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Increasing Added Value in Basalt Rocks for Making Basalt Fiber

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Abstract

Andesite and basalt are generally mined materials used only for building (construction). To increase the added value, basalt rock is currently starting to be widely used as a construction material that is converted into composites with fiber reinforcement. In this initial research, the aim is to examine the characteristics of basalt rock at three locations in the Greater Bandung area (Gunung Bohong, Cipatik, and Batu Templek), including its chemical composition, physical and mechanical properties, and mineral composition. The research methodology is carried out on three rock characteristics that can be used as basalt fiber, namely the XRF method to determine chemical composition (Al_2O_3 and SiO_2), physical and mechanical testing, as well as the petrographic analysis method to discover mineral composition by examining the presence of Plagioclase minerals. The results of the chemical analysis of all samples are suitable, but there are chemical compounds that do not match the parameters, namely Fe2O3 + FeO and MgO. Samples from Cipatik and Batu Templek are suitable. The physical properties test is also suitable. For mechanical property testing, only samples from Gunung Bohong and Cipatik are suitable. Petrographic tests conclude that the three rock samples fit into the basaltic andesite rock category.

Keywords : Andesite Rock; Basalt Rocks; Rock Characteristics; Rock category; Basalt Fibers

Introduction

West Java has a wealth of mining materials from volcanic activities, including andesite and basalt. Generally, both rocks are used as building materials (construction) in the form of 'raw' or 'semi-finished' materials. The management of the rocks is done simply, and the selling value is low. Andesite-Basalt presence in West Java, especially Garut Regency, and has a potential resource of 13.515.740 MT (Nasrudin Usman *et al*., 2017).

To add added value to basalt rocks, many construction materials in the form of composites with fiber reinforcement (Fiber Reinforced Composite) are starting to be used, including composites with basalt fiber reinforcement (Fiber Basalt Reinforced Composite). Basalt fibers have attracted a lot of attention in the composite industry since they are chemically stable and have excellent mechanical and thermal properties.

Due to its high commercial value, it has many applications in the polymer and construction industries. The current industrial production of basalt fiber has a lower cost than the cost of glass fiber that has been used so far (Khandelwal, 2020).

Basalt fiber is an artificial inorganic material obtained from natural minerals by melting them and then turning them into a very fine fiber material made from basalt rock. The filament diameter ranges from 10 to 20 μm. It is a relatively new material as compared to several types of fiber-reinforced polymers and structural composites. This fiber is similar to glass fiber; it has the same chemical composition but has better strength characteristics, and unlike most glass fibers, it is highly resistant to the effects of alkalis, acids, and salts. Another characteristic is that these fibers have a high modulus of elasticity, resulting in excellent specific strength–three times that of steel (Singha, 2012).

Basalt rocks are abundant in West Java because they include volcanic figures that stretch from west to east. Preliminary studies need to be carried out to find out whether basalt can be made from basalt fibre by examining its physical and mechanical properties.

Research Method

The research methodology was carried out through a comprehensive method on three characteristics of rocks that can be used as basalt fibers, namely applying the XRF method to determine chemical composition (Al_2O_3 and SiO_2), testing physical (density) and mechanical properties (tensile strength and Elastic Modulus), and conducting a petrography analysis method to determine mineral composition by examining the presence of plagioclase minerals.

This research was carried out at several locations in West Java that have the potential for basalt rock deposits. Sampling of 3 samples of basalt rock will be carried out randomly in the Bandung Barat Regency, precisely in the Gunung (Mount) Bohong, Batu Jajar area with coordinates (777298.206 mE, 9239034.871 mN) and sample code GB, and also in the Cipatik, Cihampelas area with coordinates (777652.216 mE, 9230457.388 mN) and sample code CPT. The next location is Bandung Regency, precisely around Batu Templek, with coordinates (796688.147 mE, 9239974.757 mN) and sample code BT.

Several physical and chemical tests will be conducted to obtain the characteristics of each rock sample at each research location, including chemical analysis of rocks, petrographic analysis, analysis of physical properties of rocks, and analysis of mechanical properties of rocks to find out whether the characteristics of each sample follow the standards to be used in basalt fiber.

Results & Discussion

The manufacture of basalt fiber from basalt rock requires the determination of certain characteristics of basalt rock needed to produce basalt fiber. There are special requirements for producing basalt fiber products, which include chemical composition, physical and mechanical properties, and petrography.

A. Chemical Analysis

This analysis is one of the analyses that can be used to determine the chemical composition of a rock mass. The chemical analysis test uses three test samples representing each research site. This analysis aims to find out the chemical composition of each sample and determine if the chemical composition qualifies for the manufacture of basalt fibers. The results of chemical testing on the composition contained in basalt rocks to produce basalt fibers can be seen in Table 1.

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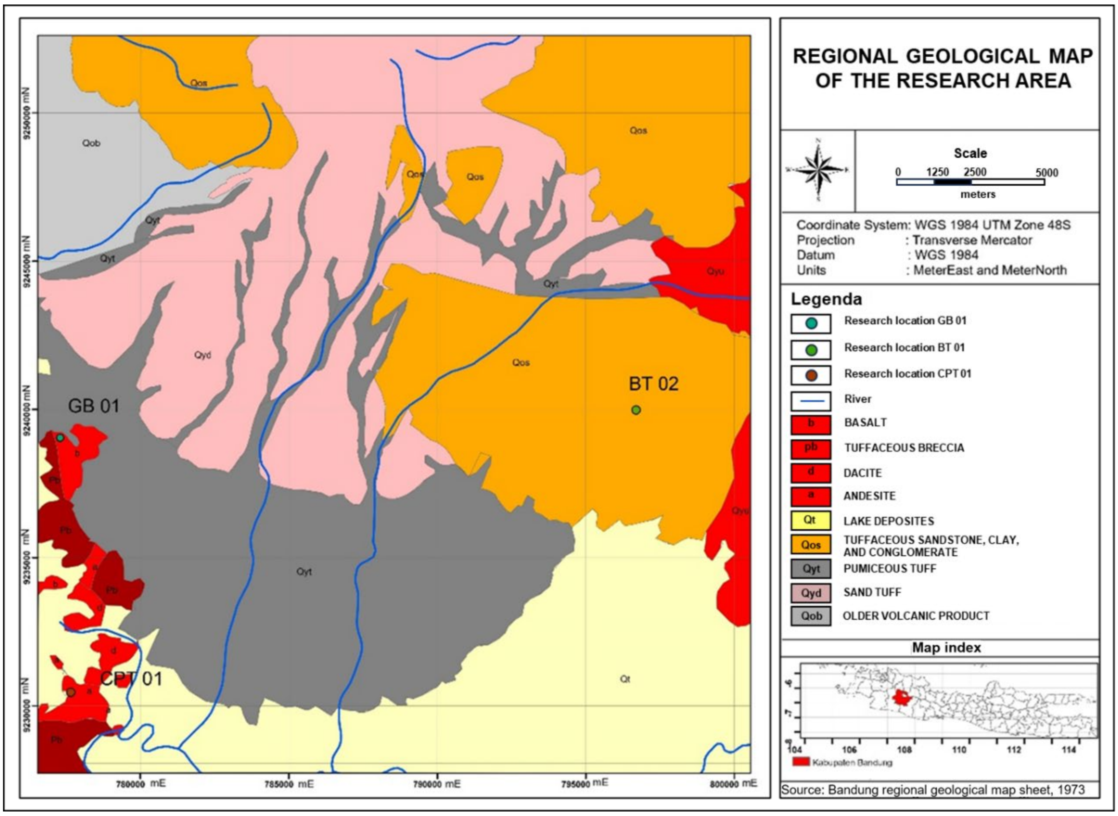

Figure 1. Regional Geological Map of The Research Site

Figure 2 shows the results of the chemical analysis carried out on 3 samples, namely GB-01, CPT-01, and BT-02. The results of this analysis are obtained from the levels of Na_2O + K_2O and SiO_2. In these 3 samples, BT-02 can be indicated as basalt rocks, while samples in CPT-01 and GB-01 can be indicated as andesitic basaltic rocks. The test parameters of this chemical analysis can refer to the classification of (Le Bas *et al*., 1986).

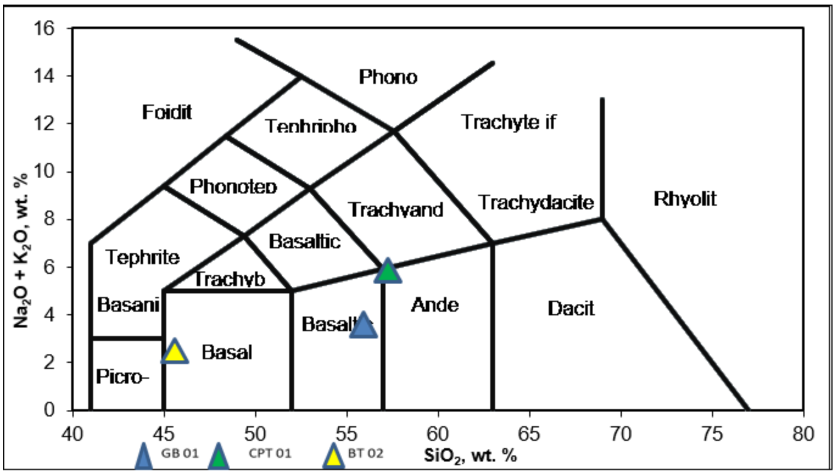

Figure 2. Chemical Analysis Test Results

The XRF method is used in testing this chemical analysis. All chemical compositions in all samples are included in the research requirements of Sharma, 2016. There is only one research area that is not included in the chemical analysis requirements, namely the Batu Templek (BT) sample. In Table 1, we can see a comparison of percentage levels in basalt rocks for basalt fibers.

Table 1
Comparative Results of Testing Good Chemical Compositions for Basalt Fibers

Composition	Grade % (*Sharma, 2016)*	GB 01 (%)	CPT 01 (%)	BT 02 (%)
SiO_2	50-60	57.12	58.75	46.85
Al_2O_3	14-19	15.37	17.34	14.26
CaO	5 - 10	6.42	6.98	10.05
MgO	3 - 5	4.92	2.92	10.51
Na_2O+K_2O	3 - 5	3.57	4.97	2.8
TiO_2	0.5-3	0.62	0.66	1.17
Fe_2O_3 + FeO	9 - 14	7.3	7.98	9.95

In Figure 3, it can be seen that, in general, all samples tested chemically contain the elements required to be included in the criteria for producing basalt fiber in line with the criteria determined in previous research by Sharma (2016), including SiO2, Al2O3, CaO, MgO, Na2O+ K2O, and TiO2. Only the presence of Fe2O3 + FeO is not included in the criteria.

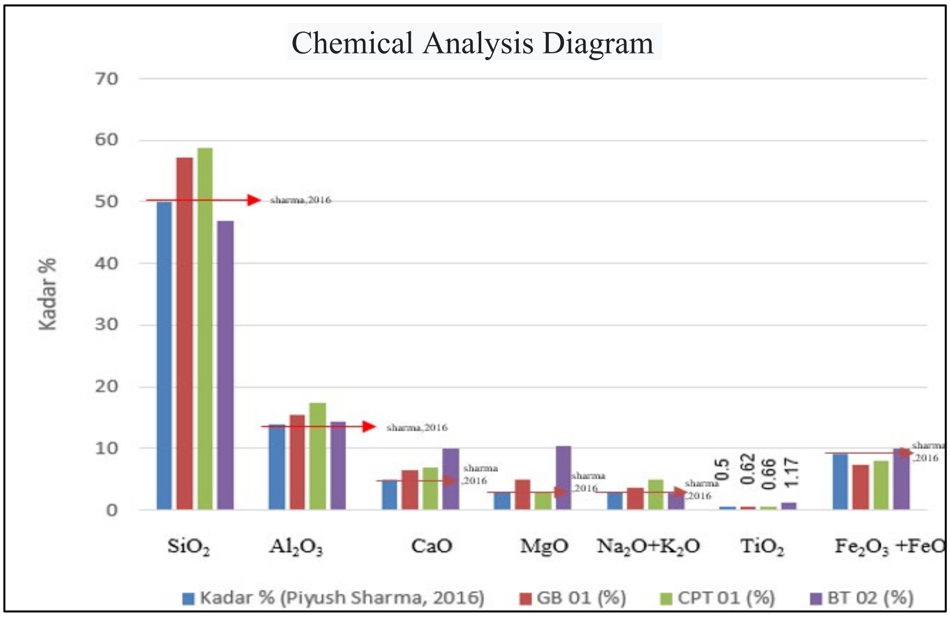

Figure 3. Comparative Results of Chemical Analysis Testing

B. Analysis of Physical and Mechanical Properties

Analysis of physical and mechanical properties is one of the conditions for the manufacture of basalt fibers. The physical and mechanical properties of basalt rock can be applied as parameters for the rock to be used as basalt fibers. Physical property testing is conducted to determine the specific gravity value of a rock. The inputs resulting from this test are the original Mass (Wn), Saturated Mass (Ww), Dependent Mass (Ws), and Dry Mass (Wo). while mechanical property testing finds the value of Tensile Strength Ksi (Mpa) and Elastic Modulus Ksi (Gpa). The physical property testing is carried out on five samples, and the results of the test comparison can be seen in Table 4.

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Table 2.
Comparative Results of Testing of Physical and Mechanical Properties for the Manufacture of Basalt Fibers

Sample	Spesific Gravity	Tensile Strength Ksi (Mpa)	Elastic Modulus Ksi (Gpa)
Basalt (*Piyush Sharma, 2016)*	2,7	40 – 695 (2800-4800)	12.500-13.000 (86 – 90)
CPT 01	2.73	2770.66	12.363 (88.82)
GB 01	2.64	4.940.025	12.882 (85.245)
BT 02	2.76	2390.76	11.103 (76.556)

Furthermore, Figure 4 and Figure 5 show the results of the physical and mechanical properties of rocks that determine the quality of basalt rocks in the Greater Bandung area. Physical and mechanical properties testing was carried out on 3 samples, namely from research locations with codes GB-01, CPT–01, and BT-02. The results indicate that the physical and mechanical properties of the three samples included in the requirements for the criteria for making basalt fibers are GB-01 and CPT-01.

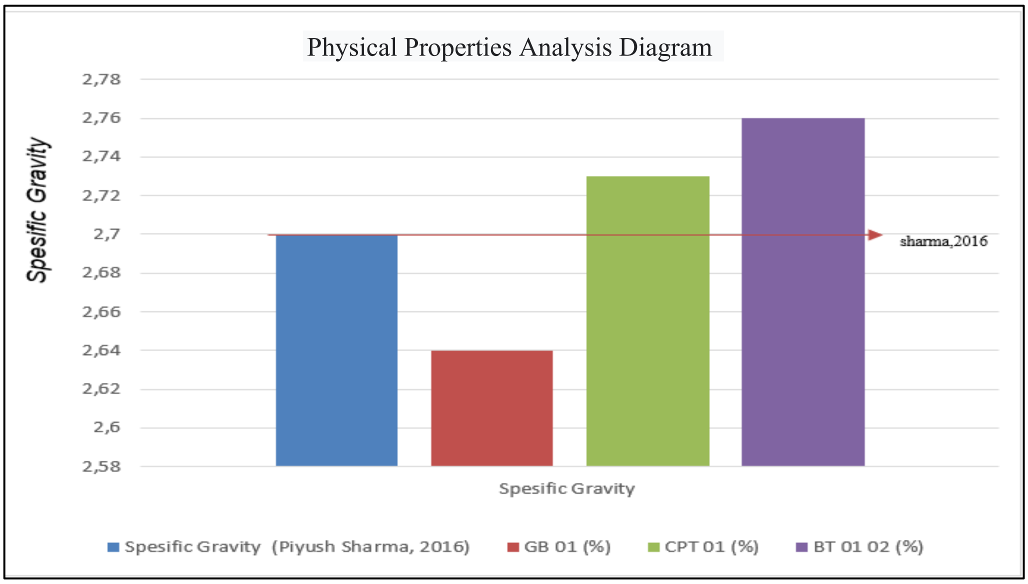

Figure 4. Results of Fission Comparison Testing Analysis

The highest Specific Gravity Test result was in the BT-02 sample, namely 2.76, followed by CPT-01, which was 2.73, except for GB-01, which obtained 2.64 because, according to Sharma (2016), the high value should be ≥ 2.7. The sample with the highest Tensile Strength was the GB-01 with 4940.025 MPa, the CPT-01 with 2770, 66 MPa, and the BT-02 with 2390,76 MPa, and according to Sharma (2016), the high value should be 2800-4800 Mpa. For the Elastic Modulus Test result, the highest value was the GB-01 sample of 12,882 Ksi, the CPT-01 of 12,363 Ksi, and the BT-02 of 11,103 Ksi, while according to Sharma (2016), the high value should be 12,500-13,000 Ksi.

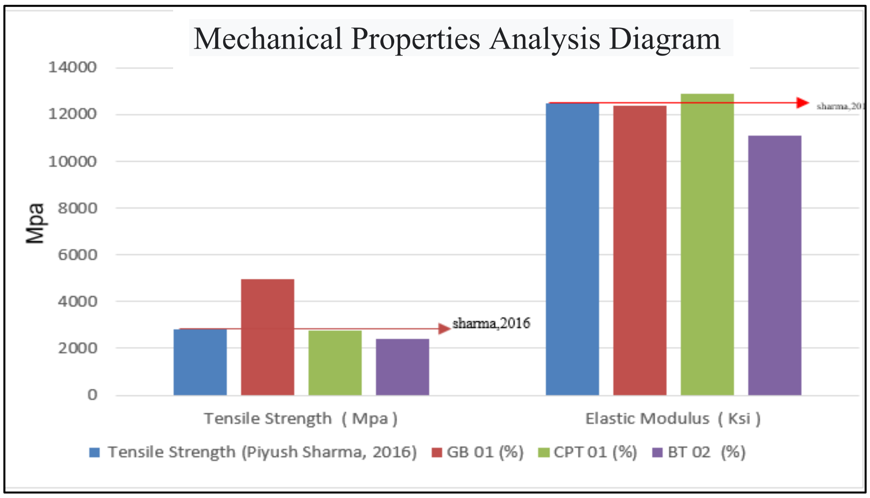

Figure 5. Mechanical Analysis Test Results

C. Petrography Testing

Petrography testing analysis of the CPT-01 sample in Figure 6 indicates that the sample is basalt (B. & D. Cargo Mallory, 1979). Meanwhile, the results of microscopic descriptions of rock incisions show the presence of holocrystalline, porphyroafanitic, hypidiomorphic-alotriomorphic textures consisting of plagioclase phenocryprics, claritypyen, and hornblende, as well as the basic mass of plagioclase microliths that are altered and replaced by secondary minerals calcite and chlorite with their mineral composition: Plagioclase (40%), Hornblende (5%), Klinopirocene (10%), Calcite (20%), Chlorite (20%), and Microlites plagioclase (10%).

Furthermore, in Figure 7 of the petrography test p, there is a sample of BT-01 that can be indicated Basalt (B. & D. Cargo Mallory, 1979). Microscopically, the incision of rocks shows holocrystalline, porphyroafanitic, hypidiomorphic-alotriomorphic textures consisting of the phenocrystals of plagioclase, claritypyxene, hornblende, and the basic mass of the microlith of plagioclase that is changed and replaced by secondary minerals calcite and chlorite. Its mineral compositions are as follows: Plagioclase (25%), Hornblende (5%), Klinopirocene (3%), Calcite (40%), Chlorite (20%), and Aphanitic base mass (7%).

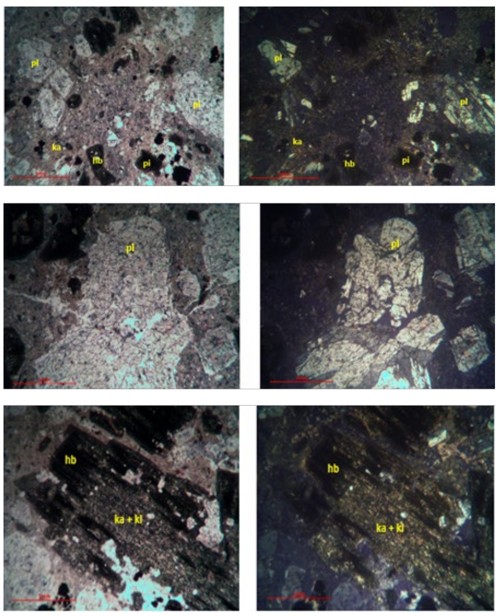

Figure 6. Observation of Parallel Nicol (left) and Crossed Nicol (right) Thin Incision in CPT-01

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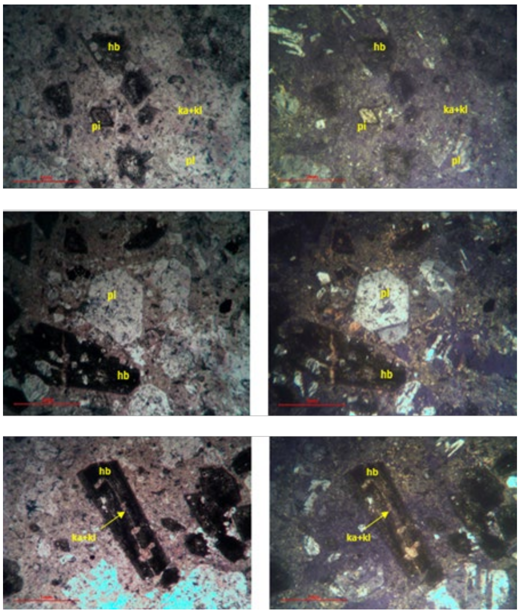

Figure 7. Observation of an Inline Nicol (left) and a Crossed Nicol (right) Thin Incision in BT0-1

Then, a sample of GB-01 shown in Figure 8 is identified as basalt (B. & D. Cargo Mallory, 1979). In microscopic description, the incision of rocks shows holocrystalline, porphyroafanitic, and hypidiomorphic-alotriomorphic textures consisting of the phenocrystals of plagioclase, claritycopy, as well as the basic mass of the microlites of plagioclase that are altered and replaced by secondary minerals chlorite and epidote. The mineral co-options are as follows: Plagioclase (20%), Clinopyroxene (20%), Chlorite (10%), Epidote (5%), and Microlite plagioclase (45%).

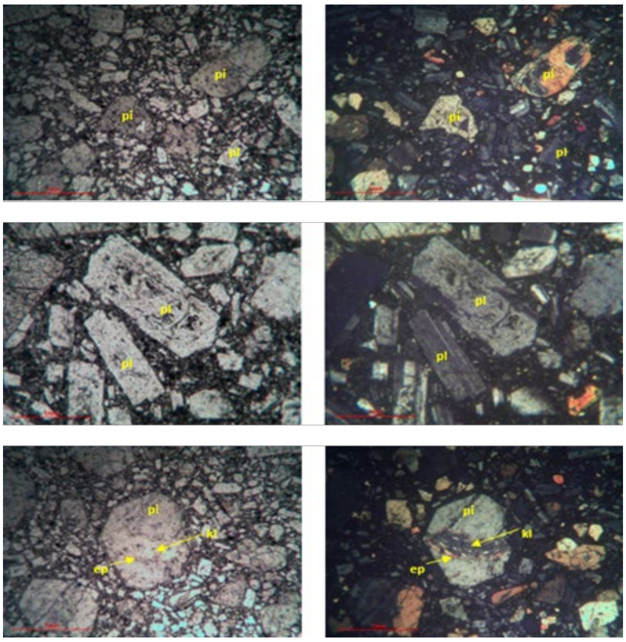

Figure 8. Observation of Parallel Nicol (left) and Crossed Nicol (right) Thin Incision in BT-01

From the test results in Figure 9, it can be seen that the plagioclase mineral of the CPT-01 sample has a percentage of 100%, BT-02 has 100%, and GB-01 also has 100%. Meanwhile, according to Streckeisen (1979), the percentage of the plagioclase mineral should be 65%–100%; thus, these test results can be identified as basalt or andesite rocks.

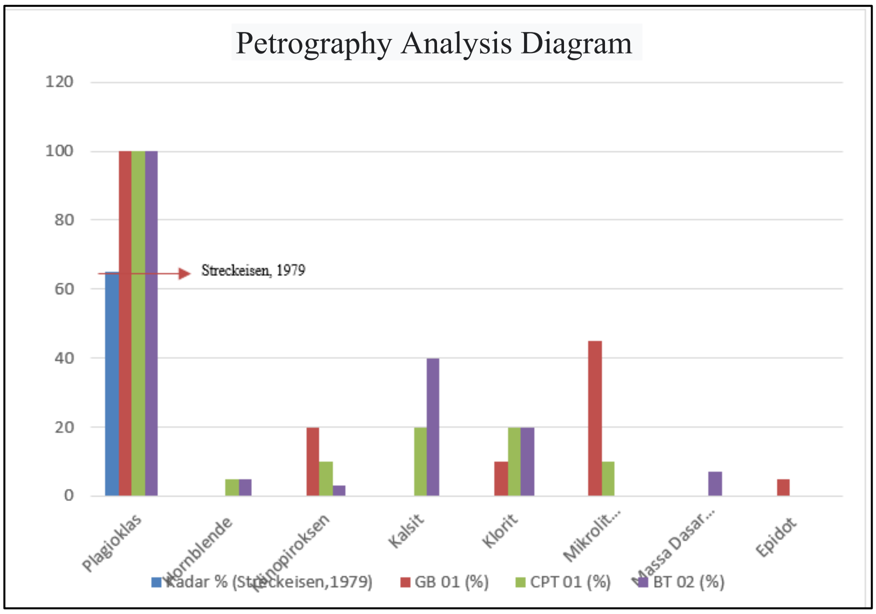

Figure 9. Comparative Results of Petrography Analysis Testing

Conclusions

The research results showed that in petrographic testing (B. & D. Cargo Mallory, 1979), chemical composition, and physical and mechanical properties, based on Sharma (2016), the three samples studied indicated that they were a type of basalt-andesite rock from which basalt fiber could be made. From standard chemical analysis, only the Gunung Bohong and Cipatik samples met the criteria for making basalt fiber, while the Batu Templek samples did not. From the results of the physical properties testing of the Cipatik and Batu Templek samples, they were included in the criteria of rocks that could be made into basalt fiber. However, in the mechanical properties testing, only the Gunung Bohong and Cipatik samples met these criteria. Therefore, overall, the rock samples that are most likely to be made into basalt fiber are the ones from Cipatik. Thus, the Cipatik sample has added value for having compositions that can be made into basalt fiber, not only for construction materials.

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