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Nature and Plasticity of Residual Soil in Relation to the Landslide Susceptibility at Marioriwawo, South Sulawesi

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ABSTRACT

Clay minerals that make up and contain in the soft soil or soil residu, have their characteristics to express their chemical and geotechnical nature. Therefore the residual soil can affect slope stability as well as infrastructure laying on it. This study aims to assess the type and distribution of clay minerals deployment in vertical section and its relationship with the nature of the plasticity of the soil layer. The method used in this research are field observations, soil sampling includes surface and subsurface ("test pit"), Petrographic analysis, XRD analysis and Atterberg test. Chemical element concentretion indicates the presence of illite mineral (32.5% - 63.7%), vermiculite (17.2% -30.6%), kaolinite (0.0% - 12.6%), montmorillonite (6.4% -12.0%), halloysite (0.0% - 20.3%) and chlorite (0.0% - 22.1%). The plasticity test is high and has a potential deployment from moderate to high.

Keywords: Limestone, soil residu, clay mineral, plasticity

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1. INTRODUCTION

Residual soil of weathering limestone in the study area is found in hilly and mountainous regions. The area as a part of a regional mountain range extending north-south from Pare-pare down to the Maros region and Pangkep [1]. Marioriwawo as the study area is located on a range of hills, this area is an important lane where the road connects between Barru and Soppeng (Figure 1). The area experiences road-avalanche and/or landslide. The road condition is mostly coverred by irregular surfaces, and has a steep slope. The utilization of the area is residential, paddy field and plantation activities [2].

The aim of this research is to (1) assess the types and deployment characteristics of clay minerals; (2) analyze the plasticity index of clay mineral each layer, resulted from limestone; (3) understand the types of clay minerals, forming from limestone for engineering property purposes.

2. METHODS

Research methodology applied in this study is field observations and laboratory analysis. Retrieval of data from outcrop and soil residu, include color, texture, material composition, as well as rock structures also is done.

Subsurface data retrieval is taken by doing "test pit" such as thickness and mineral contents of each layer of residual soil. To identify the mineral composition of the limestone, petrographic analysis is performed. Grain size of soil samples is done to further analysis of Atterberg limits. This method is done to figure out liquid, plastic limit, and plasticity index. XRD analysis is conducted to determine the percentage of clay minerals contained in the residual soil.

3.

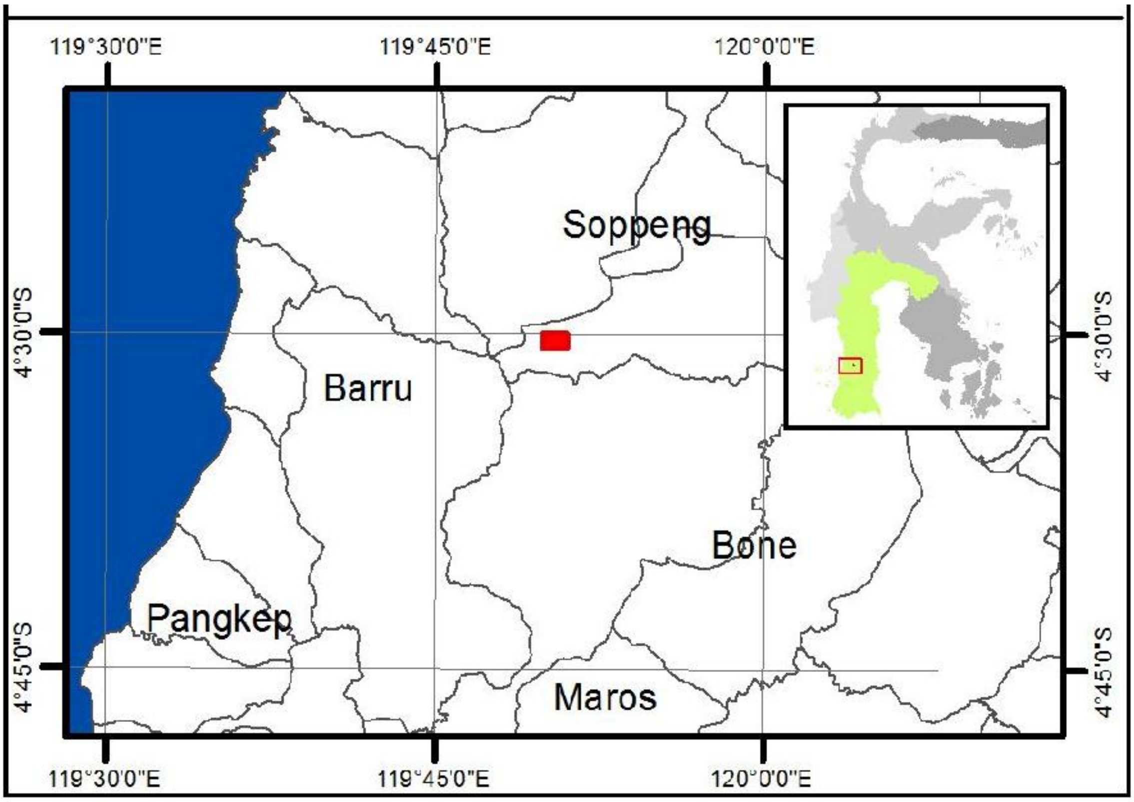

Figure 1. Map of location research (simplified from RBI Map, 1992[3])

RESULT AND DISCUSSION

A. Geologi

Morphology or landscape of research area shows high relief, undulating hilly, with slopes between 10° to 60° (Figure 2). Soil characteristics is brownish to black colour, has a coarse grained size. The conditions are interpreted as a result of weathering of limestones.

The limestone exposes widely in tis area consistes of bioclastic packstone of Dunham's classification [5]. It has white to grayish color and dark brown color in weathering (Figure 3).

Figure 2. Geomorphology (a) denudasional (b) undulating hilly/tilt.

Figure 3. Limestone Outcrop.

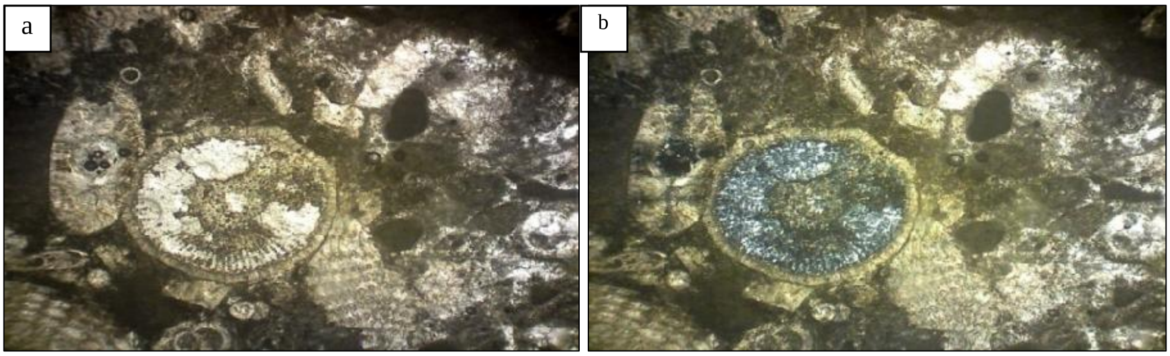

Figure 4. Limestone photomicrograph of "packstone" Rn/Btg21 (a) nikol-x, (b) nikol - //.

Petrographic analysis of bioclastic packstone [4], Rn/Btg21 and Rn/Btg22 shows bioclastics texture (Fig. 4) to fine grain texture (Fig. 5), skeletal grain components comprising of fossil foraminifera, algae and mud with lack of cements. In thin section it is shown that some minerals have undergone recristallization and dissolution [6].

B. Characteristics of Residual Soil type of Clay Mineral

Clay minerals have the basic structure consisting of silica tetrahedron and alumina octahedron [7]. Silica tetrahedron is basically a combination of silica atoms at the corners surrounded by four oxygen atoms, while alumina octahedron is a combination of a unit comprising of an alumina atom surrounded by hydroxyl atoms on the sixth side.

The basic units are united to form a sheet structure. Silica and alumina can be partially replaced by other elements. This is known as an isomorphous substance. The types of clay minerals depending on the combination of the basic structure or arrangement of the unit as well as a wide sheet piles bond between each sheet.

XRD analysis (depth from 0 to 3 m) shows a different trend. Illite and Kaolinite increase to the bottom. (Fig. 6). On the other hand vermiculite and chlorite distribution show a decreasing trend to the bottom. Different with above minerals, halloysite and montmorillonite have greatest percentage (7.1% and 20.3%) in the middle layer. The condition indicates a different water adsorption capability as As well as a different plasticity indices [8].

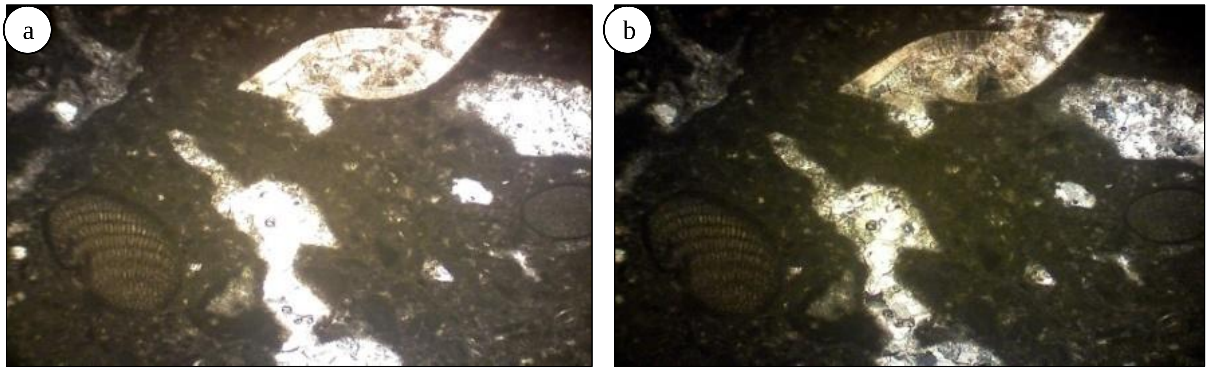

Figure 5. Limestone photomicrograph Rn/Btg22, “packstone” (a) nikol-x,(b)nikol-//.

Table 1. Chemical element analysis

Layer	Illit	Kaolinit	Montmorillonit	Vermiculit	Halloysit	Khlorit
Upper	35.5	0	12	30.6	0	22.1
Middle	32.5	8.3	7.3	19.9	20.3	11.8
Bottom	63.7	12.6	6.4	17.2	0	0

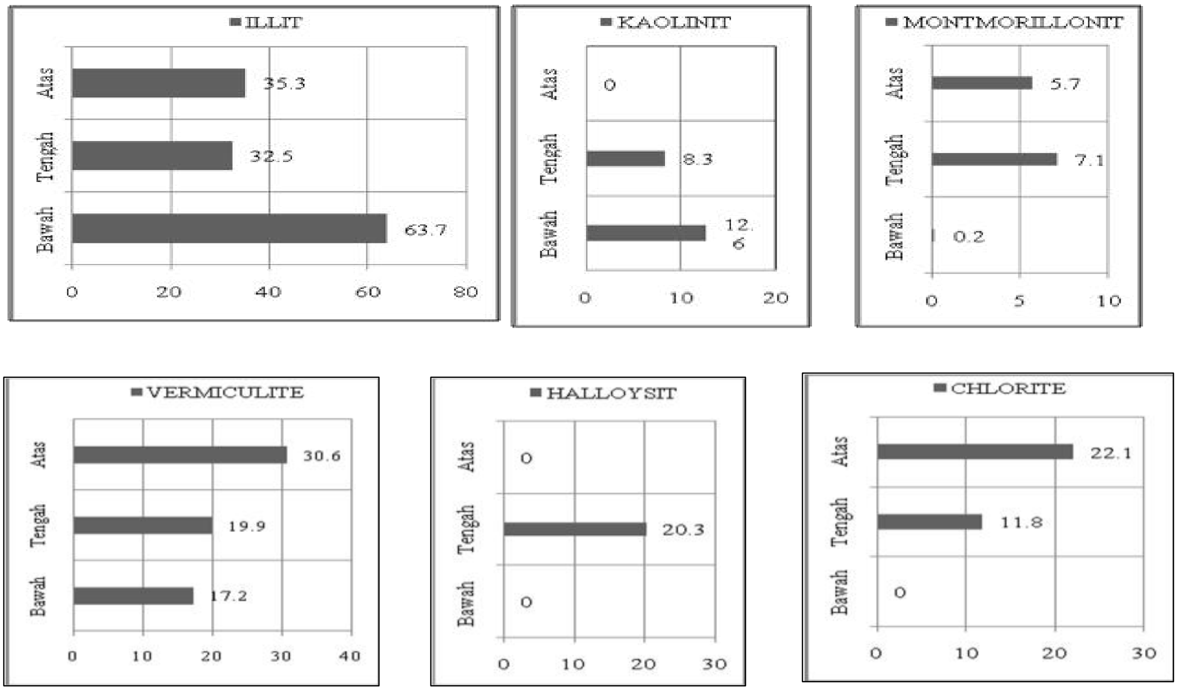

Figure 6. Distribution curve of clay mineral content.

C. Nature and Plasticity of Residual Soil

Process and rate of weathering are characterized by physical and color changes of the rocks. These changes are caused by several factors such as rock exposure, rainfall intensity, time of rock exposure, temperature [9].

Dimensional test pit with depth of 300 cm is described below (Fig.7) :

a. Top layer : topsoil, gray-brown, there are the roots of plants, grain size of silty clay and gravel, thickness ± 75 cm.
b. Middle layer : sandy silt-gravel, dark brown, silt grain size of coarse silty- sand, there are fragments of limestone, loosen and brittle with a thickness of ± 100 cm.
c. Bottom Layer : clay - sand medium, gray-brownish-black, shape of subangular grain size of clay-sand-gravel, limestone, , a thickness of ± 100 cm
d. Limestone of parent rocks

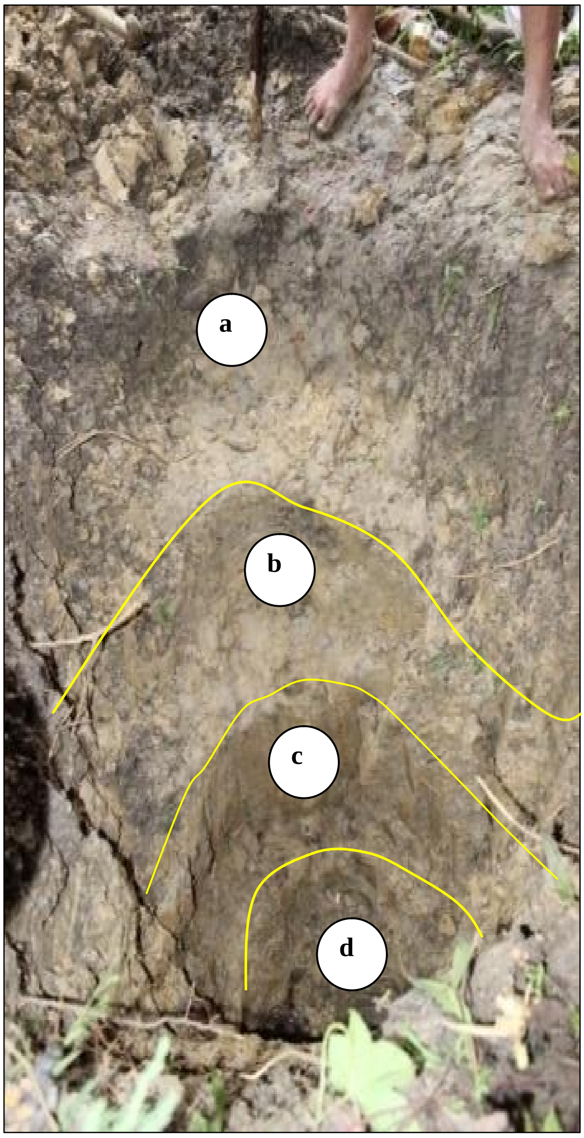

Figure 7. Vertical Profile of residual soil.

Residual soil (Fig. 8) has gray - dark brown to the bottom the residual color becomes dark brown., Its grain size is of fine sand to medium sand. It is interpreted as a result of weathering of limestone. Characteristics of soil residual from weathered limestone shows dark brown-black color in wet condition and yellowish brown in dry condition. It is hard, rigid, and stiff nature as well as sticky when gripped. It is interpreted to have a high oxidation (Figure 8).

The Atterberg test and XRD analysis show a value of plasticity index >17 (Table 2). The value relates to the expansion potential of 21.86 to 26.44 or it ranges from moderate to high [10].

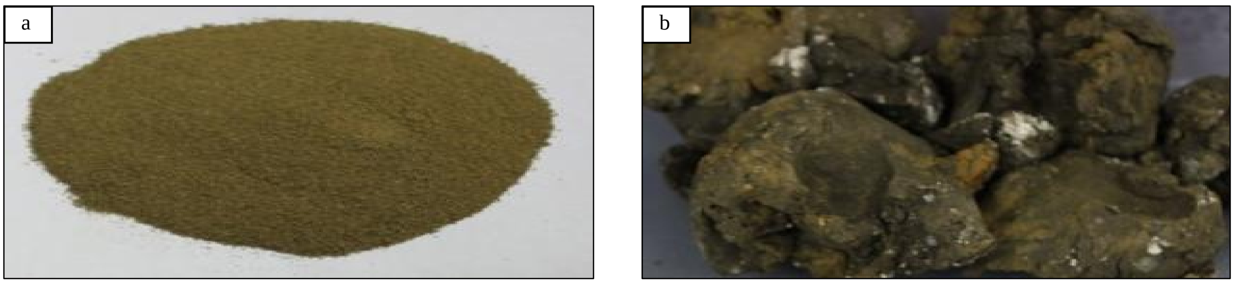

Figure 8. The appearance of residual soil color (a) wet and (b) dry.

Table 2. Atterberg Test of the soil residual

Depth	Top layer		Middle layer		Bottom layer	
Test	LL	PL	LL	PL	LL	PL
Value (%)	67.1	42.7	55.69	33.83	62.8	36.36
Plastisity Index (%)	24.45		21.86		26.44	

4. Conslusion

Based on the results of residual soil of Marioriwawo Soppeng South Sulawesi province it is concluded as follows:

- XRD analysis of clay minerals from top layer to bottom layer (300 cm thihk) consists of illite, kaolinite, montmorillonite, vermiculite, halloysite and chlorite. Distribution of illite shows greater trend to the bottom, on the other hand vermiculite and montmorillonite which decrease the bottom
- The residual soil has high plasticity and moderate to high potential deployment.

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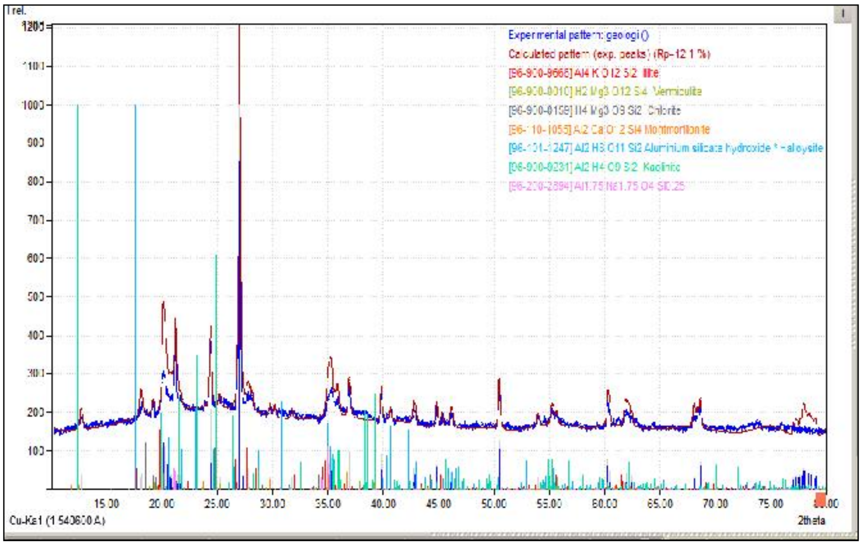
Difraktogram of Clay mineral of the residual soil : (a) Top Layer (b) Middle layer (c) Bottom Layer

a



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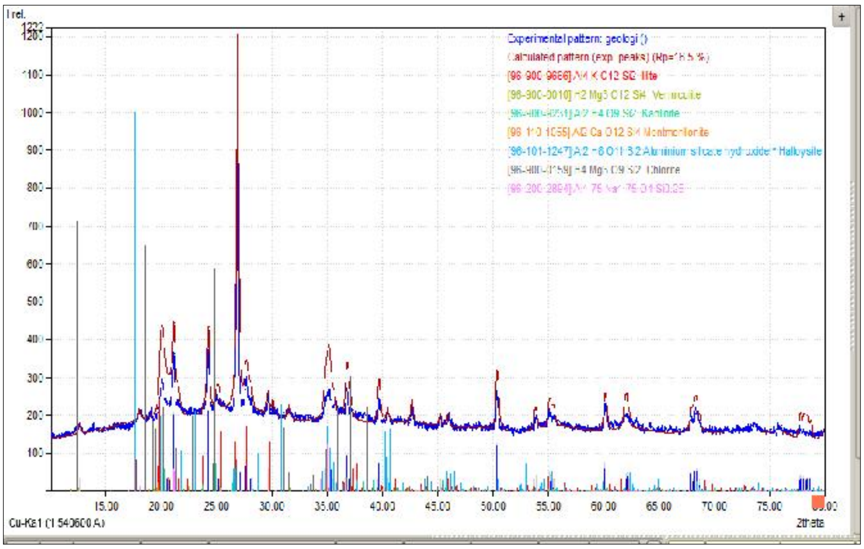

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