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## Mineralogy and micromorphology of soil from gneissic rock in East Luwu, South Sulawesi

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## 5 Mineralogy and micromorphology of soil from gneissic rock in East Luwu, South Sulawesi

A Ahmad<sup>1\*</sup>, C Lopulisa<sup>1</sup>, A M Imran<sup>2</sup>, S Baja<sup>1</sup>

<sup>1</sup>Department of Soil Science, Agriculture Faculty, Hasanuddin University, Makassar, Indonesia

<sup>2</sup>Department of Geological Engineering, Engineering Faculty, Hasanuddin University, Indonesia

\*Address: Kampus Unhas, Jl Perintis Kemerdekaan Km.10, Postal Code: 90245, Makassar, South Sulawesi Province, Indonesia

asmitaahmad@yahoo.com or asmita.ahmad@agri.unhas.ac.id

**Abstract.** Different type of rock, climate, and topography will produce specific mineralogical and micromorphological characteristic in soils. There were still a few research related to the influenced of several types of rocks to soil mineralogy and micromorphology, especially from metamorphic rocks. The objective of this research was to examine the characteristics of mineralogical and micromorphological of soil formed from gneissic rock in East Luwu, South Sulawesi. The observation of soil profiles were carried out in four profiles. The mineralogical analysis was carried out by X-ray diffractometer, and micromorphological analysis was carried out by using the thin section. Gneissic rock consisted of quartz-gneiss and muscovite-quartz gneiss. Minerals in the soil had mesomorphous alteration stage with class of alteration of 2<sup>nd</sup> and 3<sup>rd</sup> that had been altering in 25-75%. The minerals were quartz, goethite, muscovite, gibbsite, hematite, boehmite, and ilmenite. Alteration mineral formed sesquioxide horizon in soil. The high intensity of weathering of gneissic rock was influenced by the high intensity of rainfall, reached 3389mm/year. Nodules as the weathering product dominated in typic soil type. The c/f related distribution was enaulic, related distribution was porphyric and b-fabrics were granostriated and stippled speckled. High content of oxide mineral with stippled speckled b-fabric showed the advanced stage of pedogenesis process from the gneissic rock.

### 1. Introduction

Different type of rock, climate, and topography will produce specific mineralogical and micromorphological characteristic in soil [1–3], mainly in the tropical region [4,5]. East Luwu in South Sulawesi Province, Indonesia, included in the tropical climate region with the standardized precipitation index (SPI) value classified as wet with a value of 1-1.49 [6]. This condition causes the weathering process of the parent rock to become soil was faster. One way to assess the level of soil development by analyzing the mineralogical and micromorphological content of the soil has been



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formed [7,8]. Information on mineralogical and micromorphological characteristics in the soil has been widely used by several experts in assessing soil fertility and soil management [9–12]. However, the majority of these assessments are still few relationship to the soil characteristic of the parent rock or vice versa, therefore some of the land–uses actually trigger disasters [13,14]. Areas that are composed of massive parent rocks (igneous and metamorphic rock) are considered as areas that are little prone to disasters and can be used for agricultural and plantation without specific management; has led to many landslides such as in the East Luwu Region. Almost each year landslide happened and caused many victims and damage [15].

There were still few research concerning the influenced of several rock types to the soil mineralogical and micromorphological characteristics, especially from metamorphic rocks. This research aimed to examine the characteristics of mineralogical and micromorphological characteristics of the soil that formed from gneissic rock in East Luwu, South Sulawesi.

## 2. Materials and Methods

Study site of this research was located in Mangkutana Sub-District, East Luwu District of South Sulawesi Province (Figure 1). The location of four soil profiles and four rock profiles were; 120°48'0.72"E and 2°22'57.06"S (L1), 120°48'4.33"E and 2°22'59.49"S (L2), 120°47'40.19"E and 2°22'23.46"S (L3), and 120°47'36.1"E and 2°22'25.26"S (L4). The soil sampling for mineralogical and micromorphological analyses were taken at two depths: 0-30 cm (top layer) and 30-50 cm (sublayer), while the rock profiles were taken at three part of depth, namely; the top (under the soil depth/after C horizon) from 1.5 m to 6.5 m depth, middle from 6.5 to 11.5 depth, and bottom from 101.5 to 16.5 m depth.

The rock grade of weathering was analyzed with Santi (2006) method. The soil minerals were analyzed with X-ray Diffractometer (XRD-700 Shimadzu) and polarized microscope to identify clay and non-clay minerals. Identification of clay and non-clay minerals used Kerr (1959) and Grim (1968) method. Micromorphological procedures were done by impregnated the soil and rock blocks about 3 cm diameter with polyester resin and their respective thin sections were made following the procedures of Benyarku and Stoops, (2005). The thin sections were studied with polarizing microscope according to Bullock *et al.* (1985), Stoops (2003), and Kerr (1959) guidelines, paying attention to microstructure, pore type, groundmass composition, and specific pedofeatures. FitzPatrick (1993) was also used to make interpretations of some features.

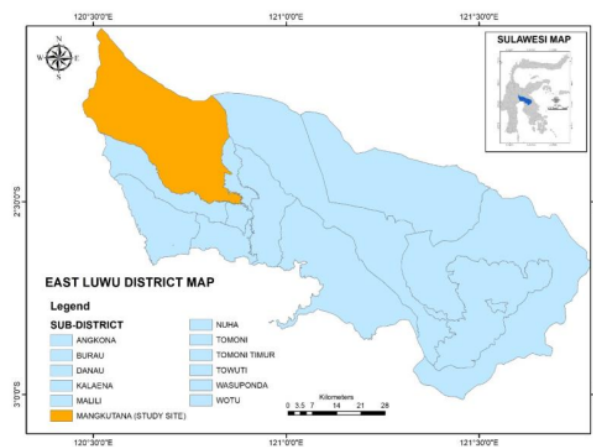


Figure 1. Location of the study site

### 2.1. Terrain Characteristic

According to Simandjuntak *et al.* (1991), there are two mountains ranges namely the Tineba Mountains and the Koro-Ue Mountains extending from northwest to southeast in the western part of East Luwu District, with altitudes about 700-3016 meters above sea level (asl) and formed by granite and metamorphic rocks from Pompangeo Complex (MTmp Formation). The MTmp Formation consisted of schist, gneiss, marble, quartzite, slate, and fillite. The area in Mangkutana Sub-district in East Luwu District had elevations of 181-320 meters asl and slope range from 41 to > more than 60%. The geologic of this area was dominated by gneissic rock, namely quartz-gneiss and muscovite-quartz gneiss.

The land system of this area was Bukit Pandan (BPD) [24]. Characteristics of BPD were hilly to mountainous geomorphology, metamorphic parent rock, 0-8 months of wet months, 0-4 months of dry months, no flood risk, 17-22°C of minimum temperature and 27-33°C of maximum temperature. The average rainfall data for ten years was 3566 mm/year [25,26]. The minimum rainfall was 3000 mm/year and the maximum rainfall was 4811 mm/year (Figure 2). Land use of this area dominated by palm plantation and mixed plant.

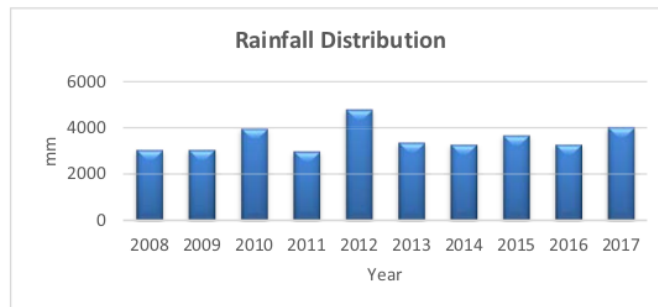


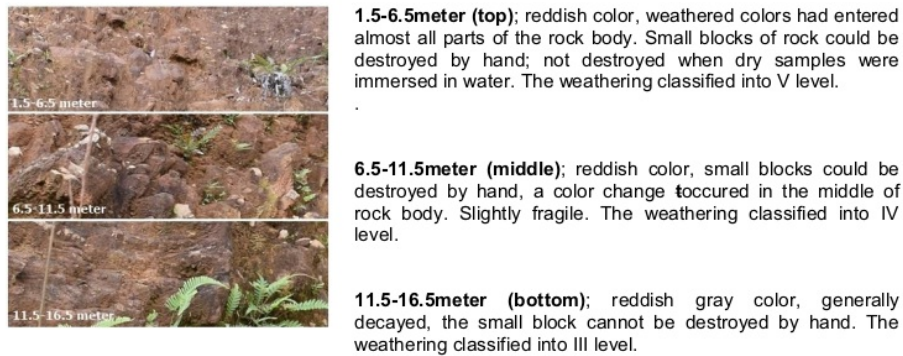
Figure 2. Rainfall distribution for ten years in Mangkutana Sub District

The soils had a reddish brown color showed the high level of iron oxide in the soil resulted from a very strong weathering process [27]. In the subhorizon layer an oxic horizon had been formed, characterized by sandy clay to sandy clay loam texture, 16.12 to 16.31 cmol+/kg of CEC (1N NH<sub>4</sub>Oac pH7), more than 35% of base saturation, and the domination of kaolinite in clay mineral. The soil was classified as Kaolinitic Inceptic Eutrudox.

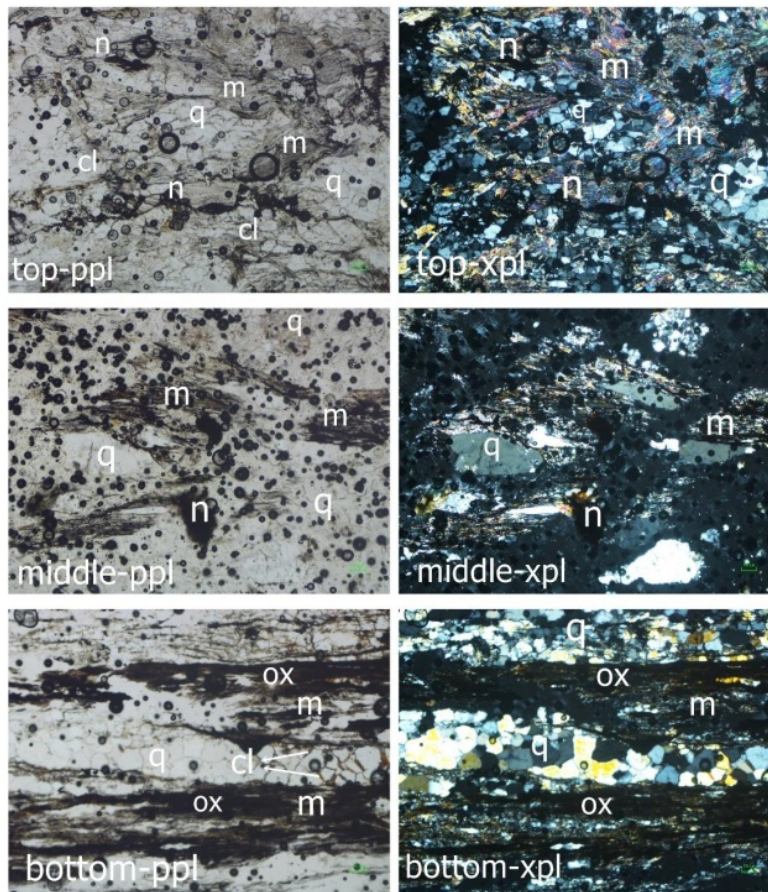
### 3. Result

The gneiss rock had III to V level of weathering and the color changed from reddish gray to reddish (Figure 3). Thin section of rocks sample showed nodule formation in all profiles, but only at the bottom of rock profiles showed coating of clay minerals at the edges of primary mineral crystals, while the imperfect formation of oxide minerals (imperfect infilling) was often found in the bottom layers of the profile (Figure 4).

The soil mineral consisted of quartz (50.7%), kaolinite (10.6%), muscovite (16.6%), gibbsite (2.9%), hematite (8.7%), and ilmenite (10.6%) (Figure 5 and Figure 6).



**Figure 3.** Weathering level of gneiss rock in studying site



**Figure 4.** Appearance rock profiles showed the nodule formation in all profiles description; q (quartz), m (muscovite), n (nodules), ox (oxide minerals), cl (clay minerals)). Magnification 10x.

Micro morphology of soil showed 3/2 c/f ratio at top and sublayer, with weak development of soil structure. High slope, rainfall and human activity in this area caused pore dynamic that destroyed the soil structure [28]. The minerals had mesomorphous alteration stage. The class of alterations were 2 and 3 and alteration minerals were 25-75%. Nodules as one of alteration product dominated with typical type to show the intense of redox process in the soil. The soil had enaulic c/f related distribution and smaller unit aggregates consisted of quartz and muscovite minerals (Tabel 1 and Fig. 7). Varied fabric types and common clay coating showed intensive weathering and clay illuviation in this area together with redoximorphic features. The reddish color of the micromass indicated that a gleyic stage is was not reached.

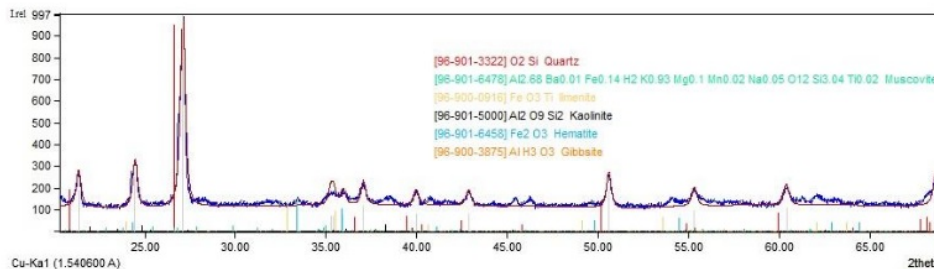


Figure 5. Graphic pattern minerals of soil from muscovite-quartz gneiss

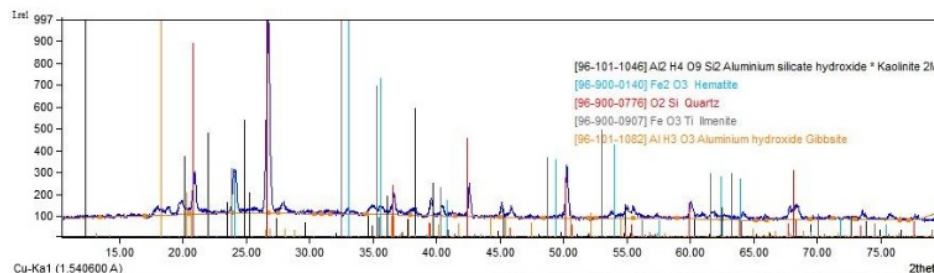
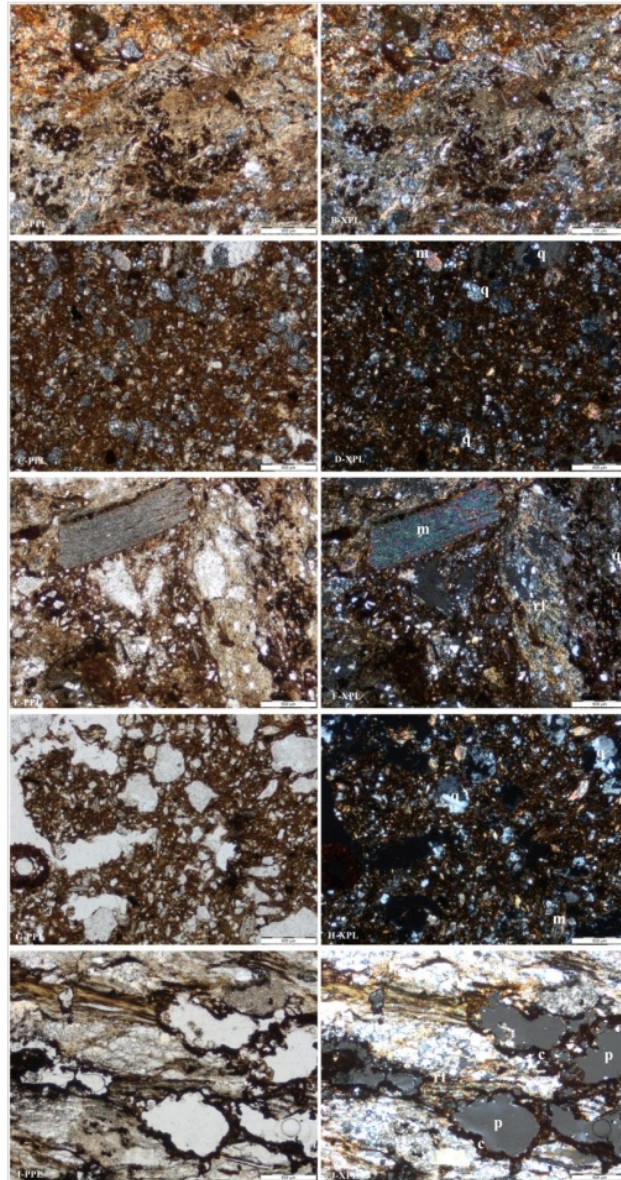
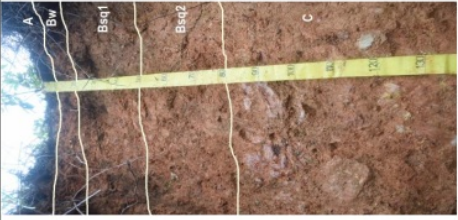


Figure 6. Graphic pattern minerals of soil from quartz gneiss



**Figure 7.** Micromorphological characteristic showed enaulic related distribution (A-B), porphyric, c/f ratio (C-D), granostriated b-fabric and mineral weathering (E-F), stippled speckled b-fabric (G-H), and silt and clay coatings (I-J). caption; m: muscovite, q: quartz, p: pore, rf: rock fragment. Size 500 $\mu$ m.

**Table 1. Soil micromorphology characteristic**

Profile	Layer	Groundmass				Micromorphology characteristic								
		limit	cf ratio	related distribution	color	Micromass composition	b-fabric	C coarse component	Structure	type	Diameter size	Porosity abundance	accommodation	Pedofeatures
	Top	2 $\mu$	3/2	Emulic and porphyric	Reddish brown	Clay and oxide	Stipple speckle, slightly granular and strained	Quartz; size 2-10 $\mu$ , anhedral shape; abundance 30% Gneiss rock fragment; size 24-50 $\mu$ , abundance 20% Quartzite rock fragment; size 12-30 $\mu$ , abundance 30% Muscovite; size 5-9 $\mu$ , abundance 15%, mesomorphous alteration	Clay and oxide	Weak structure and weak sub-angular blocky	Weak channeled	10%		Nodule; disorthic, moderately - strongly impregnated with oxide minerals; type and nodule type
	Sub	5 $\mu$	3/2	Emulic	Reddish yellowish brown	Clay, silt, and oxide	Mosaic speckle, granular, poro-strained, and uniserial	Quartz; size 2-15 $\mu$ , anhedral shape; abundance 30% Gneiss rock fragment; size 20->50 $\mu$ , abundance 20% Quartzite rock fragment; size 10->50 $\mu$ , abundance 25% Muscovite; size 10-30 $\mu$ , anhedral shape; abundance 10%, mesomorphous alteration	Clay, silt, and oxide	Weak structure	-	-		Nodule; disorthic, strongly impregnated with oxide minerals; type Coating: coating in pores with clay and oxide, the textural of the coating was impure clay coating The excrements have ellipsoids type

#### 4. Discussion

Weathering of gneissic rocks showed a high level of weathering with oxide mineral content and increasing of clay fraction as a weathering product. The presence of clay coating on primary minerals reduced rock stability and triggered the mass movement in sloping areas. [5,29], therefore the slope stability was needed to maintain the stability for land sustainability.

Weathering minerals in soil had destroyed the stability of primary mineral and produced clay minerals and oxide mineral. High intensity of weathering could be seen in high accumulation of clay fraction in groundmass and the model in micro mass (Fig. 7). The dominant mineral such as quartz, kaolinite and iron oxide, especially gibbsite showed that soil had advanced stage processes [1,30], and had formed sesquioxide horizon. Land management in this condition needed the additions of organic fertilizer and lime as the most appropriate soil management options[31,32].

The soil micro mass contained clay fraction and separately associated with oxide and silt fraction. Striated b-fabric in the sublayer with clay oxide (Fig. 6), caused friction intergrain and increased shear stress and reduced the shear strength of grain [27,33,34]. According to Drees *et al.*, (2003) b-fabric striated indicative shear failure of a soil mass. Type of striated b-fabric in the sublayer become more varied with clay illuviation from the top layer and mineral weathering in the sublayer. Clay coating in pores had reduced the porosity and percolation as found in the soil of Ishia, Italy that triggered the landslide [36].

#### 5. Conclusions

The high content of oxide mineral with striated b-fabric showed the advanced stage of pedogenesis process from the gneissic rock. Striated b-fabric in the sublayer with clay oxide could cause friction and trigger disaster.

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