrystalline materials such as allophane, imogolite, ferihydrite, and Al/Fe humus complexes is a characteristic feature of the process of andosolization.

Bulk density that less than 0.9 g cm^{-3} refers to the light parent material of ash and other pyroclastic materials. No other mineral soils that have bulk density less than 0.9 g cm^{-3} However, organic soil can have bulk density less than 0.4 g cm^{-3} The bulk density of mineral soils is normally more than 1. 1 g cm^{-3} Therefore, the bulk density that less than 0.9 g cm^{-3} is an indication of the presence of short range order minerals weathered from ash or other pyroclastic materials (Leamy *et al.*, 1990).

Aland Fe extracted with acid ammonium oxalate are the indication to estimate the weathering rates in allophane. Aluminum released from tephra is incorporated mainly into allophane, imogolite, and Al-humus complexes in youngAndisols, and can be preferiantially extracted by the oxalate acid solution. SinceAl is one ofthe major elements present in tephras, Al contained in such noncrystalline minerals is used to estimate the rate of chemical weathering in Andisols when soil age is known (Shoji *et al.*, 1993). In addition, the humus content in Andisols shows a close linear relationship withAl and Fe which are complexes with humus. Therefore, the rate of humus

Table 3. Analyses for Investigation of Andie Soil Properties of Profiles from Mt. Tangkuban Parahu

Profile	Horizon	Depth (em)	Org.Carbon (%)	Al+ Fe	Bulk Density (g cm-3)	P-retention (%)
TPR 1	Ap 1	0- 14	8.42	5.3	0.58	99.20
	Ap2	14- 22	4.71	3.4	0.61	99.70
	Ap3	22- 48	4.25	3.5	0.71	99.80
	BC	48- 58	4.84	3.4	0.69	99.10
	2Ab 1	58- 87	9.28	3.5	0.63	99.60
	2Ab2	87- 110	9.45	3.9	0.69	99.50
	2BA	110- 119	5.65	5.4	0.68	99.20
	2Bw 1	119- 144	3.58	6.7	0.88	99.90
	2Bw2	144- 162	2.62	5.8	0.71	99.80
	2BC	162- 200	1.62	5.7	0.76	99.50
TPR2	Ap 1	0- 14	8.97	2.3	0.78	97.38
	Ap2	14- 30	8.95	2.6	0.70	95.81
	Ap3	30- 45	8.19	4.5	0.69	95.75
	BA	45- 62	5.62	3.9	0.87	95.71
	Bw 1	62- 77	3.24	4.0	0.70	%.08
	Bw2	77- 90	6.94	4.7	0.67	%.08
	BC	90 - 105	6.49	5.3	0.74	95.85
	2Ab 1	105- 115	7.76	4.5	0.66	95.74
	2Ab2	115-147	8.97	4.2	0.61	95.66
	2Ab 3	147- 183	8.97	4.3	0.74	95.36
	2Bwb	183- 200	5.62	4.7	0.66	95.65
TPR3	Ap 1	0 - 13	8.97	3.9	0.72	%.44
	Ap2	13- 32	7.76	4.8	0.65	95.99
	BC	32- 45	5.34	5.2	0.72	%.51
	2Ab 1	45- 71	7.64	4.5	0.72	%.22
	2BA	71- 78	7.41	4.4	0.67	%.21
	2Bw 1	78 - 126	6.86	5.1	0.71	%.01
	2Bw2	126- 144	1.64	5.7	0.68	%.35
	2Bw3	144- 164	2.54	6.4	0.76	%.09
	2Bw4	164-172	2.57	5.7	0.71	%.28
	2BC 1	172- 184	1.60	5.5	0.81	%.30
	2BC2	184- 200	1.79	2.6	0.84	%.22

accumulation can also be estimated by Al release rates from tephras or the relationship between soil age and oxalate acid extractable Aland Fe.

Andisols have a high capacity for phosphate retention due to their high content of active Aland Fe compounds. The phosphate retention capacity of less weathered Andisols is smaller than weathered Andisols (Ito *et al.*, 1991). Fresh tephra contain 0.004-0.6 g kg^{-1} of acid extractable phosphorus, possibly occuring as apatite. However, the amount of acid extractable phosphorus in Andisols tends to decrease with the advance of weathering, because active Aland Fe were formed from weathering of the parent material react to form insoluble Al and Fe phosphate compounds. This is resulted in phosphorus deficiency for crops grown on these soils.

Following the Soil Taxonomy (Soil Survey Staff, 2010), Andisols order will be followed by the suborders. Soil moisture regime is one consideration used in defining the suborders. The soils in the vicinity of Mount Tangkuban Parahu were not dry in any part as long as 90 days cumulatively, therefore they have been classified as udic. Udic Andisols is further abbreviated as Udands.

Melanic or fulvic Andisols come to the great group level. The investigation of melanic or fulvic Andisols was done through the organic carbon content and colour in Soil Munsell Colour Chart (value and chroma). Table 4 shows the organic C, colour, and soil pH in every horizon within those profiles.

Investigation of melanic and fulvic Andisols were started from the organic carbon content. The

Table 4. Organic Carbon Content, Colour (hue value/chroma), Melanic Index, and pHHp ofProfiles from Mt. Tangkuban Parahu

Profile	Horizon	Depth (em)	Organic-C (%)	Color Hue Value/Chroma	Melanic index	pH O
TPRl	Ap 1	0- 14	8.42	10YR 5/6		5.33
	Ap2	14- 22	4.71	10YR 4/6		5.23
	Ap3	22- 48	4.25	10YR 4/4		5.18
	BC	48- 58	4.84	10YR 3/4		5.43
	2Ab 1	58- 87	9.28	10YR 2/2	1.81	5.35
	2Ab2	87- 110	9.45	10YR 211	1.89	5.29
	2BA	110-119	5.65	lOYR 2/3		5.56
	2Bw 1	119- 144	3.58	10YR 3/3		5.73
	2Bw2	144- 162	2.62	10YR 3/6		5.54
	2BC	162- 200	1.62	10YR 4/6		5.64
TPR2	Ap 1	0- 14	8.97	10YR 5/4		4.59
	Ap2	14- 30	8.95	10YR 5/6		4.76
	Ap3	30- 45	8.19	10YR 4/6		5.21
	BA	45- 62	5.62	10YR 5/6		5.42
	Bw 1	62- 77	3.24	10YR 3/6		5.43
	Bw2	77- 90	6.94	10YR 4/4		5.42
	BC	90 - 105	6.49	10YR 3/3		5.23
	2Ab 1	105- 115	7.76	10YR 3/2		5.21
	2Ab2	115- 147	8.97	10YR 2/2		5.12
	2Ab 3	147- 183	8.97	lOYR 211		5.26
	2Bwb	183- 200	5.62	10YR 3/2		5.50
TPR3	Ap 1	0 - 13	8.97	10YR 5/4		4.56
	Ap2	13- 32	7.76	10YR 4/6		4.76
	BC	32- 45	5.34	lOYR 3/4		4.92
	2Ab 1	45- 71	7.64	10YR 2/2		4.97
	2BA	71- 78	7.41	10YR 3/6		5.13
	2Bw 1	78 - 126	6.86	10YR 4/6		5.06
	2Bw2	126- 144	1.64	10YR 5/6		5.04
	2Bw3	144- 164	2.54	10YR 5/8		4.71
	2Bw4	164- 172	2.57	10YR 5/6		4.69
	2BC1	172- 184	1.60	10YR 4/6		4.38
	2BC2	184- 200	1.79	10YR 4/4		5.23

organic carbon content must be 6% or more with the average of **4%** or more in the A horizon with the minimum thickness of30 em. Profiles in Mount Tangkuban Parahu showed that the organic carbon was more than 4% in each profiles to the depth of 30 em. Meanwhile, the average of organic carbon content in the upper 30 em was 5.79 %, ranging from 4.25 to 8.25% in TPR 1; 8,96% (varies from 8.19 to 8.97 %) in TPR 2; and 8.36%, ranging from 5.34 to 8.97% in TPR 3. These facts indicate that profile TPR 1 did not fulfill the requirements of melanic or fulvic because the average of organic carbon content is less than 6%. Conversely, profiles TPR 2 and TPR 3 have the averaged organic carbon content of more than 6% and therefore fulfill the requirements of organic carbon of melanic or fulvic.

Refering to the colour of Munsell Soil Colour Chart, the value and chroma (moist) for melanic must be 2 or less, otherwise it will be fulvic. Both TPR 2 and TPR 3 showed that their value and chroma moist were more than 2, therefore both were fulvic Andisols.

Profile TPR 1 was then classified as Haplic Udic Andisols which abbreviated as Hapludands, meanwhile profiles TPR 2 and TPR were classified as Fulvic Udic Andisols, abbreviated as Fulvudands. Shoji *et al.*, (1988) reported that the soils under beech forest *(Fagus crenata)* were substantially developed to fulvic Andisols. In this research, Andisols developing under pine forest *(Pinus mercusii)* had a relatively low degree of humification of humus accumulation. This was related to the low pH of the soils (less than 6), due to acid parent materials (andesitic) and acid exudate of pine rizhosphere as a needle leaf tree. The low degree of humification produced a fulvic Andisols, and it was reflected in the high content of organic carbon with light colour (value and chroma were more than 2). Vegetation of *Fagus crenata* in Japan (Shoji *et al.*, 1988), *Pinus merkusii* in Indonesia, together with acid parent materials supported the development of fulvic Andisols.

The interesting things in Tangkuban Parahu's profiles were the clear indication of lithologic discontinuity, which reflected in the presence of the A burried horizons (2 Ab). An A burried horizon was previously an A horizon which was burried by the later pyroclastic deposits from later volcanic ejecta. Actually, this is the common feature in the soils developing from volcanic materials, as the volcanoes errupt not only just once (Shoji *et al.*, 1982). Andisols occuring in the vicinity of volcanoes often develop a multisequum as soil age increase since they were formed by intermittent tephra deposits. However, within these three profiles (TPR 1, TPR 2, and TPR 3), the presence of A burried horizons were very clear indicated by the decreasing of value and chroma compared to the overlying horizon as from 5/6, 4/6 and **4/4** to 2/2 and 211 in TPR; from 5/4, 5/6 and 4/6 to 2/2 and 211 in TPR 2 and from 5/4 and 4/6 to 2/2 in TPR 3. Morphologically, it can clearly be seen that their colour were darker than the overlying horizon (Figure **4).**

Figure 4. The soil profiles ofMt. Tangkuban Parahu.

Based on the average of organic carbon content (more than 6%) and the point of value and chroma in A burried horizons (2 or less), there was an interesting feature of the possibility of melanic or fulvic in the depth of 50 em or deeper in TPR 1, TPR 2, and TPR 3. The soils were analysed for their melanic index guided by Honna (1988). The results showed that the melanic index of these soils are more than 1. 70 (Table 4) informing that there was no melanic, but fulvic epipedon. However, it could not be considered as fulvic epipedon, because they were not present in the surface layer. Nevertheless, it probably could be identified that it was a fulvic epipedon before burried. Shoji *et al.* (1993) mentioned that A burried horizon of Andisols can indicate the paleovegetation in that area. Previously, profile TPR 1, TPR 2, and TPR 3 were estimated to have developed under the same pine forest vegetation as found nowadays.

Soil derived from Mount Tilu

As the investigation of melanic and fulvic Andisols to the soils derived from Mount Tangkuban Parahu, the investigations to soils derived from Mount Tilu were also started first by classifying the soil as Andisols through the andic soil properties guided by Soil Survey Staf (2010). The result of analyses for andic soil properties for every horizon are presented in Table 5. The results show that the criteria for andic soil properties are fulfilled till the depth of 60 em, even fulfilled for the whole depth. As soils derived from Mount Tangkuban Parahu, there were no doubt for classifying the soils derived from Mount Tilu as Andisols.

Related to the nature and age ofthe parent materials within these locations, there were no difference between the soils produced either derived from Mount Tangkuban Parahu (andesitic, Holocene) or Mount Tilu (basaltic, Pleistocene). Both developed as Andisols by fulfilling all the criteria of andic soil properties. Andesitic and basaltic parent materials are both equally contributed to the high organic matter content (25% or lower), low bulk density (less than 0.9 gcm^{-3}), sufficiently weathered (Al + Yz Fe more than 2), and high P-retention (more than 85%). Parent materials from Holocene and Pleistocene ages are also equally enabled to develop and maintain Andisols in its andic soil properties for no changing to another soil order.

The difference between these locations are slightly seen through their pH (Tables 4 and 6). Andisols in Mount Tangkuban Parahu has a lower pH thanAndisols in Mount Tilu area. These are the reflection of their parent materials which are more acid in Tangkuban Parahu (andesitic) compared to Mount Tilu (basaltic). The pH value in Mount Tangkuban Parahu ranges beetwen 4.38- 5.64, while in Mount Tilu varies from 5.25 - 6. 71. However, the pH value is not a prerequisite for classifying these soils as Andisols, therefore lower or higher pH has no influence at all.

The soils in the vicinity of Mount Tilu were not dry in any part as long as 90 days cumulative, and therefore they are classified as udic. As soil moisture regime is considered as suborder (Soil Survey Staff, 2010), Andisols in Mount Tilu could be classified as Udic Andisols (Udands). There is no difference in the suborders of Andisols in Mount Tangkuban Parahu and Mount Tilu, as their rainfall were fell in the same group in type B (Schmidt and Fergusson, 1951).

Melanic or fulvic Andisols come to the third level of soil classification (great group). The investigation were done through the organic carbon content and colour in Soil Munsell Colour Chart (value and chroma). Table 6 shows the organic C and colour and soil pH in every horizon within those profiles. The melanic or fulvic Andisols in the Mount Tilu vicinity were investigated first through their organic carbon content, that must be more than 6% with the average of 4% or more till the depth of 30 em. Profile TL2 (ranges in 3.18 - 7.34%, averaged 5.16%) does not fulfill these criteria, and could not been classified as melanic or fulvic Andisols. Following Soil Survey Staff (2010), this soil is classified as Haplic Udic Andisols, and abbreviated as Hapludands. Profile TLU 1 (ranges in 6.71- 9.83%, averaged 8.67%) and TLU 3 (ranges in 8.66 - 10.14%, averaged 9.59%). Therefore, profiles TLU 1 and TLU 3 could be classified as melanic or fulvic Andisols.

For ensuring TLU 1 and TLU 3 as melanic or fulvic Andisol, Munsell Soil Color Chart was used for checking whether the value and chroma (moist) were less 2 or less. Table 6 informs that both profiles has value and chroma (moist) more than 2, and therefore are not classified as melanic but as fulvic Andisols. In accordance with the previous

Table 5. Analyses for Investigation of Andie Soil Properties of Profiles from Mt. Tilu

Profil	Hor	Depth (em)	Organic C (%)	Al + Fe	Bulk Density (g cm-3)	P-retention (%)
TLU 1	Ap 1	0- 7	9.48	5.3	0.62	96.73
	Ap2	7- 18	9.83	3.4	0.60	96.38
	Ap3	18- 31	6.71	3.5	0.64	96.45
	Bw 1	31 - 57	4.20	3.4	0.63	96.57
	Bw2	57- 70	2.93	3.5	0.69	96.52
	Bt 1	70- 79	2.58	3.9	0.66	96.44
	Bt2	79- 90	3.72	5.4	0.65	96.50
	BC	90 - 116	3.55	6.7	0.72	96.48
	CB	116-135	3.01	5.8	0.80	96.47
	2AB 1	135- 148	4.21	5.7	0.74	96.42
	2Bw 1	148- 162	2.85	2.3	0.76	96.37
	2Bw2	162- 200	2.32	2.6	0.64	96.33
TLU2	Ap 1	0- 7	7.34	4.5	0.67	98.80
	Ap2	7 - 12	6.53	3.9	0.75	97.40
	AB	12- 27	3.62	4.0	0.62	99.30
	Bw 1	27- 37	3.18	4.7	0.71	99.40
	Bw2	37- 46	2.83	5.3	0.65	99.30
	Bw3	46- 58	2.10	4.5	0.64	98.90
	Bt 1	58- 80	1.71	4.2	0.66	99.10
	Bt2	80- 99	1.47	4.3	0.72	99.20
	BC	99 - 114	1.06	4.7	0.65	99.90
	CB	114- 130	1.00	3.9	0.72	99.40
	2Ab	130- 156	3.84	4.8	0.71	99.70
	2Bw	156- 200	3.61	5.2	0.67	98.90
TLU3	Ap 1	0 - 11	10.14	4.5	0.74	96.31
	Ap2	11- 19	8.66	4.4	0.76	96.52
	AB	19- 30	9.98	5.1	0.64	96.19
	Bw 1	30- 51	6.66	5.7	0.67	96.29
	Bw2	51 - 65	4.33	6.4	0.75	96.44
	Bt	65- 75	3.27	5.7	0.62	96.44
	BC	75- 92	3.45	5.5	0.71	96.60
	2Ab 1	92 - 109	4.76	2.6	0.65	96.55
	2Ab2	109- 126	6.05	2.6	0.64	96.45
	2Bw 1	126-158	3.97	5.7	0.75	96.52
	2Bw2	158-173	2.20	5.5	0.62	96.51
	2Bt	173- 200	2.22	2.9	0.71	96.27

Table 6. Organic Carbon Content, Color (hue value/chroma) and pH Hp of Profiles from Mt. Tilu

Profil	Hor	Depth (em)	Color	Organic C (%)	pH O
TLU 1	Ap 1	0- 7	lOYR 3/3	9.48	5.25
	Ap2	7- 18	lOYR 3/4	9.83	5.53
	Ap3	18- 31	lOYR 4/4	6.71	5.44
	Bw 1	31 - 57	lOYR 4/6	4.20	6.25
	Bw2	57- 70	lOYR 5/8	2.93	6.22
	Btl	70- 79	lOYR 5/8	2.58	6.07
	Bt2	79- 90	lOYR 6/8	3.72	5.67
	BC	90 - 116	l0YR 5/8	3.55	5.81
	CB	116- 135	lOYR 5/8	3.01	5.78
	2AB 1	135- 148	lOYR 5/6	4.21	5.34
	2Bw 1	148- 162	l0YR 4/6	2.85	5.48
	2Bw2	162-200	lOYR 5/6	2.32	5.91
TLU2	Ap 1	0- 7	lOYR 3/3	7.34	5.74
	Ap2	7 - 12	lOYR 4/3	6.53	5.95
	AB	12- 27	lOYR 3/4	3.62	6.18
	Bw 1	27- 37	l0YR 4/4	3.18	6.40
	Bw2	37- 46	lOYR 3/6	2.83	6.46
	Bw3	46- 58	lOYR 4/4	2.10	6.71
	Btl	58- 80	lOYR 4/6	1.71	6.50
	Bt2	80- 99	lOYR 5/6	1.47	6.52
	BC	99 - 114	lOYR 5/8	1.06	6.52
	CB	114- 130	lOYR 5/6	1.00	6.63
	2Ab	130- 156	lOYR 5/4	3.84	6.48
	2Bw	156-200	l0YR 5/6	3.61	6.19
TLU3	Ap 1	0 - 11	lOYR 3/3	10.14	5.27
	Ap2	11- 19	lOYR 3/4	8.66	5.40
	AB	19- 30	lOYR 4/4	9.98	5.47
	Bw 1	30- 51	lOYR 3/6	6.66	5.83
	Bw2	51 - 65	l0YR 4/6	4.33	6.30
	Bt	65- 75	lOYR 5/6	3.27	6.41
	BC	75- 92	lOYR 5/8	3.45	6.43
	2Ab 1	92 - 109	lOYR 4/4	4.76	6.50
	2Ab2	109- 126	lOYR 4/6	6.05	6.70
	2Bw 1	126- 158	lOYR 5/6	3.97	6.51
	2Bw2	158 - 173	l0YR 5/8	2.20	6.25
	2Bt	173-200	lOYR 6/8	2.22	5.91

classification of Andisols in udic moisture regime (Udands), this Andisols is classified as fulvic udic Andisols abbreviated as Fulvudands. If the value and chroma are 2 or less, the classification will be melanic udic Andisols which is abbreviated as Melanudands.

Fulvudand and Melanudands have striking differences mainly in morphological and chemical properties relating to soil humus (Shoji *et al.*, 1988). Ofthe morphological properties, the difference between the two Andisols is most pronounced in the colour of the humus horizon (Figure 5). Although the humus horizon of Fulvudand is thick and contains a high concentration (6%) of organic carbon, the colour of this horizon is dark brown (value and chroma > 2). In contrast, Melanudands have darker coloured humus (value and chroma ::; 2). Fulvudands reflect Andisols with high organic carbon content with low degree ofhumification of humus accumulation, while Melanudands reflect a high degree humification of humus accumulation.

Soil under beech forest *(Fagus crenata)* in Japan developed to fulvic Andisols (Shoji *et al.*, 1988), while in this region it was found under pine forest *(Pinus mercusii).* Soil organic carbon is markedly accumulated in the upper part of the soil profile with more than 6 % as a weight average in the depth of 0 - 30 em. It decreases significantly with depth, related to how organic matter was added to soil surface by the plant residue of pine. The low degree ofhumification in the soils under pine forest was due to the acid exudate of the pine root retard the humification process.

Andisols in the Mount Tilu vicinity also show the lithologic discontinuity as the Andisols in Mount Tangkuban Parahu. There are horizons of 2Ab or A burried horizons in each profiles. However, these burried horizons do not indicate nor melanic neither fulvic as the Andisols in Mount Tangkuban Parahu, because their organic carbon content is not more than 6% in every horizons. Nevertheless, it presents a relatively higher organic carbon content than the overlying horizon (3.01 to 4.21% in TLU 1, 1.00 to 3.84% in TLU 2, and 3.45 to 4.76% in TLU 3). It also shows a darker colour which reflects in smaller value and/or chroma (5/8 to 5/6 in TLU 1, 5/6 to 5/4 in TLU 2 and 5/8 to 4/4 in TLU 3).

The presence of A burried horizons indicates that these soils developed not only from one parent material, but from at least two parent materials from at least two periods of eruption. This phenomenon is commonly found in the volcanic soils. In some cases like in Mount Tangkuban Parahu, the paleovegetation could be indicated from the A burried horizons since the horizons are found like fulvic epipedons. Since the same phenomenon in Mount Tilu, we could not predict the paleovegetation in this area. The age of parent material in Mount Tilu (Pleistocene) which is older than in Mount Tangkuban Parahu (Holocene) make some charaterictics in Mount Tilu that has further been changed from their original one.

Figure 5. The soil profiles ofMt. Tilu.

CoNCLUSION

Both studied areas in Mount Tangkuban Parahu and Mount Tilu have fulvic Andisols, classified as Fulvic Udic Andisols, abbreviated as Fulvudands. No melanic Andisols found in such area. No influence of the difference of source of eruption, nature, and age of parent materials developed in these fulfic Andisols. The same pine forest vegetation is predicted as the main factor in developing the Andisols to be the fulvic Andisols.

Acknowledgement-The authorwould like to thank: the Indonesian Ministry of Education and Culture c.q The Directorate General of Higher Education for funding this research. The author also thank Prof. E. Van Ranst from Ghent University Belgium for facilitating some laboratory anal yses in the Labora tory of Soil Science - Ghent University. A deeply gratitude is addressed to Ir. Ridha Hudaya, M.S., for the valuable technical support and field guidance.

REFERENCES

Alzwar, M., Akbar, N., and Bachri, S., 1976. *Geology of Garut Quadrangle*. Geological Research and Development Centre, Bandung.

Blake, G.R. and Hartge, K.H.,1986. Bulk Density. In: Klute, A. (ed), *Methods of Soil Analysis, Part I Physical and Mineralogical Methods*, p.363-375.

Blakemore, L. C., Searle, P. L., and Daly, B. K., 1987. Methods for Chemical Analysis of Soils. Lower Hutt, New Zealand. *Soil Bureau Science Report*, 80pp.

Devnita, R., Arifin, M., Salim, E. H., Sudrajat, H., Hudaya, R., and Van Ranst, E., 2010. Soil developed on volcanic materials in West Java, Indonesia. *International Journal of Arts and Sciences*, 9, p.180-192.

Honna, T., Yamamoto, S., and Matsui, K., 1988. A simple procedure to determine the melanic index that is useful for differentiating melanic from fulvic Andisols. *Pedologist*, 32, p.69-75.

Imaya, A., Morisada, K., and Ohta, S., 2002. Chemical Properties and Classificaion of Japanese Brown Forest Soils Derived from Various Parent Materials. *Proceedingson J'J'h WCSS, 14-21August2002, Thailand*

Ito, T., Shoji, S., and Saigusa, M., 1991. Classification of volcanic ash soils from Konsen district Hokkaido according to the last Keys to Soil Taxonomy. *Journal of Soil Science Plant Nutrition*, 62, p.237-247.

Leamy, M.L., 1988. International Comrnitee on Andisol (ICOMAND). *Circular Letter no 10*. New Zealand Bereau. DSIR. Lower Hutt.

Leamy. M.L., Kinloch, D. 1., and Parfitt, R. L., 1990. International Commitee on Andisol. Soil Management Support Services, Washington DC. *Technical Monograph*, 20. 78pp.

National Soil Survey Center (NSSC), 2002. *Field Book for Describing and Sampling Soils Version 2. 0*. Natural *Resources* Conservation *Service*. United State Departement of Agriculture, 219pp.

Ottawa, M., 1985. Criteria of great group of Andisols. In: Beinroth, F. E., Maldonado, P., and Eswaran, H., (Eds.). *Proceedings of 6h International Soil Classification Workshop*, Chile and Equador, p.191-208.

Schmidt, T. and Fergusson, B., 1951. *Climatology*. Blacksburg, Virginia. 263pp.

Shoji, S., 1988. Separation of melanic and fulvic Andisols. *Soil Science and Plant Nutrition*, 34, p.303-306.

Shoji, S., Fujiwara, Y., Yamada, I., and Saigusa, M., 1982. Chemistry and clay mineralogy of Ando soils, Brown forest soils and Podzolic soils formed from recent Towada ashes, northeastern Japan. *Soils Science*, 33, p.69-86.

Shoji, S., Takahashi, T., Saigusa, M., Yamada, 1., and Ugolini, F. C., 1988. Properti es of Spodosols and Andisols showing climosequential and biosequential relations in southern Hokkoda, North-eastern, Japan. *Soil Science*, 145, p.l35-150.

Shoji, S., Nanzyo, M., and Dahlgren, R., 1993. Genesis of volcanic ash soils. In: Shoji, S., Nanzyo, M. and Dahlgren, R., (Eds.). *Volcanic Ash Soil - Genesis, Properties and Utilization*. Elsevier, Amsterdam, p.37-71.

Shoji, S., Ito, T., Saigusa, M., and Yamada, I., 1985. Properties of nonallophanic Andosols from Japan. *Soil Science*, 140, p.264-277.

Shoji, S., Takahashi, T., Saigusa, M., Yamada, l., and Ugolini, F.C., 1988. Properties of Spodosols and Andisols showing climosequential and biosequential relation in southern Hakkoda, northeastern Japan. *Soil Science*, 145, p.135-150.

Silitonga, P. H., 2003. *Geology of Bandung Quadrangle*. Geological Research and Development Centre, Bandung.

Smith, G. D., 1978. A Preliminary Proposal for the Reclassification of Andept and Some Andie Subgrops. *New Zealand Soil Bureau*, New Zealand. 48pp.

Soil Survey Staff, 1990. *Keys to Soil Taxonomy*. 4'h ed. AID. USDA. SMSS. Technical Monograph No. 19. Blacksburg, Virginia, 280pp.

Soil Survey Staff, 2010. *Keys to Soil Taxonomy*. 11'h ed. Natural Resources Conservation Service, 332pp.

The Third Divison of Soils, 1973. *Criteria for making soil series and a list of soil series*. The first approximation. National Institute of Agricultural Research.

Van Reeuwijk, L. P., 1992. *Procedure for Soil Analysis*. Fourth Edition, ISRlC. Wageningen, The Netherland, 56pp.

World Reference Base, 2006. World Reference Based for World Soil Resources. A Framework for International Classification, Correlation and Communication. *fUSS Working Group, FAO*, Rome Report No. 103. 130pp.