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# Soils Developed on Volcanic Materials in West Java, Indonesia

**Rina Devnita,** Padjadjaran University, Indonesia
**Mahfud Arifin,** Padjadjaran University, Indonesia
**E. Hidayat Salim,** Padjadjaran University, Indonesia
**Adjat Sudradjat,** Padjadjaran University, Indonesia
**Ridha Hudaya,** Padjadjaran University, Indonesia
**Eric Van Ranst.** Ghent University, Belgium

**Abstract:** Six profiles developed on volcanic materials were selected in West Java, Indonesia. Three profiles derived on andesit parent material from Holocene age, and three others derived on basalt parent material from Pleistocene age. The soils were described and analyzed for having the morphological, mineralogical, chemical and physical characteristics. Fieldwork and laboratory analyses were done, include the analyses with acid oxalate, phyrophosphate and X-Ray Diffractometer. The results showed that the soils developed on andesit parent materials have the lower pH and CEC than the soils developed on basalt parent material. Soils derived from Holocene age have different mineralogical composition than soils derived from Pleistocene age. However, all soils have C-organic lower than 20 %, bulk density lower than 0.9 g $cm^{-3}$, P-retention higher than 85 %, and Al and Fe (extracted with acid oxalate) higher than 2 % and therefore, fulfilled the requirements for andic soil properties, and be classified as Andisols.

**Keywords**: andic, Andisol, andesit, basalt, Holocene, Pleistocene

# Introduction

Mountains of volcanic origins are rather widespread in West Java Province, Indonesia. Out from the 129 active volcanoes in the whole territory of Indonesia, 18 volcanoes are located in West Java (Sudradjat, 2009). Therefore, soils derived from volcanic materials are found in the volcanoes vicinities for example around Mt. Tangkuban Parahu and Mt. Tilu (Arifin, 1994).

Volcanic soils have unique and distinct physical properties encourage plant growth, such as low bulk density (Broquen et al, 2005), high water retention, high organic matter content (Yuan et al, 2000), high permeability and stable structure (Hoyos & Comerford, 2005) and provide an important area for agriculture, especially for tea plantation and horticulture. However, soils derived from volcanic materials are characterized by the abundance of short range order minerals assemblage dominated by allophane, imogolite and ferrihydrite (Van Ranst, 2008). These minerals are defined as variable charge minerals and the soils charge therefore are largely dependent on the pH and electrolyte concentration of the soil solution (Uehara & Gillman, 1981). The variable charge soils have high $pH_0$ and low cation exchange capacity (CEC) resulting the limited ability to retain cations and worst, excessive losses of cations at low soil pH. Volcanic soils also have a high capacity for phosphate retention due to their high content of active Al and Fe compounds, make the available P for plant is low and become a serious problem for plant production (Van Ranst et al., 1993).

Mineralogical and chemical analyses of volcanic soils indicated that their mineral composition varies depending on the stage of soil formation, the horizon, the nature of parent materials, the thickness of overburden ash deposits and probably other factors. The formation and transformation of clay minerals by weathering of volcanic materials are also affected by accumulation of humus which forms complexes with Al and Fe and with some clay minerals.

Volcanic soils in West Java are varies due to the natural of parent materials and ages. Soils derived from Mt. Tangkuban Parahu are andesit origin from Holocene age (Silitonga, 2003), meanwhile soils derived from Mt. Tilu are basalt origin from Pleistocene age (Alzwar et al, 1976). Soils from different the natural parent materials and ages were described for macromorphological features and analyzed for their mineralogical, chemical and physical characteristics.

## State of the Art

The main reasons for investigating the mineralogical, chemical and physical characteristics of these soils are: (1) to assess the profile homogeneity (2) to evaluate the degree of weathering, and (3) to classify the soil.

## Literature Review

The unique properties of volcanic soils influenced by volcanic parent materials, result from active solid phase of active Al and Fe, which consist of allophane, imogolite and ferrihydrite or Al/Fe humus complexes often together with opaline silica. These two groups have an inverse relationship, because the two groups have the opposing conditions favoring their formation (Parfit & Kimble, 1989). Metal-humus complexes are dominant at pH values less than 5, while allophane and imogolite are dominant at higher pH values. Another common constituent in many volcanic soils displaying a wide range of structural disorder halloysite. Halloysite is found as the dominant clay mineral in Si-rich environment, while Al-rich allophane and imogolite are found at comparatively lower Si concentration. Volcanic soils in Indonesia could also contain quartz, cristobalite, trydimite, feldspar, gibbsite, goethite, hematite, mica, and some other layer silicate minerals (Syarif, 1990; Utami, 1998; Fiantis, 2004).

The composition of parent material strongly affects the formation clay minerals in volcanic soils. Higher proportions of volcanic glass in basaltic material result in the formation of more allophane and imogolite than more andesitic parent materials (Mizota, 1981). Volcanic soils containing 2:1 and 2:1:1 layer silicates are derived from quart-rich parent materials, while gibbsite and allophane dominate in soils from andesitic ashes that do not contain quartz. Some studies of volcanic soils in Indonesia indicated that there was no systematic differences between the noncrystalline and crystalline mineral composition from different parent materials, although the soils developed on basaltic parent materials contain significantly more allophane and imogolite than those more acidic parent materials, and no significant relationship between parent materials and sand mineralogical composition (Sutanto, 1988; Syarif, 1990).

The age of parent materials and the development stage of the soils also affected the clay mineral compositions. In tropical areas, allophane predominates in the clay fraction of young volcanic soils (Bleeker & Parfitt, 1974). With increasing age, allophane is replaced by halloysite and gibbsite. However, young soils may be dominated by smectite, vermiculite, chorite intergrade and opaline silica. The allophane content and its $SiO_2/Al_2O_3$ molar ratio tend to increase with age (Shoji & Saigusa, 1977). Some studies indicated that the effect of age is still confusing.

Volcanic soils exhibit distinctive physical properties which distinguish them from other soils like low bulk density, high 1.5 MPa water content, high water content at field capacity, high liquid limit and low plasticity index, problem in dispersion, and irreversible changes in physical properties in drying (Maeda et al, 1984). These characteristics are attributable directly to the properties of the parent material, the short range order constituents formed by weathering, and soil organic matter accumulated during soil formation (Nanzyo et al, 1993, Bartoli, 2004).

The low bulk density of volcanic soils is attributable to the development of highly porous soils structure. The low bulk density and the unique consistence greatly contribute to the easy tillage of volcanic soils. Volcanic soils also show the low degree of stickiness, plasticity and hardness that result from the abundance of short-range order minerals and organic matter. It is possible to till these soils even when soil water content is lower than the shrinkage limit and somewhat higher than the plastic limit. Volcanic soils also have a well developed soil structure resulting in high porosity with a range of pore size that retains a large amount of water. These physical properties provide an excellent environment for root growth (Nanzyo et al, 1993)

The noncrystalline constituents of volcanic soils have been shown to have a strong influence on chemical behaviour of these soils. The studies indicate that the common chemical characteristics of volcanic soils are high of organic matter content (Van Ranst, 1991), high phosphate retention (Van Ranst et al., 1993), and high $pH_0$ (Qafoku et al, 2004). These soils naturally have high basic cations released from the weathering of parent materials as far as the CEC of the soils can be maintained high for preventing the loses of the cations through leaching and percolating (Uehara & Gilman. 1981).

# Material and Method

## Study areas

The study areas are located in the vicinity of two volcanoes, Mt. Tangkuban Parahu and Mt. Tilu. Mt. Tangkuban Parahu, located at 107°38’57.0” - 06°47’07.7” and a summit reach 1400m above sea level , is about 50 km from the city of Bandung, the capital city of West Java Province, to the north. Soil samples and profile description were taken from the eastern upper slope, namely as TPR 1, TPR 2 and TPR 3. Mt. Tilu, located at 107°32’31.4” - 07°10’49.7”, and a summit reach 1500 m above sea level, is about 98 km from the city of Bandung to the south. Soil samples and profile descriptions were taken from the eastern upper slope, namely as TLU 1, TLU 2 and TLU 3.

The soil profiles from both volcanoe are located under the pine forest vegetation (Figure 1). The forest vegetations were chose for minimizing the anthropogenic influence to the soils development. All profiles were made in the slope of 8 – 15 % for minimizing the influence of erosion to the horizonation of the soils. Historically, the eruptions of both volcanoes have occurred intermittently over the years varying from flank vents to eruption of mostly moderate in sizes.

(a)

(b)

Figure 1. Vegetation and Landuse of Mt. Tangkuban Parahu (a) and Mt. Tilu (b)

Table 1 shows the location, nature of the parent material and age of the study areas, meanwhile Table 2 shows the coordinate number and the elevation of the soil profiles.

Table 1 Location, source of eruption, nature of parent materials and age of the study site

| Location | Source of eruption | Nature of parent materials | Ages |
|---|---|---|---|
| TPR, Cikole District | Mt Tangkuban Parahu | Andesit[1)] | Holocene [1)] |
| TLU, Pulosari District | Mt. Tilu | Basalt[2)] | Pleistocene [2)] |

Source : [1)] Silitonga, 2003
[2)] Alzwar et al, 1976

Table 2. Geographical position of study areas

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

In the field, the profiles were described guided by National Soil Survey Center / NSSC (2004). Laboratory analyses are minerals in sand fraction with polarizing microscope, clay mineralogy with XRD, P-retention (Blakemore et al, 1987), pH $H_2O$ and pH KCl (glass electrode), organic carbon (Walkley & Black), extractable Fe, Al and Si with acid oxalate and pyrophosphate (Blakemore, 1987), $pH_0$ (Gillman & Abel, 1986), bulk density, CEC (ammonium acetate, pH 7) and follow the Van Reeuwijk (1992). The analyses of clay mineralogy with XRD, P-retention, organic carbon, $pH_2O$, pH KCl and $pH_0$, extractable Fe, Al, and Si with acid oxalate and phyrophosphate were done in the Laboratory of Soil Science in Ghent University, Belgium. The rest of analyses were done in the Laboratory of Soil Chemistry and Soil Physic, Faculty of Agriculture, Padjadjaran University, Indonesia.

## Result and Discussion

### Soil Morphology

Morphological characteristics of volcanic soils focused on the in situ description supported with the laboratory analyses. Soil horizon indicate that there were lithologic discontinue, marked by the presence of A buried horizon (2 Ab) below the C or BC horizon. These are the indication that the soil derived not only from one period of erosion but at least from two periods of eruptions.

The depths of the overlying buried horizons are different between TPR and TLU profiles. In TPR, the depth is less than 100 cm, while in TLU the depth is more than 100 cm. This is one of indication that the TPR (Holocene) profiles are thinner and younger than TLU (Pleistocene).

B horizons were found in all profiles, indicated that all soils have developed enough to form an elluvial horizon. However, the B horizons in TPR were still quite similar with C horizons (Ap-BC-CB-C), while the B horizon in TLU have far more developed, indicated by the formation of Bw and Bt horizons (Ap-Bw-Bt-BC-CB).

The soils have the medium texture due to the high content of sand and silt fractions. The textures therefore, are in the range of silt, silty loam and silty clay loam. TPR profile (Holocene) dominated by silt and silty loam texture, while TLU profile (Pleistocene) have the higher clay indicated by the silt, silty loam up to silty clay loam texture.

### The composition of sand fraction

The parent material of the soils of Mt. Tangkuban Parahu are tuff of sand with the coarse hornblend crystall and weathered reddish lahar in andesit composition from the eruption of Mt. Dano dan Mt. Tangkuban Parahu (Van Bemmelen, 1949) of Holocene age symbolized by Qyd in the geological map of Silitonga (2003).

The parent material of soils of Mt. Tilu are from old volcanoe of tuff, breccia, lahar with a few of pumice and lava in basalt composition from the eruption of Mt. Tilu of Pleistocene age, symbolized with Qtl in the geological map of Alzwar et al (1976).

The composition of mineral in sand fraction is presented in Table 3.

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Table 3. Mineral composition of the sand fraction of the represented profile and horizon in TPR and TLU

| Profil | Heavy Minerals/HM % | | | | | Light Minerals/LM % | | | | | Total % | HM % | LM % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Op | Hor | Aug | Hip | Oli | NCVG | CVG | Fel | Qua | RF | | | |
| **TPR** | **Andesit - Holocene** | | | | | | | | | | | | |
| Ap | 2 | 7 | 8 | 5 | 0 | 20 | 4 | 35 | 4 | 15 | 100 | 22 | 78 |
| BC | 3 | 7 | 13 | 1 | 0 | 15 | 7 | 34 | 5 | 15 | 100 | 24 | 76 |
| 2 Ab | 6 | 6 | 14 | 2 | 0 | 15 | 7 | 27 | 3 | 20 | 100 | 28 | 72 |
| 2 Bw | 6 | 7 | 14 | 3 | 0 | 13 | 2 | 30 | 5 | 20 | 100 | 30 | 70 |
| 2 BC | 6 | 8 | 6 | 3 | 0 | 25 | 7 | 25 | 3 | 17 | 100 | 23 | 77 |
| **TLU** | **Basalt - Pleistocene** | | | | | | | | | | | | |
| Ap | 6 | 2 | 9 | 2 | 3 | 2 | 21 | 25 | 4 | 26 | 100 | 22 | 78 |
| Bw | 6 | 2 | 10 | 4 | 4 | 5 | 16 | 21 | 3 | 29 | 100 | 26 | 74 |
| Bt | 2 | 9 | 12 | 4 | 2 | 2 | 15 | 27 | 4 | 23 | 100 | 29 | 71 |
| BC | 5 | 7 | 7 | 4 | 3 | 3 | 24 | 19 | 3 | 25 | 100 | 26 | 74 |
| 2 Ab | 5 | 9 | 4 | 5 | 5 | 3 | 15 | 35 | 3 | 16 | 100 | 28 | 72 |
| 2 Bw | 7 | 6 | 6 | 2 | 5 | 2 | 15 | 26 | 4 | 27 | 100 | 26 | 74 |

Op = Opaque
Hor = Hornblende
Aug = Augite
Hip = Hypersthene
Oli = Olivine

NCVG = Non coloured volcanic glass
CVG = Coloured volcanic glass
Fel = Feldspar
Qua = Quartz
RF = Rock fragment

## The quantitative of mineralogical analyses of the clay fraction

Table 4. The quantitativeof mineralogical analyses of the clay fraction

| Profil | Hor | Sio % | Alo % | Feo % | Fep % | Alp % | Alo + ½ Feo | Alo–Alp | Alo-Alp/Sio | al % | im % | fer % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TPR I | Ap1 | 1.08 | 4.48 | 1.58 | 0.24 | 0.69 | 5.3 | 3.79 | 3.51 | 8 | 6 | 3 |
| | Ap2 | 0.74 | 2.93 | 0.84 | 0.37 | 0.68 | 3.4 | 2.25 | 3.04 | 5 | 5 | 1 |
| | Ap3 | 0.86 | 3.09 | 0.72 | 0.28 | 0.72 | 3.5 | 2.37 | 2.76 | 6 | 5 | 1 |
| | BC | 1.07 | 3.03 | 0.77 | 0.15 | 0.59 | 3.4 | 2.44 | 2.28 | 8 | 4 | 1 |
| | 2 Ab1 | 0.77 | 2.9 | 1.27 | 1.76 | 1.72 | 3.5 | 1.18 | 1.53 | 5 | 3 | 2 |
| | 2 Ab2 | 0.85 | 3.3 | 1.15 | 1.23 | 1.59 | 3.9 | 1.71 | 2.01 | 6 | 3 | 2 |
| | 2 BA | 1.33 | 4.85 | 1.1 | 0.37 | 0.81 | 5.4 | 4.04 | 3.04 | 9 | 5 | 2 |
| | 2 Bw1 | 2.04 | 6.21 | 0.92 | 0.08 | 0.5 | 6.7 | 5.71 | 2.8 | 15 | 5 | 2 |
| | 2 Bw2 | 2.19 | 5.1 | 1.49 | 0.01 | 0.33 | 5.8 | 4.77 | 2.18 | 16 | 4 | 3 |
| | 2 BC | 2.51 | 5.34 | 0.75 | 0.02 | 0.33 | 5.7 | 5.01 | 2 | 18 | 3 | 1 |
| TLU 2 | Ap1 | 1.42 | 4.26 | 0.8 | 0.28 | 0.6 | 4.7 | 3.66 | 2.58 | 10 | 4 | 1 |
| | Ap2 | 1.41 | 3.45 | 0.94 | 0.34 | 0.79 | 3.9 | 2.66 | 1.89 | 10 | 3 | 2 |
| | AB | 1.9 | 4.23 | 1.12 | 0.14 | 0.51 | 4.8 | 3.72 | 1.96 | 14 | 3 | 2 |
| | Bw1 | 2.09 | 4.51 | 1.31 | 0.11 | 0.36 | 5.2 | 4.15 | 1.99 | 15 | 3 | 2 |
| | Bw2 | 1.94 | 3.87 | 1.28 | 0.09 | 0.44 | 4.5 | 3.43 | 1.77 | 14 | 3 | 2 |
| | Bw3 | 1.8 | 3.94 | 1 | 0.02 | 0.26 | 4.4 | 3.68 | 2.04 | 13 | 3 | 2 |
| | Bt1 | 2.14 | 4.38 | 1.39 | 0.03 | 0.27 | 5.1 | 4.11 | 1.92 | 15 | 3 | 2 |

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| Profil | Hor | Sio % | Alo % | Feo % | Fep % | Alp % | Alo + ½ Feo | Alo–Alp | Alo-Alp/Sio | al % | im % | fer % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Bt2 | 2.47 | 4.94 | 1.47 | 0.01 | 0.25 | 5.7 | 4.69 | 1.9 | 18 | 3 | 2 |
| | BC | 2.67 | 5.53 | 1.77 | 0.01 | 0.27 | 6.4 | 5.26 | 1.97 | 19 | 3 | 3 |
| | CB | 2.54 | 5.02 | 1.45 | 0.01 | 0.27 | 5.7 | 4.75 | 1.87 | 18 | 3 | 2 |
| | 2 Ab | 2.61 | 4.86 | 1.18 | 0.01 | 0.24 | 5.5 | 4.62 | 1.77 | 19 | 3 | 2 |
| | 2 Bw | 1 | 2.08 | 1.07 | 0.29 | 0.72 | 2.6 | 1.36 | 1.36 | 7 | 2 | 2 |

Sio = Si extracted by acid oxalate
Alo = extracted by acid oxalate
Feo = extracted by acid oxalate
Fep = Fe extracted by phyrophosphate
Alp = extracted by phyrophosphate
All = allophane
Imm = immogolite
Fer = ferryhidrite

## Qualitatitive mineralogical analyses with XRD

The XRD analyses indicated that the soils have the quite similar reflection consist of feldspar (0.376, 0.363, 0.321, 0.315 nm), crystoballite (0.405, 0.252 nm), gibbsite (0.485, 0.438 nm), ferrihydrite (0.212, 0.195 nm) and quartz (0.425, 0.334 0. 245, 0.228, 0.181, 0.154 nm). These reflections can be seen in the Figure 2.

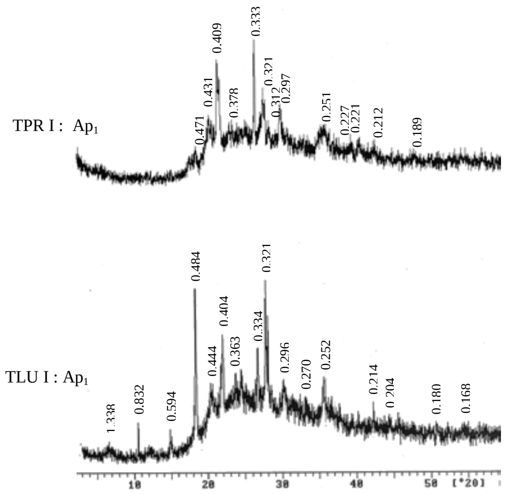


Figure 2. The reflection of profile TPR and TLU

The differences of the profiles were seen from the 1:1 and 2:1 crystalline minerals as can be seen in the Figure 3 and 4.

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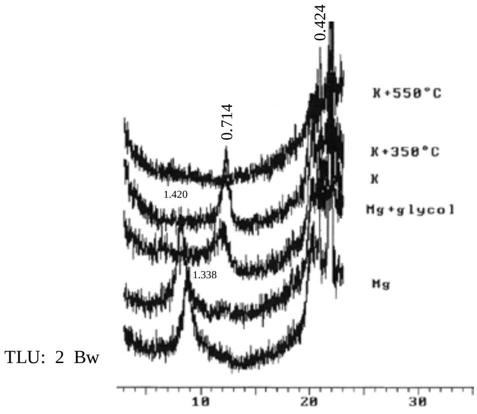


Figure 3. The reflection of mineral 1:1 and 2:1 after the treatment of oxalate, and the saturation of Mg, Mg+glycol and heated at 350 $^0$C dan 550 $^0$C of TLU profile

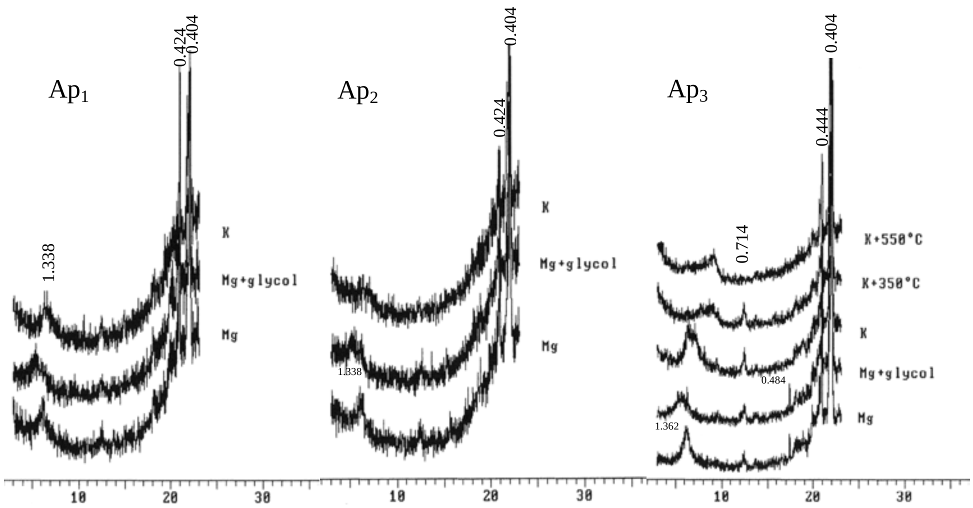


Figure 4. The change of reflection after the treatments of TPR profile

## The chemical and physical characteristics

The chemical characteristics of the soils are presented in Table 5 and 6.

Table 5. The chemical and physical characteristics of the profiles TPR

| Profile | Hor | Depth | pH | CEC | Bulk Density | Organic Carbon | Alo + ½ Feo | P-retention |
|---|---|---|---|---|---|---|---|---|
| | | (cm) | | cmolkg--1 | g $cm^{-3}$ | % | % | % |
| TPR 1 | Ap 1 | 0-14 | 5.33 | 12.94 | 0.58 | 8.42 | 5.3 | 99.20 |
| | Ap 2 | 14 -22 | 5.23 | 8.86 | 0.61 | 4.71 | 3.4 | 99.70 |
| | Ap 3 | 22 - 48 | 5.18 | 17.03 | 0.71 | 4.25 | 3.5 | 99.80 |
| | BC | 48 - 58 | 5.43 | 9.86 | 0.69 | 3.84 | 3.4 | 99.10 |
| | 2 AB 1 | 58 - 87 | 5.35 | 10.42 | 0.63 | 9.28 | 3.5 | 99.60 |
| | 2 AB 2 | 87 -110 | 5.29 | 12.96 | 0.69 | 9.45 | 3.9 | 99.50 |
| | 2 BA | 110 -119 | 5.56 | 14.51 | 0.68 | 5.65 | 5.4 | 99.20 |
| | 2 Bw 1 | 119 -144 | 5.73 | 13.43 | 0.88 | 3.58 | 6.7 | 99.90 |
| | 2 Bw 2 | 144 - 162 | 5.54 | 14.26 | 0.71 | 2.62 | 5.8 | 99.80 |
| | 2 BC | 162 - 200 | 5.64 | 12.51 | 0.76 | 1.62 | 5.7 | 99.50 |
| TPR 2 | Ap 1 | 0 - 14 | 4.59 | 12.89 | 0.78 | 8.97 | 4.7 | 97.38 |
| | Ap 2 | 14 - 30 | 4.76 | 7.90 | 0.70 | 8.95 | 3.4 | 95.81 |
| | Ap 3 | 30 - 45 | 5.21 | 16.78 | 0.69 | 8.19 | 4.1 | 95.75 |
| | BA | 45 - 62 | 5.42 | 14.96 | 0.87 | 5.62 | 5.3 | 95.71 |
| | Bw 1 | 62 - 77 | 5.43 | 11.79 | 0.70 | 3.24 | 4.0 | 96.08 |
| | Bw 2 | 77 - 90 | 5.42 | 12.32 | 0.67 | 6.94 | 3.4 | 96.08 |
| | BC | 90 - 105 | 5.23 | 14.40 | 0.74 | 7.49 | 4.1 | 95.85 |
| | 2 AB 1 | 105 - 115 | 5.21 | 12.70 | 0.66 | 7.76 | 3..7 | 95.74 |
| | 2 AB 2 | 115 - 147 | 5.12 | 14.36 | 0.61 | 8.97 | 4.4 | 95.66 |
| | 2 AB 3 | 147 - 183 | 5.26 | 19.06 | 0.74 | 8.97 | 3.7 | 95.36 |
| | 2 Bwb | 183 - 200 | 5.50 | 12.81 | 0.66 | 5.62 | 4.5 | 95.65 |
| TPR 3 | Ap 1 | 0 - 13 | 4.56 | 14.17 | 0.72 | 8.97 | 5.4 | 96.44 |
| | Ap 2 | 13 - 32 | 4.76 | 17.95 | 0.65 | 7.76 | 6.1 | 95.99 |
| | BC | 32 - 45 | 4.92 | 14.21 | 0.72 | 5.34 | 5.7 | 96.51 |
| | 2 Ab 1 | 45 - 71 | 4.97 | 17.09 | 0.72 | 7.64 | 5.1 | 96.22 |
| | 2 BA | 71 - 78 | 5.13 | 16.52 | 0.67 | 7.41 | 3.5 | 96.21 |
| | 2 Bw 1 | 78 - 126 | 5.06 | 8.96 | 0.71 | 6.86 | 4.1 | 96.01 |
| | 2 Bw 2 | 126 - 144 | 5.04 | 19.00 | 0.68 | 1.64 | 5.1 | 96.35 |
| | 2 Bw 3 | 144 - 164 | 4.71 | 18.05 | 0.76 | 2.54 | 3.4 | 96.09 |
| | 2 Bw 4 | 164 - 172 | 4.69 | 17.96 | 0.71 | 2.57 | 4.5 | 96.28 |
| | 2 BC 1 | 172 - 184 | 4.38 | 15.34 | 0.81 | 1.60 | 5.4 | 96.30 |
| | 2 BC 2 | 184 - 200 | 5.23 | 14.52 | 0.84 | 1.79 | 4.6 | 96.22 |

Table 6. The chemical and physical characteristics of profiles TLU

| Profil | Horizon | Depth (cm) | pH | CEC cmolkg$^{-1}$ | Bulk density g cm$^{-3}$ | Organic Carbon % | Alo + ½ Feo % | P-retention % |
|---|---|---|---|---|---|---|---|---|
| TLU 1 | Ap 1 | 0 - 7 | 5.25 | 21.94 | 0.62 | 9.48 | 4.7 | 96.73 |
| | Ap 2 | 7 - 18 | 5.53 | 17.31 | 0.60 | 9.83 | 3.9 | 96.38 |
| | Ap 3 | 18 - 31 | 5.44 | 14.86 | 0.64 | 6.71 | 4.8 | 96.45 |
| | Bw 1 | 31 - 57 | 6.25 | 21.19 | 0.63 | 6.20 | 5.2 | 96.57 |
| | Bw 2 | 57 - 70 | 6.22 | 21.39 | 0.69 | 5.93 | 4.5 | 96.52 |
| | Bt 1 | 70 - 79 | 6.07 | 21.82 | 0.66 | 5.58 | 4.4 | 96.44 |
| | Bt 2 | 79 - 90 | 5.67 | 19.61 | 0.65 | 4.72 | 5.1 | 96.50 |
| | BC 1 | 90 - 116 | 5.81 | 10.93 | 0.72 | 3.55 | 5.7 | 96.48 |
| | CB | 116 - 135 | 5.78 | 22.61 | 0.80 | 6.01 | 6.4 | 96.47 |
| | 2 AB 1 | 135 - 148 | 5.34 | 19.19 | 0.74 | 4.21 | 5.7 | 96.42 |
| | 2 Bw 1 | 148 - 162 | 5.48 | 18.08 | 0.76 | 2.85 | 5.5 | 96.37 |
| | 2 Bw 2 | 162 - 200 | 5.91 | 20.22 | 0.64 | 3.32 | 2.6 | 96.33 |
| TLU 2 | Ap 1 | 0 - 7 | 5.74 | 19.88 | 0.67 | 7.34 | 4.8 | 98.80 |
| | Ap 2 | 7 - 12 | 5.95 | 21.71 | 0.75 | 6.53 | 5.2 | 97.40 |
| | AB | 27 - 12 | 6.18 | 17.02 | 0.62 | 3.62 | 4.5 | 99.30 |
| | Bw 1 | 27 - 37 | 6.40 | 18.27 | 0.71 | 3.18 | 4.4 | 99.40 |
| | Bw 2 | 37 - 46 | 6.46 | 21.27 | 0.65 | 2.83 | 5.1 | 99.30 |
| | Bw 3 | 46 - 58 | 6.71 | 26.95 | 0.64 | 2.10 | 5.7 | 98.90 |
| | Bt 1 | 58 - 80 | 6.50 | 21.02 | 0.66 | 1.71 | 6.4 | 99.10 |
| | Bt 2 | 80 - 99 | 6.52 | 20.08 | 0.72 | 1.47 | 5.7 | 99.20 |
| | BC | 99 - 114 | 6.52 | 19.46 | 0.65 | 1.06 | 5.5 | 99.90 |
| | 2 AB 1 | 114 - 130 | 6.63 | 15.58 | 0.72 | 1.00 | 5.4 | 99.40 |
| | 2 AB 2 | 130 - 156 | 6.48 | 19.39 | 0.71 | 0.84 | 6.1 | 99.70 |
| | 2 Bw 1 | 156 - 200 | 6.19 | 20.33 | 0.67 | 0.61 | 5.7 | 98.90 |
| TLU 3 | Ap 1 | 0 - 11 | 5.97 | 23.27 | 0.76 | 10.14 | 4.1 | 96.31 |
| | Ap 2 | 11 - 19 | 5.40 | 19.13 | 0.68 | 8.66 | 3.6 | 96.52 |
| | AB | 19 - 30 | 5.47 | 18.04 | 0.59 | 9.98 | 4.3 | 96.19 |
| | Bw 1 | 30 - 51 | 5.83 | 23.99 | 0.64 | 8.66 | 4.1 | 96.29 |
| | Bw 2 | 51 - 65 | 6.30 | 15.48 | 0.56 | 7.33 | 3.9 | 96.44 |
| | Bt | 65 - 75 | 6.41 | 20.17 | 0.74 | 5.27 | 4.1 | 96.44 |
| | BC | 75 - 92 | 6.43 | 11.89 | 0.71 | 7.45 | 4.4 | 96.60 |
| | 2 AB 1 | 92 - 109 | 6.50 | 21.73 | 0.73 | 4.76 | 4.6 | 96.55 |
| | 2 AB 2 | 109 - 126 | 6.70 | 19.31 | 0.77 | 6.05 | 5.1 | 96.45 |
| | 2 Bw 1 | 126 - 158 | 6.51 | 12.06 | 0.83 | 5.97 | 5.0 | 96.52 |
| | 2 Bw 2 | 158 - 173 | 6.25 | 22.20 | 0.74 | 6.20 | 4.4 | 96.51 |
| | **2 Bt** | 173 - 200 | 5.91 | 23.12 | 0.76 | 4.52 | 3.8 | 96.27 |

Table 5 and 6 show the physical and chemical characteristics of the soils from both locations. The data indicate that the soil pH in TPR (4.38 – 5.50) are lower than the pH in TLU (5.40 – 6.71). This trend is in relation with the nature of the parent material of these soils. Soil in TPR

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derived from andesit parent materials which have the lower pH than basalt parent materials. The values CEC are followed by the value of the CEC, where the soils derived from andesit parent materials have lower CEC than the soils derived from basaltic parent material. As the soils with variable charge, besides be influenced by the parent materials, the values of CEC are depending on the value of the soil pH. The lower the pH give the lower CEC as well, and vice versa.

Another data on the Table 5 and 6 inform about the organic carbon, bulk density, Al and Fe extracted by acid oxalate (Alo + ½ Feo), and P retention. These data are required for an indication of the presence of andic soil properties of these soils. Andic soil properties are the properties involved with the soils derived from volcanic parent materials. Having the andic soil properties, the soils must have bulk density less than 0.9 $gcm^{-3}$ , organic carbon less than 20 %, Alo + ½ Feo more than 2 % and P-retenion more than 85 %. The soils in TPR and TLU which developed from the different nature of parent materials and ages, however, fullfiled all the requirements for andic soil properties, and therefore, can be classified as Andisols (Soil Survey Staff, 2010).

The soil classifications to the lower categories (family) are presented in Table 7.

Table 7. Soil classification refer to Soil Survey Staff, 2010.

| **Profile** | **Classification** |
|---|---|
| **TPR 1** | Typic Hapludand, medial, amorph, isohyperthermic |
| **TPR 2** | Typic Hapludand, medial, amorph, isohyperthermic |
| **TPR 3** | Typic Hapludand, medial, amorph, isohyperthermic |
| **TLU 1** | Ultic Fulvudand, medial, amorph, isohyperthermic |
| **TLU 2** | Ultic Hapludand, medial, amorph, isohyperthermic |
| **TLU 3** | Ultic Fulvudand, medial, amorph, isohyperthermic |

## Conclusions

The soils developed on volcanic materials in West Java, Indonesia showed the difference in the morphological, mineralogical, physical and chemical composition related to their parent materials and ages. However, all of the soils fulfilled the requirements of andic soil properties and therefore, can be classified as Andisols.

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