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REVIEW ARTICLE

CORRELATION OF MICROSTRUCTURE CHARACTERISTICS WITH THE SLOPE STABILITY AT TRUSMADI FORMATION, SABAH, MALAYSIA

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ABSTRACT

This study focuses on the influence of weathered rock's microstructure and its effect to the stability of slope at the Trusmadi Formation. Trusmadi Formation (Palaeocene to Eocene age) had experience a slightly metamorphism process and makes it highly susceptible to instability. Regional metamorphism that happened during tertiary has given rise to the formation of argillaceous rock. This rock then suffering a weathering process that change them to soil. Four samples were collected based on fail slope and stable slope. These samples were analysed using polarizing microscopic and scanning electron microscopic (SEM). Microstructural features identified that all slopes had the same platy minerals and mineral grain size and shape except for the cracks and porosity percentage. Percentage of cracks and porosity in stable slope are 35% and 40% in the average while 55% and 65% in fail slope. For SEM study, the percentage of porosity is 37% for stable slope and 55% for fail slope. The presence of 1:1 clay that is kaolinite gives only a small impact to slope stability.

KEYWORDS

Microstructure, Trusmadi Formation, slope stability, optical microscopy, SEM.

1. INTRODUCTION

This paper deals with microstructural study since it is the latest and simplest technique used to study the rock's behavior. A few people had published their research on microstructural from different scope of study. A previous researcher had study the natural slip zone from the angle of quantification and deformation history [1]. They had found out that clay mineralogy plays a more important role of the slip zone's development than the abundance of clay-size particles. Even though clay mineralogy is important factor in their study, a researcher reveal that engineering properties appears to be more important than the mineralogy [2]. From the angle of this study, the microstructure is having a relationship on quantifying the degree of weathering and thus gives the impact to slope stability.

The study area consist only Trusmadi Formation that cover the area from Ranau to Tambunan highway, Sabah. This formation is slightly metamorphosed during the tertiary time. This activity contributes to the sheared and faulted rocks that leads to microstructural changing. Details study on this changing might give a clue on why some slopes in Trusmadi Formation are stable and some are not.

2. LOCATION OF SAMPLING

Two slopes will be study to rectify this problem. Both slopes are marked as 1a and 2a for stable slopes while 1b and 2b for fail slope. Both are controlled by the same slope gradient (around 45º to 55º), equal vegetation covered, same degree of weathering (VI to V), same geological structure and the existence of water seepage. The sampling is done to collect the rocks for petrographic analysis and soils for Scanning Electron Microscopic study. The sampling locations are located as shown in the Fig. 1.

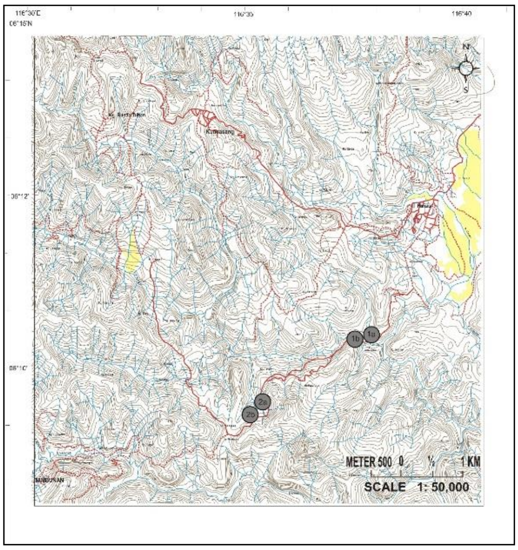


Figure 1: Location of sampling area in Trusmadi Formation

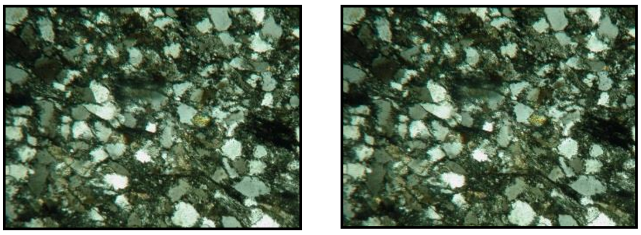
3. PETROGRAPHIC DESCRIPTION

All samples were cut and and peel off to give a petrographic description using a polarizing microscope. This technique concentrated on quantifying the degree of weathering and thus will give some kind of effect to slope stability. Large number of tectonic activity's series in study area have been attributed to the variations in petrographic characteristics such as grain size, number of cracks and porosity and mineralogical composition.

Eventhough this activity happened in same area, but the petrographic characteristics may vary depending on parent rock's materials and degree of weathering.

3.1 Grain Size Analysis

Petrographic analysis showed that all samples do have a fine grain size. This is due to the same formation of sampling area. Trusmadi Formation had experienced a slightly metamorphisme process that break the mineral into small fragments. In general, when the grain size decreased, the rock strength will increased (Photo 1).



(a) (b)

Photo 1: The small size of minerals were abundance in stable and fail slope produced by the tectonic deformation process (samples taken from slope 1)

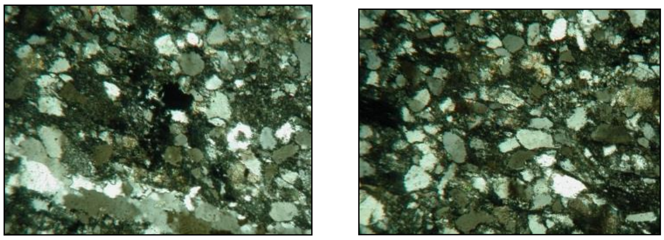
3.2 Number of cracks and porosity

Study revealed that number of cracks and porosity are higher in fail slopes compared to stable slopes. 10 points were selected in each sample to give a summary on number of cracks and porosity (Table 1)

Table 1: The summary percentage of cracks and porosity in four samples

Sample	Cracks (%)	Porosity (%)
1a	45	44.1
2a	25	36.9
1b	51.7	62.4
2b	58.3	67.6

The big number of cracks is produced by the abundance of easily cleavable minerals. This type of minerals would result in low strength value [3]. This is because the cracks will produced more weaknessess surface which control the direction in which failure occurs (Photos 2 & 3).



(a) (b)

Photo 2(a): Showed the percentage of porosity in stable slope **(b):** Showed the higher percentage of in porosity fail slope that leads to slope failure

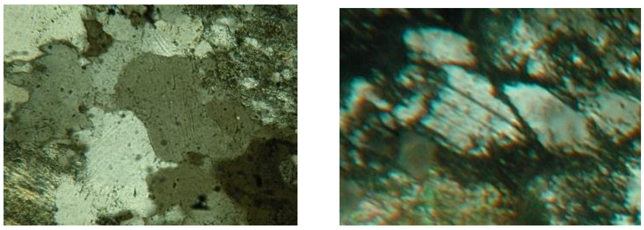


Photo 3(a): Showed the less cracks existence in stable slope due to good within each mineral **(b**): Showed that cracks in Quartz from fail slope that will make the weathering interlocking grade go higher and make way for water to flow in

3.3 Mineralogical composition

A brief mineral composition result from this petrographical analysis is shown in the Table 2. Due to metamorphism process, minerals in rock will change usually from primary to secondary minerals (Photo 4). This is proof by the presence of plagioclase, feldspar, sericite and clay. Clay is the last product in weathering produced from feldspar (Photo 5). Detailed study on the existence of clay in all samples should be done to determined the type of clay. Detailed study using SEM is needed because several researcher reported that clay plays an important roles in slope failure. It may give effect if the clay type is differ from each slope. Eventhough Quartz (primary mineral) is still abundance in all samples but it was fragmented into smaller Quartz and prooving that it was changed too. Analysis showed that mineral composition and percentage are not vary significantly in each slope. This is due to the same parent rock's material. But, detailed study on the existence of clay in all samples should be done to determined the type of clay.

Table 2: The percentage of common minerals in the thin section analysis

Sample	Q (%)	Sericite (%)	K-f (%)	B (%)	Clay (%)	Matrix (%)	SUM (%)
1a	47.3	29.8	5.6	2.1	4.3	10.9	100
1b	49.5	30.4	6.3	1.8	3.6	8.4	100
2a	47.9	28.9	6.5	1.3	5.7	9.7	100
2b	46.7	29.5	5.8	1.9	4.5	11.6	100

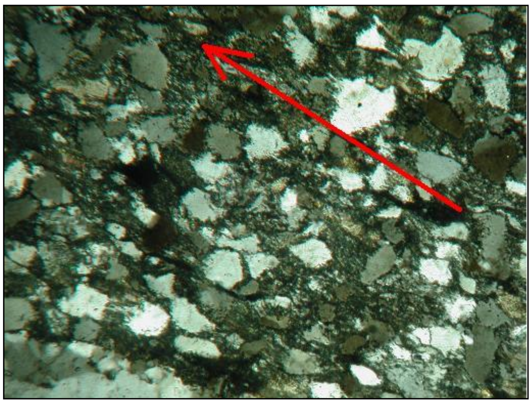


Photo 4: All samples showed the same direction of mineral orientation that was skew due to metamorphism process (sample taken from 1a)

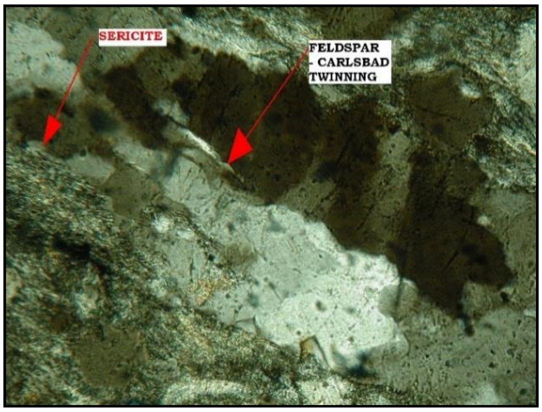


Photo 5: The feldspars in sample 1b is replaced by fine-grained muscovite (sericite). In this rock, sericite is a product of hydrothermal alteration (sample taken from 1b)

4. SEM STUDY

Microfabrics of the soils were described according to the Handbook of SEM Atlas. Each sample was examined with JEOL JSM – 5610LV scanning electron microscope and was coated with Titanium using JEOL JFC – 1600 auto fine coater. This SEM purpose is to study the clay microfabric and its effect to slope stability. Analysis of the samples revealed that both slopes contain clay mineral that is kaolinite (Photo 6). Such clay is abundant in weathered rocks. This clay usually did not give bad effect to slope stability but due to changing structure, it may leads to slope failure (Photo 7).

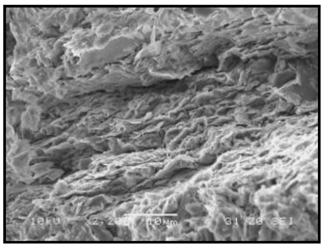
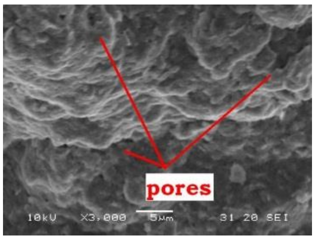
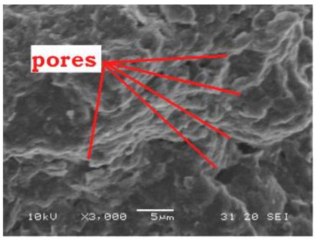


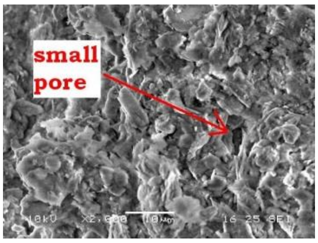
Photo 6: Structured layer of kaolinite found in Trusmadi's soils. It is not much differ structure between stable and fail slope



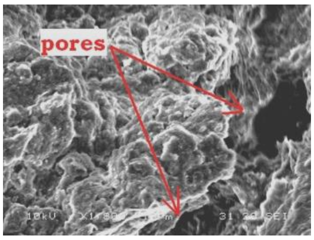
(a)



(b)



(c)



(d)

Photo 7: The pores found in stable slopes (a and c) and fail slopes (b and d). Stable slopes show the existence of pore but in small size and small percentage. Pores in fail slopes are larger and more abundance

Quantitave analysis of the pores in each slopes is shown in Table 3. Generally stable slopes have 37% while fail slopes have 45% porosity. Even though fail slopes show only a little bit more percentage than stable slope, but porosity can control the rock's behavior. A small change can give big impact to the slopes. Porosity is directly related to moisture content. Moisture exchange will occur between different porous materials. Due to the higher suction force in finer pores, water transportion is much easier from coarse porous material to fine porous material.

Table 3: Quantitave analysis of porosity percentage in both stable and fail rock slopes

Sample	Porosity (%)
1a	32.8
2a	41.2
1b	46.4
2b	53.6

5. DISCUSSION

Evidence showed that Trusmadi Formation had experienced metamorphism process that changes the rocks and its chemistry composition. Tectonic deformation also occurred that sheared and brecciated the rocks. When the rocks sheared, it will raise the volume of weathering process because of the presence of big number of cracks and producing more surfaces for the process of climate change, water transportation and organism activities. The hot and wet Ranau's climate, the existence of water seepage and heavy rains during evening time rose up the process to change the rocks to fragmented one and directly to soils. This will change the mechanical strength of the rocks and microstructural properties such as mineralogy and porosity. The changing process was proof by the presence of small grain size that has its own orientation and secondary mineral such as clay and sericite. Study revealed that the weathering products that are clay and porosity changes are the main cause for slope instability. Small changes in porosity may give big impacts to slope. The rock will be easier to slip due to water flowing into the pore and cracks. Clay plays a deleterious effect on rock's durability. Clay is mechanically weak and may change its structure through water absorption and dehydration. SEM study on this clay showed that the clay is kaolinite. This 1:1 clay type consists of silica sheets and a gibbsite sheet with silicon tetrahedral and alumina octahedra as a basic unit. Kaolinite is relatively stable due to low water or material adsorption because adsorption is limited to the surface of the particles (planes, edges), unlike the case with montmorillonite, where the clay also adsorbed water between the layers [4-6]. This proofing that clay in Trusmadi Formation (kaolinite) is not the main factor of slope instability. The main factor is actually the cracks in the rocks and porosity in rocks and soils. The moisture properties are directly related to porosity. Water present in the finer pores is bound tightly to the material and the contribution of the finer pores to capillary transport is more limited while the coarser pores contribute to capillary water transfer. Pores coarser than 100 µm and open cracks contribute ways to water permeability mainly through gravity or wind-driven water ingress [7-9]. The conclusion is the combination of cracks and porosity will leads to slope failure when triggered by water from usually rains and water seepage.

6. CONCLUSION

1. Cracks produce more weaknesses surfaces for weathering process and leads to slope failure

2. Porosity helping in water adsorption and make rocks and soil's grains easier to slip and fail.

3. All processes for slope failure are triggered by water.

6.1 Recommendation

1. Detail study using xrd n xrf should be done to study the components in Trusmadi soils n rocks since different formation will give different result

2. Further study must be done before any construction because the slopes of Trusmadi Formation. Information obtain from this paper is not enough for any intended purposes.

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