STUDY OF PYROCLASTIC BRECCIA WEATHERING IN PRENDENGAN VILLAGE, PAWINIHAN MOUNTAIN, BANJARMANGU, BANJARNEGARA

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Abstract. The lithology of pyroclastic breccia is the lithology that forms the basis of the rock in the Pawinihan mountain landslide that occurred in 2006. This landslide resulted in a large number of victims, more than 80 people died. The landslide occurred in the weathering of the Rogojembangan pyroclastic breccia rock in Banjarnegara Regency. So to find out the weathering factors that affect landslides, a study was carried out on the degree of weathering of pyroclastic breccias. The degree of weathering of pyroclastic breccias plays an important role in supporting the occurrence of landslides because the slip surface is at the degree of weathering. The method used is the identification of the level of weathering with the standard British method for heterogeneous materials. The result obtained is that there is a weathering degree of one to six that can be observed in the field. And the slip surface occurs at weathering levels 3 and 4, so that this weathering level is used as the limit of the slip surface for landslides in pyroclastic breccias.

Keywords: pyroclastic breccia, pawinihan, landslide, weathering, slip surface

A. Introduction

An understanding of the weathering profile begins with an understanding of weathering itself. Weathering is the process of changes that occur in rocks under the direct influence of the atmosphere and hydrosphere. Weathering occurs very much in the tropics, because it is influenced by local conditions in the tropics, such as climate influences (temperature and solar radiation). Climate directly or indirectly affects rock weathering processes [1]. According to [2] stated that the causes of material damage are mostly controlled by external influences such as thermal expansion and demolition. In general, it can be explained that the occurrence of physical weathering is caused by external forces acting on the rock which can then damage the rock, forming a fracture plane, beam or sheet in smaller sizes [Figure 1].

Weathering will affect all types of rock, and furthermore the degree of development of rock weathering depends on the type of rock and the type of weathering process, climate, and time. In wet climates, chemical weathering is generally more important than other climatic conditions. The weathering process can be described in Figure 1. The main processes that cause weathering are physical processes (disintegration) and chemical processes (decomposition). Physical weathering is weathering caused by physical processes. In this process the rock will undergo physical changes both in shape and size. Then chemical weathering is weathering that destroys rock mass accompanied by changes in its chemical structure. According to [2], the decomposition process includes:

1. Oxidation is the reaction between minerals and oxygen. This reaction results in unstable rocks or minerals. This process is common in minerals containing iron and aluminum. This oxidation process can be recognized by the discoloration of the original rock to red or

yellow. In addition, the effective oxidation process occurs in tropical climates with high rainfall intensity and temperature.

2. Hydrolysis is a reaction that occurs between minerals with ions contained in water molecules (H + and OH-). The hydrolysis process can produce new compounds and will affect the acidity (pH). During the hydrolysis process, the cations are separated from the mineral structure and replaced by H+ ions. This process is very effective in weathering silicate minerals and alumina silicates.
3. Hydration is the absorption of water molecules into the crystal structure of a mineral.
4. This process plays a role in accelerating chemical decomposition by enlarging the crystal structure.
5. Dissolution (solution) is a reaction that involves many elements of water. This reaction forms a wide variety of acids and bases. Dissolving tends to be more effective in hot and wet climates.

Then the physical aspects that can be observed are changes in color, structure, and texture as well as fracture intensity. The changes that occur are generally a gradual change, but can still be distinguished from the observed indicators. Determination of the degree of weathering can also be done by quantitative analysis using the parameters of porosity, tensile strength, block punch strength, and P wave velocity [3]. Especially for the territory of Indonesia, it has been studied regarding changes in physical and mineralogy properties in several rocks, namely andesite, diorite, limestone, tuffaceous, and claystone [4]. This change has an effect on changes in the value of each degree of weathering. The changes that occur are an increase in the value of effective porosity, a decrease in the density value, a decrease in the value of the point load strength index, and a linear decrease in the value of cohesion and internal shear angle [1]. Then in another place, namely Saudi Arabia, research on weathered basalt showed changes in compressive strength, modulus of elasticity, Poisson ratio, and sonic velocity [5]. The influence of the degree of weathering will have an impact on the formation of a sliding plane and different types of landslides [6]. Research area is located in Pawinihan landslide, Sijeruk Village, Banjarmangu, Banjarnegara [Figure 2].

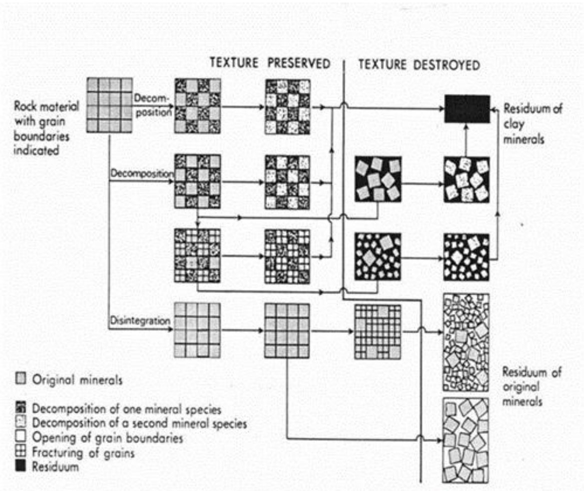


Figure 1. The ideal diagram of the weathering process is related to the development of the degree of weathering [7]

Each rock has a different thickness and mineralogy distribution in each weathering [8]. Topography also affects the spread of weathering zoning. Research related to this has been carried out in northern Virginia on igneous rocks [8]. The results showed that the general characteristics observed in saprolite with a thickness of over 20 m were found in the highlands and thinned along the slopes to a minimum along the valleys [8]. The thickness of the saprolite which is part of the weathering zone is also influenced by the relief of the landscape. Mount Pawinihan is an ideal area for research, because the landslide occurred in weathered pyroclastic breccia with avalanche crown height of 1,007 m above sea level and belongs to the pyroclastic mountain area [9] (Figure 3). Landslides are very dangerous because the movement is classified as very fast [10]. This type of debris slide which is then converted into debris flow often occurs in the pyroclastic breccia lithology of the Rogojembangan quarter. Almost all of these landslides caused quite a lot of casualties (more than 70 people). From several observations in the field, several soil movements that occur have relatively the same slip plane, namely at the intermediate weathered level, so this research is very interesting to be able to answer the question of why soil movements occur in this zone in pyroclastic breccia lithology.The area is also limited by lithology, Rambatan Formation clay [11].

Figure 2. Geological map of research area

B. Methods

The method used for heterogeneous materials such as breccia is the British Standard BS EN ISO 14689-1 classification (Table 1). Several important indicators and have become the most frequently used procedures include the discoloration index, the change in packaging (fabric) or texture and structure, the ratio between rock and soil, and the intensity or discontinuity of fractures. In addition, laboratory tests are also carried out to determine the existence of further changes, such as changes in mineralogy and chemical composition of rocks at each degree of weathering, as well as several tests on index properties, such as water content, density, specific gravity, porosity, liquid limit, limit plasticity and plasticity index.

Table 1. Classification of degree of weathering base on British Standard BS EN ISO 14689-1 for heterogeneous material [12]

Zone	Description	Typical Characteristic
1	100% grades I-III	Behave as rock, apply rock mechanics principles to Mass assessment and design
2	>90% grades I-III <10% grades IV-VI	Weak materials along discontinuities, shear strength stiffness and permeability affected
3	50% to 90% grades I-III 10% to 50% grades IV-VI	Rock framework still locked and control strength, and stiffness, matrix control permeability
4	30% to 50% grades I-III 50% to 70% grades IV-VI	Rock framework contribute to strength, matrix or weathering product control stiffness and permeability
5	<30% grades I-III 70% to 100% grades IV-VI	Weak grades will control behavior, core stones may be significant for investigation and construction
6	100% grade IV-VI	May behave as soil although relict fabric may still be significant

C. Results And Discussion

Based on field observations, the rocks in the landslide area are pyroclastic breccias. This rock was exposed under the landslide area and around Mount Pawinihan (Figure 4.8) The characteristics visible in the field are gray color, fragments measuring 3 cm - 35 cm with andesite composition, sand matrix containing tuffaan, good and bad sorting, bad rounding, packed closed-open. Breccia undergoes weathering and can be classified into 5 parts of weathering zones, namely weathering zones 2, 3, 4, 5, and 6. (Figure 3). Each weathering zone has different characteristics and can be distinguished megascopically by changes in color, percentage of soil and rock, and structure and texture. Based on field observations, the breccia formed is the result of volcanic activity, which is estimated to be a fall pyroclastic product. This is indicated by the shape of the texture that has good sorting in the form of graded bedding.

[13] stated that the formation of pyroclastic breccias with uniform sorting indicated that they were formed due to falling pyroclastic activity, then the gradation changes in pyroclastic breccias in the field which smoothed upwards indicated a decrease in volcanism activity (3). Observations of the pyroclastic breccia stratigraphy were carried out in Sijeruk Village and Prendengan Village. This observation is to explain the condition of the material from volcanic breccia by genesis. In the classification based on weathering zones, fresh rock conditions enter weathering zone 1 where each material behaves as rock based on the British Standard BS EN ISO 14689-1 criteria. The material of origin is very important to identify because it can explain the changes in the material as the weathering zone changes. Following are the results of identification in the field regarding the weathering characteristics of pyroclastic breccias in Prendengan Village.

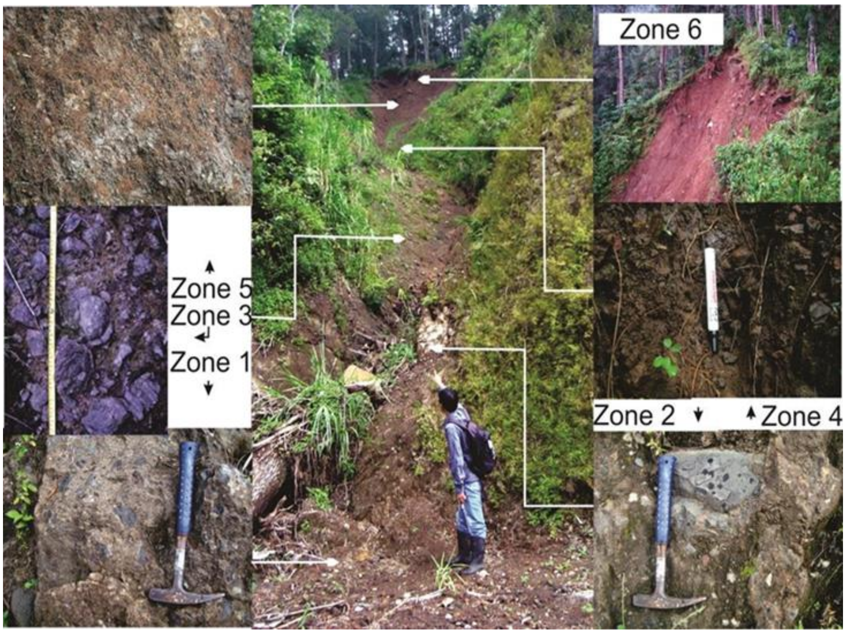


Figure 3. Breccia outcrops showing characteristic changes due to weathering, location: Prendengan Village (photo facing west) [14]

Furthermore, the pyroclastic breccia rock mass undergoes a weathering process and produces weathering products which are divided into 5 levels of weathering, namely lightly weathered, moderately weathered, medium weathered, highly weathered, completely weathered, and residual soil. Each weathering zone was identified based on the British Standard BS EN ISO 14689-1 table for non-uniform materials [12]. This classification is a zoning which is still based on [7] classification for homogeneous materials. Then with a certain percentage of homogeneous classification, it can be divided into weathering zones for heterogeneous materials (Table 1). The parameters used are color change, comparison of the intensity of rock and soil materials, rock structure, and discontinuities. Based on the results of previous research reference studies, not much has been explained about the weathering of breccias, so the method used to determine the level of weathering is the British Standard method. The parameters used are still using the method of Dearman, but there is already a weathering percentage rate for each. Following are the results of identification in the field regarding the weathering characteristics of pyroclastic breccias in Prendengan Village. The degree of weathering will affect the occurrence of soil movement and change of engineering properties [15].

Breccia lithology is indeed a material that has high heterogeneity, so that changes in the level of weathering are difficult to identify at a certain level of weathering. The method used is the British Standard BS EN ISO 14689-1 method to identify heterogeneous materials. Weathering develops from zone 2 to zone 6 (Figures 4 and 5). Observations were made in two places, namely the location of Sijeruk Village and Prendengan Village; these locations almost have almost the same rock stratigraphic pattern. Each is included in the category of pyroclastic fall with a stratigraphic pattern of graded bedding. The graded bedding pattern can be clearly observed in zones 2 to zone 3 (Figures 4 and 5), for zone 4 to residual soil, some of the matrix and fragments experience fragments of peeling onions so that they are released into flat fragments that are scattered between the weathered soil matrix [16]. The pattern of fragment distribution at this weathering level has started to be random, then in zone 5 the position of the remaining fragments no longer has a pattern or is random. In the residual soil, almost all of it has been converted into a soil mass with a very soft hardness level, but sometimes there are still fragments that have not been weathered. The stratigraphic cross-section of the original rock in this study is absolutely necessary because from the lithological conditions on the stratigraphic cross-section [17], the weathering zone will be determined. The outcrop in the study area is in the form of pyroclastic breccias with a high matrix and rock fragment ratio. Seeing that the criteria for determining the weathering zone are based on the ratio between the fragments compared to the rock matrix (current rock), it is necessary to determine the ratio of the matrix to the original rock fragments (before weathering). Modeling to obtain fresh rock composition on a stratigraphic cross section is carried out in the following stages:

1. Macroscopic description of rock outcrops to obtain composition and comparison of matrix presence with rock fragments.
2. A petrographic description of a particular rock section to ascertain the percentage of weathering products in the rock matrix and fragments.
3. Obtained the percentage of weathering on the matrix and on rock fragments.
4. By knowing the original components that form the matrix and rock fragments, as well as the percentage of the presence of weathering products in both, the percentage of weathered and unweathered material will be estimated.
5. With different values of weathering velocity between matrix and rock fragments, the percentage of breccia weathering zone is made with the percentage of 2 conditions, namely weathered I-III and IV-VI.
6. Looking at the comparison of the matrix with the fragments at the beginning (fresh) and compared with the comparison of the matrix and fragments at this time, it will be possible to know the weathering zones that exist in each segment of the stratigraphic cross section

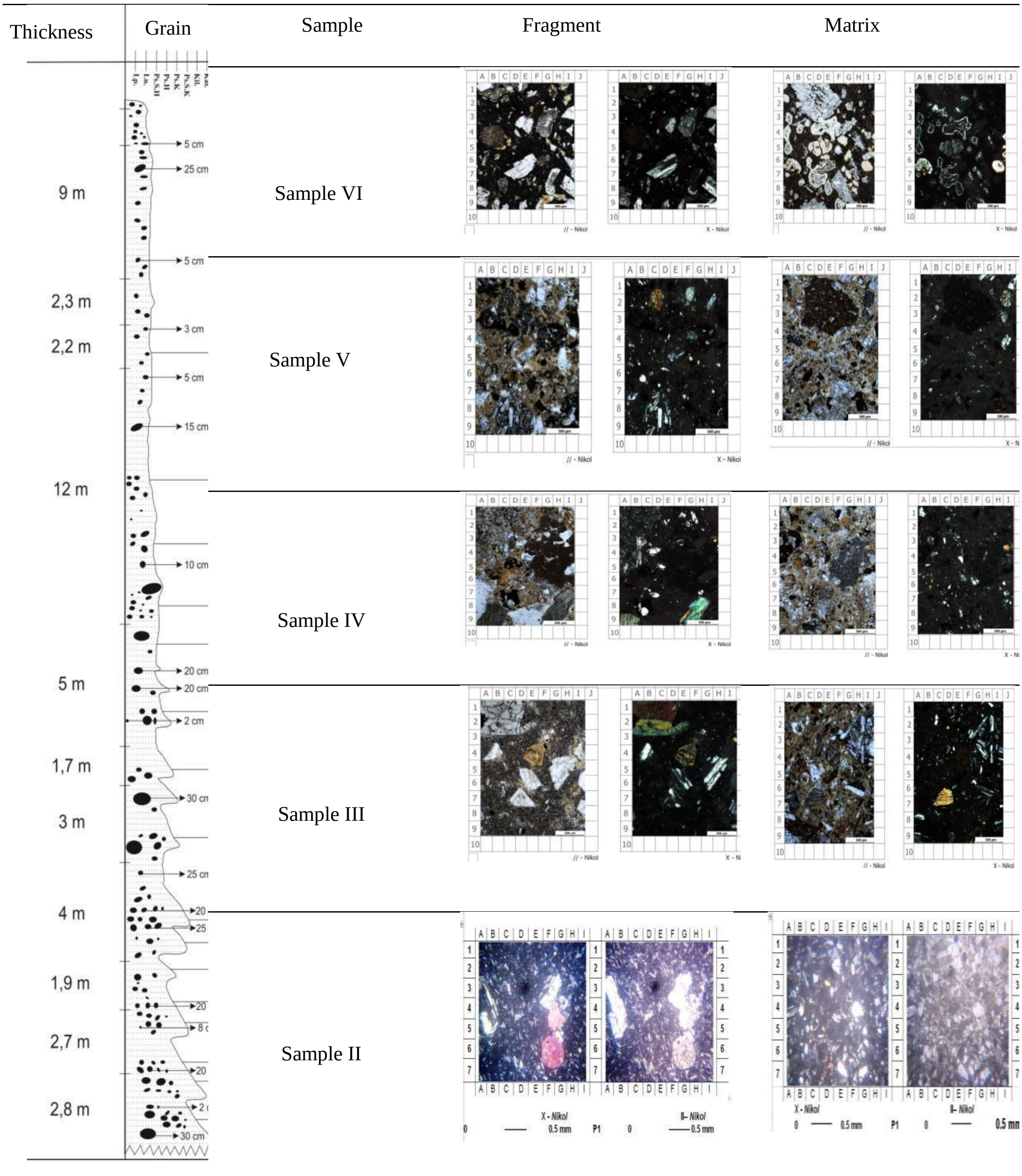
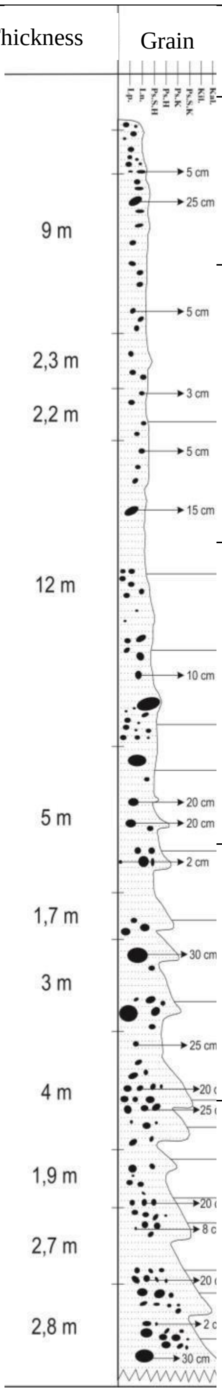


Figure 4. Microscopic comparison of fragment and matrix conditions on weathering breccias in Sijeruk Village



Sample	Percentage F dan M	British Standard Model	Degree of Weathering
Sampl eVI	F= 100% M= 100% (dominated cement)	100/100X5)+(10 0/100 X 95) = 100% weathered (Grade IV-VI)	Zone 6
Sampl e V	F= 75% weathered M= 90% weathered (dominated cement)	(80/100X7)+(90 /100X 93)= 89,3% weathered (Grade IV-VI)	Zone 5
Sampl eVI	F= 60% weathered M= 65% weathered (dominated cement)	(60/100 X5) + (65/100 X95)= 65,4% weathered (Grade IV-VI)	Zone 4
Sampl eIII	F= 40% weathered M= 45% weathered (dominated fragment)	(40/100X70) + (70/100X30)= 49% weathered (Grade IV-VI)	Zone 3
Sampl e II	F= 8 % weathered /M= 9% weathered (dominated fragment)	*(8/100 X80)+ (9/100 X20)=* 8,2% weathered (Grade IV-VI)	Zone 2

Figure 5. Determination of the degree of weathering of rocks based on the ratio of fragments and matrix as well as the composition of microscopic weathering changes

D. Conclusion

Based on the description of weathering zones according to British Standard on the conditions in the field, four weathering zones were obtained, namely: weathering zone 2, weathering zone 3, weathering zone 4, weathering zone 5, weathering zone 6. The four zones are based on differences in color, physical characteristics observed in the field such as identification of brittleness by hand, texture observation, and calculation of different material conditions. The observations are also based on the condition of the core rock against its matrix and the function of the matrix as a permeable area.

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