Mineralogy and Micromorphology Characteristic of Vertisol Lying on Limestone Parent Rocks at Jeneponto District of South Sulawesi Province, Indonesia

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Abstract: The objective of this is paper is to determine the mineralogy and micromorphology characteristics of vertisol in the limestone parent rock at Jeneponto district of South Sulawesi Province, Indonesia. The pedons represent deposits of volcanoes basalt. The study consisted of field and laboratory research. Field research comprises of soil profile descriptions and soil sampling, while laboratory analysis consists of clay minerals analysis using X-rays, as well as sand and rock mineral. Micromorphology analysis undisturbed soil samples were taken from identifiable horizon for thin section preparation. X-ray analysis revealed that clay minerals of the vertisol mainly consists of montmorillonite group. While the mineral composition of parent rock (limestone) generally consists of foraminifera fossil, calcite, dolomite, clay minerals, orthoclase, opaque minerals and quartz. The mineralogy of sand fraction generally consists of easily weathered minerals like pyroxene, feldspar, hornblende, plagioclase, biotite and hard weathered mineral (quartz and opaque). Soil micromorphology analysis revealed that raw material, in general is dominated by coarse material which is consist of quartz mineral mixed with other minerals such as pyroxene and plagioclase. On the other hand, organic coarse-sized components are not found and the microstructure of the soil is generally in the loose form (massive), and the type of soil pore vary from vugh to channels pore.

Keywords: Vertisols; montmorillonite; vugh and channels pore

1. Introduction

Mineralogy and micromorphology are important soil properties since they influence the other properties of the soil. Vertisol is one of the specific soil with vertic properties, they are difficult to work, being hard when dry and very sticky when wet. Vertisol can be highly productive but usually present management problems. Some researches of vertisol mineralogy in all parts of the world found that vertisol is mainly dominated by smectite, especially montmorillonite (Ahmad and Jones, 1969; Ixon, 1982; Dudal and Eswaran, 1988; Wilding and Tessier, 1988; Blokhuis *et al*., 1990; Buhman and Schoeman, 1995; Eswaran *et al*., 1999; Shirsath *et al*., 2000, Heidari *et al*, 2008). Some researches also found mixed minerals in vertisol. Agusman (2006) found a mixture of the montmorillonite and kaolinite mineral in the vertisol in Gunungkidul yogyakarta, while Shirsath *et al.* (2000) found a mixture of kaolinite, vermiculite and chlorit in the vertisol in Ghana. Besides that, other study results also found palygorskite minerals in vertisol (Khademi and Mermut, 1999; Khormali and Abtahi, 2003).

Many soil mineralogical vertisols studies usually determined clay fraction but sand and rock fraction are limited. Actually, this data can used to know fertility status in vertisols. Micromorphology studies have been conducted and published especially on ultisols, oxisols, spodosols and paleosols (Goenadi and Tan, 1989a and 1989b). However, researches on vertisols are still rare. Micromorphology promises a more definitive identification of all the processes involved in the formation of the soil types and can be applied on various aspects that include soil physics, soil chemistry and soil biology. Furthermore, it is widely used in archeology, ecology, geology and soil mechanics (Bullock *et al.,* 1985).

In order to appreciate the management related properties of vertisols, it is necessary to know mineralogy and micromorphology properties. The research results of the mineralogical study of vertisol can be used as a basis for information management of vertisol. Mineral is the main component of a soil which is closely related to soil fertility potential and soil management strategies (Nursyamsi *et al,* 2005). Besides mineralogy, the study of micromorphology is also very important because it can identify all the processes involved in the formation of vertisol.

2. Materials and Methods

2.1 Location and Description of Study Area

The soils from different land system lying on limestone parent rocks of Tonasa Formation in Jeneponto Dystrict, South Sulawesi, Indonesia. BRA (Baraja) land system represented by pedon T1P1, T2P3 and T3P1 (Basaltic, karstic terrain, flat to wavy (2-8 %) slope, relief 2–10m, consists of limestone rock and marl). KAS (Kasusu) land system represented by pedon T2P1 (Basaltic, karstic terrain, wavy to hilly (41-60%) slope, relief 11-50m, consits of limestone rock and napal) whereas PLU land system represented by pedon T3P3 (Basaltic, non-volcanic alluvial fan of slope (2-8%), relief < 2m, an alluvium and alluvial fan sediments). BRU (Beru) land system represented by pedon T2P2 (flat terain in napal and limestone rock, (2-8%) slope, relief 2-10m, consist of napal and limestone rock).

2.2 Materials and Methods

The research was conducted in two stages namely field research and laboratory analyses. The materials used in the research were six pedon which have been observed and described based on the Guidelines For Soil Description (FAO, 1990).

Soil mineralogy analysis was conducted on clay and sand fractions. Clay fractions are separated by filtration and pippete methods. Mineral of sand fraction was determined by cross thread method under a polarizing microscope, while the clay fraction mineral analysis was conducted by X-ray Diffractometer, determination of mineral clay fraction was carried out after saturation with ethylene glycole. Rock minerals analysis was done in the bed rock that oversees with thin section method.

Soil samples for micromorphology analysis was taken with an aluminum box with the size of 40 x 65 x 40 mm^3 in some selected horizons. The process of making a thin slice of soil (thin section), from drying, saturation with resin, cutting, thin slice preparations were conducted by the Benyarku and Stoops method (1995).

Preparation of the soil thin sections involved hardening of the samples by impregnation. Observations of the undisturbed samples were made with the naked eye, a magnifier lens, binocular stereomicroscope, polarization microscope and scanning electron microscope. The terminology and concepts of the handbook for Soil Thin Section Description (Bullock *et al.,* 1985) were used a basic reference, with a few modifications.

3. Results and Discussion

3.1 Characteristics of Soil Mineralogy

3.1.1 Mineralogy of sand fraction

Mineral analysis of sand fraction included opaque minerals. Associated mineral was determined by the type of the dominant mineral. The mineralogy of sand fraction generally consists of easily weathered minerals like pyroxene, feldspar, hornblende, plagioclase, biotite and hard weathered mineral (quartz and opaque). Mineral textures (afanitic), the soil parent material was classified as volcanic basalt parent material. Easily weathered minerals contained in the soil indicates a higher nutrient reserves, however dominance resistant minerals such as T2P1 profiles showed poor nutrient reserves.

3.1.2 Mineralogy of clay fraction

The results of clay analysis showed that the composition of clay minerals through out the all pedon is dominated by the same mineral which is montmorillonite, characterized by a strong first peak basal (14^{o}A) and expand into (17^{o}A) when preparations were given a solution of ethylene glycol, second and third basal will show the wavelength 7^{o}A and 3.5 ^{o}A. The soil dominated by montmorillonite mineral indicated that weathering environment is rich in bases and high pH and poorly drained. Hence, the position of the environment in the valley area allows the accumulation of bases.

3.1.3 Mineralogy of rocks

Based on the composition of composed minerals the rock is classified into the carbonate class. The mineral composition of parent rock (limestone) generally consists of foraminifera fossil, calcite, dolomite, clay minerals, orthoclase, opaque minerals and quartz. In the T2P1 and T2P2 profiles, mineral materials may be formed biologically such as by organisms (foraminifera shells) and leaves the rest of the fossil on rock. The T1P1, T2P1, T3P3 profiles also contained primary minerals of volcanic activity so that limestone may be formed from sediments of the changing of igneous rocks deposited in the marine environment.

3.2 Characteristics of Soil Micromorphology

Study of soil micromorphology consisted of coarse sized mineral components, organic components soil fabric, microstructure and pedological features. The results of observations showed the coarse material is generally dominated by the quartz mineral mixed with other minerals such as pyroxene and plagioclase except T2P3 and T3P1 only discovered quarzt mineral. The presence of plagioclase and pyroxene minerals indicate that soil parent material derived from new volcanic sediments and from volcanic eruptions as well (Fauzi *et al.,* 2004).

Quartz is the most stable mineral and difficult to weather so that if it is found in the soil pack it means that the soil parent material is composed of materials deposited some distance a way from the source resulting in minerals that tend to form an angled and rounded shape.

Newly formed minerals occured during the process of soil formation, mainly found on the T1P1 profile (horizon Aw) in the form of iron oxide (magnetite). New formations in the form of iron oxide is the result of several gleization processes.

Raw organic component was not found, which indicated that the decomposition of organic matter was in advanced so that organo mineral component formed on the smooth pack component. Clay and sandy clay minerals found in the smooth component pack can not be categorized as argillan because it has a low level of uniformity as a result of the soil turbation.

Soil microstructure is generally not in the form (massive) due to high clay content. The soil pore varies from hollow on vugh (A & B horizon T1P1, T2P1, T2P2, T2P3, T3P3) to a pore channel (T3P1). Vugh pore generally forms in the soil structure composed of particles of the fine fraction which has a great power of cohesion and adhesion. Vugh can also be formed by the cementation of primary particles while the channel pore formed by the activity of vegetation and animals in the soil, and also as residue of rooted or insect holes.

Pedological feature of the whole profile is Tipic. Tipic included in the nodule group that was formed pedological feature which was not associated with pores, mineral and aggregate but it because of the influence of wetting and drying soil.

4. Conclusion

Dominant mineral (feldspar and pyroxene) and additional minerals (quartz, hornblende, biotite) are present in limestone parent rocks While the dominant mineral in the clay fraction is montmorillonite and rock fraction is classified into the carbonate class. Track of soil formation processes are not too visible on the microstructure of the soil due to the high clay content of the soil so that clay membranes are difficult to identify. The results of mineralogical and micromorphological studies indicated that the soil have mineral grains in pedon originated from younger parent material. Thus, the base saturation is high, whichmeans that the vertisols are considered as the most fertile soils. Although natural fertility is high, vertic properties impose critical limitations on low-input agriculture. Montmorillonite is responsible for the general attributes of the soils and their vertic properties. One technique that mitigates the problem is the surface addition of mulch or non-Vertisol soils, preferably sandy materials. Basaltic parent material is derived from transported material and the presence of montmorillonite is prone to cause soil erosion.

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