The Phenomenon of existence Batu Angus on the eastern slopes of mount Gamalama Ternate island North Maluku

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Abstract. This study aims to determine the process of the formation of Batu Angus and the type of Batu Angus on the East Slope of Mount Gamalama Ternate Island, North Maluku. This research is a type of qualitative research that reveals how the process of the formation of Batu Angus and the types of rocks of Batu Angus Mount Gamalama. The research data was collected through interviews, observations, and petrographic laboratory analysis. The research data were analyzed using a polarization microscope to determine the type of Batu Angus Mount Gamalama. The results showed that the process of Batu Angus formation on the eastern slope of Mount Gamalama was initiated by an effusive volcanic eruption in 1907 in the form of lava flowing down the slope which took place in the northeast part of Mount Gamalama and piled up in the Kulaba village. Based on the results of the petrographic analysis in the laboratory, it was obtained the results that Batu Angus contained Plagioclase minerals, Pyroxene, Opaque minerals, and Glass minerals, so that it can be concluded that Batu Angus is one of the Andesite Pyroxene igneous rocks.

1. Introduction

Indonesia is a state having the most active volcanic mountains in the world, there are 129 active volcanic mountains and other hundreds of non-active volcanic mountains. Volcanic mountains found in Indonesia are continuations of a set of world mountain lines, such as Mediterranean and Pacific circumcisions. Mediterranean line enters into the Indonesian region starting from the west end of Sumatera (Aceh) – Java – Bali - Nusa Tenggara and finally rounding into the Banda Sea. Other lines derive from Pacific circumcision entering into the Indonesia region through the islands of Dangihe – Talauad – Minahasa - Halmahera and continuing into the Banda sea [1].

Most of the volcanic mountains are due to Indonesia located in the plate crash zone between Eurasia and Indo-Australia as well as Pacific plates in east Indonesia. The results of researches by volcanologists indicate that the pattern of volcanic mount distribution to the world is not random; however, it follows specific lineation and pattern. Distribution of volcanic mountains to the world is actually to follow plate borders (divergent, convergent and transform) so that these are close to earthquake lines in the world. Indonesia is a country that has the potential to have geothermal energy because the country is in a ring of fire on the volcanic path [2]. Of the results of research, it is understood that the main lines of distribution of the world volcanic mountains are Pacific and Mediterranean circumcisions. As a result of the lines, the Indonesian region has many volcanic mountains. The Gamalama volcano is an active volcano located on Ternate Island [3].
Many volcanic mounts in the Indonesian region cause high threat of disaster occurring anytime such as the eruption of volcanic mounts. When volcanic mounts erupt, hot materials discharged when erupting are glowing cloud, toxic gas, rocky fragments in various sizes called as bomb, and lava flow. Eruption can cause disasters affecting local people. Generally, eruption of volcanic mounts results in disasters such as earthquakes, ash rain, hot lava flood, etc.; however, it also brings advantages for the local people. Advantages of eruption results are fertility of land so that people living near volcanic mounts get changes of forms and body of even, it can make natural panorama extraordinary, and proper to be tourism objects. An Example is phenomenon of existence Batu Angus in Ternate Island, North Maluku.

Existence Batu Angus found in the east slope of the Gamalama mount is black rock rugs. Ternate Island is a volcanic island formed by the product of the Gamalama volcano thousands of years ago until today [4]. These rocks form because these are lava rocks (outer frozen rocks) formed by dry and rocky discharges of Gamalama volcanic mount lavas such as newly burnt rocks. The eruption of Gamalama mount generally takes place in the main crater and it is nearly magmatic; however, in 1907, it erupted in east slope (side eruption) producing melt lavas (Batu Angus) reaching the shore. The formation of rock types in a place is influenced by many factors such as tectonic and volcanic systems in the place [5]. These rocky rugs present very beautiful panorama the side of the round island of Ternate Island in east slope. The uniqueness becomes an attraction to know the depth. Therefore, the people of Ternate City need to understand essences of the existence Batu Angus scientifically, both the process and the type of stone so that people's understanding of the phenomenon of existence Batu Angus is not only limited to legend, therefore researchers feel the need to conduct a scientific study of these existence Batu Angus phenomena.

2. Data and Research Methodology
This study is qualitative research. Qualitative data were collected by taking rock samples found in frozen and Batu Angus lava deposits in Gamalama Mount. In the next stage, rock samples were observed microscopically in the laboratory. The research carried out by analyzing rock samples, and microscopic to find descriptions of mineral content [6].

2.1 Preparation and Planning Stage
In the preparation stage, the researcher prepares everything needed before leaving the field. Preparations include the management of licensing issues, the fulfillment of field equipment so that research activities can run smoothly. The preparation phase includes a literature review to find a picture of the condition of the research area both regionally and locally.

2.2 Field Observation Stage.
At this stage, the researchers collected data in the field by observing and sampling rocks in the Batu Angus area on the eastern slope of Mount Gamalama. The purpose of taking this sample is to be investigated in the Laboratory regarding its mineral content so that the rock type can be determined. Laboratory analysis is carried out using a polarizing microscope called microscopic analysis.

2.3 Petrographic Analysis Stage in the Laboratory.
At this stage, the rock samples that have been taken are brought to the Laboratory for later mineral examination so that the rock type can be determined. The first step taken is rock samples included in the Petrographic Labotarium to make a thin incision process, the next step the researchers bring the rocks that have been sliced thin to the Optical Geological Engineering Laboratory to check mineral contents. Qualitative data in the form of types of minerals contained in rocks. The mineral composition in igneous rocks is very complex [7]. The results of microscopic observations at the Geological Engineering Laboratory of the thin section of the sample were made. Checking the mineral content of rock by researchers with the help of laboratory assistants in optical geology to know for certain the
content of minerals present in Batu Angus, so that it can be known with certainty the type of rock of Mount Gamalama Ternate Island North Maluku.

3. Results And Discussion

3.1. Process of Batu Angus Formation
The process of the formation of Batu Angus on the eastern slope of Mount Gamalama begins with the melting of active lava Gamalama volcano in 1907. Batu Angus found on the island of Ternate is lava from Mount Gamalama that has been frozen black like a scorched object. This expanse of rock stretches from the slopes of Mount Gamalama to the beach. Formation of rocks associated with subduction by partial melting of mantles, oceanic crust and coated magma, with potential for crust contamination on the way [8].

The history of the eruption of Mount Gamalama shows that the eruption occurred several times which began in 1538, with an effusive eruption, then occurred in 1687 also effusive lava flow to the west. Volcanic eruptions are very effusive or explosive can damage the surrounding environment [9]. The eruption of Mount Gamalama reoccurred in 1772, killing 40 people. In 1775 erupted again with the lava flow towards the east. Gamalama has been active for decades and the history of the biggest eruption occurred in 1775 which claimed the lives of around 141 people and destroyed several villages around the volcano [10]. In 1839 and 1843 lava flow occurred again, the lava flow towards the north, while in 1864 the lava flow headed northwest. Batu Angus Mount Gamalama sedimentary unit occurred in 1907. Lava flow towards the northeast which flows to the coast. These lava deposit units can be seen in Figure 1.

![Figure 1. These lava deposit units](image)

3.2. Type of Batu Angus in Gamalama Mount
Type of Batu Angus of Gamalama Mount was determined by some stages as follows: (1) taken rock samples were brought to the laboratory for thin slicing, (2) petrography analysis was conducted. The
following are processes of rock determination. Thin slicing of Batu Angus of Gamalama Mount, procedures of thin-slicing for rock are [11]:

- Tool (cutting machine; rotary grinder; polish glass; hotplate machine; ultrasonic; washing machine; polarizing microscope;
- Process of Rock Cutting:
- Process of chip refining:
- Process of washing and drying:
- Process of slide glass and chip waxing:
- Process of refining using refiner grinder:
- Process of thinning on polisher glass:
- Process of examination using polarization microscope:
- Process of cover-glass pasting;
- A Thin slice is ready to observe under polarizing microscope.

3.3. Petrography Analysis

Stage of Petrography Analysis is one of the analytic methods used to determine the name of the rock type. Based on the results of Petrography Analysis in the laboratory, the following samples are taken:

As seen in Figure 2, Volcanic igneous rock incision, brownish-blackish gray, in equigranular, subhedral-anhedral, hypocrystalline, with tracheal texture (phenocrystic and rock bottom showing the alignment of minerals), subhedral-anhedral form, a mineral composition consisting of plagioclase, pyroxene minerals, opaque minerals, and glass.
3.3.1 Petrography analysis tables

Table 1 shows that there are variations in the mineral composition for each rock specimen which consists of primary minerals and secondary minerals with the petrographic names [11],[12],[13]. for the results as follows.

**Table 1. Mineral composition at the specimen figure 2 (a), dan (b).**

| Primary Minerals |  |
|------------------|------------------|
| Plagioclase (60%), white-gray, refractive index n> kb, medium relief, twin Karlsbad-albite, as phenocrysts (QS, 8-11) (25%) measuring 0.5-5.5 mm, subhedral-anhedral form, An43 (andesine type), as the base mass (J, 4) (35%) measuring 0.1-0.25mm, An42 (andesine type), spread evenly in the incision. |
| Kwarsa (1%), colorless-yellow order I, low relief, measuring 0.05-0.2mm, blackout corrugated angle. (E,7). |
| Piroksen (15%), pale light green, pale gray, moderate relief, weak-absent pleochroism, subhedral-anhedral shape, size 0.05-2.5 mm. Present as klinopiroksen (Augite) Most minerals have been converted into chlorite. (I-H,5-7) |
| Mineral opak (1%), black, high isotropic relief, grain size 0.05-0.1mm. (I-J,9-10) |
| Gelas (20%) colorless, observations with dark Nikol cross, using misty pink plaster casts. Some have experienced the change in the clay. |

| Secondary minerals |  |
|-------------------|------------------|
| Chlorite (3%) light green-green, parallel / one-way hemisphere, grain size 0.05-0.1 mm. Present as a mineral change from the mineral Pyroxene. (I-H,5-7). |
Figure 3. Petrography Analysis Nikol silang (a) dan Nikol parallel (b) pada nomor sayatan 2/2 pembesaran 30 x 0.5 mm.

As seen in Figure 3, As seen in Figure 2, Volcanic igneous rock incision, brownish-blackish gray, in equigranular, subhedral-anhedral, hypocrystalline, with trachaeal texture (phenocrystic and rock bottom showing the alignment of minerals), subhedral-anhedral form, a mineral composition consisting of plagioclase, pyroxene minerals, opaque minerals, and glass.

Table 1 shows that there are variations in the mineral composition and the result of primary minerals more dominant than secondary minerals.

Table 2. Mineral composition at the specimen figure 3 (a) dan (b)

| Primary Minerals | Secondary minerals |
|------------------|--------------------|
| PlagioClase (45%), white-gray, refractive index n> kb, medium relief, twin Karlsbad-albite, as phenocrysts (AE, 8-11) (20%) measuring 0.5-5.5 mm, form subhedral-anhedral, An43 (type of andesin), as a base mass (CD, 1-2) (25%) measuring 0.1-0.25mm, An44 (type of andesin), spread evenly in the incision. | Chlorite (3%) light green-green, parallel / one-way hemisphere, grain size 0.05-0.1 mm. Present as a mineral change from the mineral Pyroxene. (H-L,1-4) |
| Kwarsa (1%), colorless yellow order I, low relief relief, measuring 0.05-0.2mm, blackout corrugated angle. (C-D,2-3) | |
| Piroksen (20%), pale light green, pale gray, moderate relief, weak-absent pleocroism, subhedral - anhedral shape, size 0.05-2.5 mm. Present as klinopiroksen (Augite) Most minerals have been converted into chlorite. (H-L,1-4) | |
| Mineral opak (1%), black, high isotropic relief, grain size 0.05-0.1mm. (I,10) | |
| Gelas (25%) colorless, observations with dark Nikol cross, using misty pink plaster casts. Some have experienced the change in the clay. | |

Table 2 shows that there are variations in the mineral composition and the result of primary minerals more dominant than secondary minerals. The petrographic names pyroxene andesite, andesite, trachyte andesite [12],[13],[14].

Batu Angus located on the eastern slope of Mount Gamalama is a stretch of black rock. This rock is formed from the release of Gamalama volcanic lava that has dried and petrified which looks like a rock that has just burned. The existence of this Batu Angus stone is very important to answer all events that occurred in the past relating to the events of the nature of the active volcano the Gamalama. Batu Angus is one of the geographic objects that gives a lot of information that needs to be understood both regarding the process, the type of rock, and its benefits to the world of science so that the existence of this Batu Angus needs to be used as special studies. Batu Angus is lava from Mount Gamalama whose process is preceded by molten lava that flows down the slope in the east which is currently used as a tourist attraction. Petrographic analysis results show that this Batu Angus is a type of igneous pyroxene andesite rock. Andesite igneous rocks derived from melt diorite magma are found in many fold mountains which are found in Indonesia [15]. Similar research was also carried out by Muhammad Kasim, Ahmad Zainuri, and Nurfaiika who are in the Sumalata area, located in North Gorontalo. Petrographic analysis shows that the rocks in the area are in the form of andesite, trachyte, latite and latite quartz. The difference between these andesitic rocks is in the composition of plagioclase, orthoclase, and quartz. Andesite has the dominant mineral plagioclase compared to trachyte. Meanwhile, latite and quartz differ only in the composition of quartz minerals in which latite quartz increases by more than 5 percent of quartz, but all four stones come from the same andesitic magma.
4. Conclusions
Phenomenon existence on Batu Angus in the eastern slope of Gamalama Mount in Ternate Island, Northern Maluku the following conclusions is Process of Batu Angus formation found in the eastern slope of Gamalama Mount was started by volcanic process, namely melting lavas discharging from the Gamalama Mount. These melting lavas took place in 1907, mounted in the eastern slope of Gamalama Mount, in the Village of Kulaba, which currently becomes Tourism Object of Batu Angus. Based on the results of petrography analysis in the laboratory, it is found that this Batu Angus is one frozen rock of pyroxene andesite type.

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