Learning the properties of Buton asphalt as an oil shale in Buton island to expand the knowledge of students about physics

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Abstract. Asphalt in Buton Island, Southeast Sulawesi, Indonesia, has a large reserve amount of around 650 million tons. In Buton, asphalt is only used for road construction, but this asphalt has characteristics that can be utilized as a substance to produce crude oil. The purposes of this research are to increase or expand the knowledge of educated participants about the characteristics and advantages of Buton asphalt and oil shale as community natural resources and to compare the density of each asphalt mining area namely Kabungka (winto mine), Lawele, and Sampolawa. It aims is to make Buton asphalt as a source of learning. The research method used is the literature study and experiment. The results of the study are that the characteristics of asphalt Buton approach the characteristics of oil shale in Green River, US. The density of Buton asphalt in each region is different. Conclusion of the research that asphalt/tar sand on Buton Island is categorized as a solid /semi-solid type hydrocarbon oil shale. The implementation of this study can be used for senior high school of class X student by visiting the asphalt mine to conduct simple experiments such as measuring the height of the asphalt cliff and determining the direction of the wind eye. Asphalt is used to measure its density. The experiment procedure is made in a module that will later be used by students.

1. Introduction
Indonesia is one country that is rich in tribes, cultures [1,2], and natural resources. One area in Indonesia is famous for its natural resources, namely Buton Island. It has natural resources in the form of Buton asphalt. Buton asphalt owned is only used in highway refinement, but based on its characteristics, Buton asphalt can be used to produce crude oil. This is based in Tobing [3] states that solid bitumen deposits are layers of shale with thicknesses varying from 0.05 m - 1.48 m and the solid bitumen resources (oil shale) found in the Sampolawa area and its surroundings are 4,510,136, 32 tons of rock is equivalent to 504208.11 barrels of crude oil [3]. Oil shale is a fine-grained sedimentary rock containing a lot of hydrogen which is known as kerogen (a dense admixture of organic chemical compounds) that can be distilled into fuel. Soluble bitumen fractions, which is about 20% of organic matter, while the remainder is insoluble kerogen [4].

Characteristics of Buton asphalt as oil shale can provide new information for students and the community so that the community and students can get to know the potential of the region. Buton asphalt can also be used as a source or media of physics learning through simple experiments that can increase the knowledge and skills of students. Therefore, this study aims to determine Buton asphalt...
deposit, compare the density of Buton asphalt for each deposit (Kabungka, Lawele, and Sampolawa, and compare the characteristics of Buton asphalt with green river oil shale in terms of its physical and mineral composition in general.

2. Methods
The methodology of this research is the literature study and experiment. The main study that was carried out was about the differences in the content of mineral oil shale in Buton Island and Green River. Experiments carried out were to determine the asphalt cliff height (asphalt layer thickness) to determine the deposit area to determine the direction of eye of the study sample and compare the density of Buton asphalt in each different region, Kabungka (Winto mine), Lawele, and Sampolawa (Rongi) with using digital balance, shower glass, and measuring cup, with asphalt mass of 20.02 grams. This research was conducted from January 22 to February 2019 on Buton Island with three research areas, namely Kabungka (Winto mine), Lawele, and Sampolawa (Rongi).

2.1. Measurement of asphalt cliff height
At first, the observer's height is measured from the base of the foot to the eye using the meter. Measure the distance of the observer with the asphalt cliff. Observe the asphalt cliff using a simple clinometer, then note the elevation angle, so that the actual angle of the equation is obtained (1)

\[ \theta = \text{elevation angle} - 90^\circ \] (1)

The value of \( \theta \) is then substituted to equation (2) so that the height of the cliff is obtained:

\[ Y = \tan \theta \times X \] (2)

The Y value obtained is then substituted to equation (3), so that the mine deposit area is obtained:

\[ V = L 	imes Y \] (3)

with Y, X, L, and \( \theta \) showing the altitude of the asphalt cliff from the ground, the observer with the asphalt cliff, wide mine, and the actual angle. The area is obtained based on sources from companies and mining service sources.

2.2. Determination of Wind Eyes Using a Compass and Measurement of the Type of Buton Asphalt Mass
In this experiment, a compass was used to determine the wind direction of Buton asphalt sampling. The compass is directed to the sample to be taken. The sample taken is then measured by mass using a digital balance. The sample is then put into a shower glass. The volume that comes out of the shower glass is measured using a measuring glass thus the density of the Buton asphalt is obtained:

\[ \rho = \frac{m}{v} \] (4)

With \( \rho \) is the density of the substance, \( m \) is the mass of the substance, and \( v \) is the volume of the substance. Density is a scalar quantity with SI units is kg / m\(^3\) [5].

3. Results and Discussion
3.1. Deposit Mine Research

| Area                  | Angle (°) | Cliff distance & observer (m) | Height (base-eye) observer (m) | Asphalt cliff height (m) | Wide mine (Ha) | Deposite (wide x height mine (ton)) |
|-----------------------|-----------|-------------------------------|-------------------------------|---------------------------|----------------|-----------------------------------|
| Kabungka (winto mine) | 25        | 12                            | 1.44                          | 7.04                      | 315.49         | 2,221,049.6                       |
| Lawele                | 33        | 5                             | 1.44                          | 4.69                      | 100            | 469,000                           |
| Sampolawa (Rongi)     | 33        | 4                             | 1.44                          | 4.03                      | 97             | 390,910                           |
This research was conducted in three different places, namely in Kabungka, Lawele, and Sampolawa. Of the three places obtained deposit for each research area shown in table 1. The table above shows the total deposit in small amounts. This is not in accordance with data from the Department of Mining and Energy of Buton Regency in 2017 that the total reserves of Buton asphalt were 207,019,120 tons [7]. This is because the researcher only determines the deposit in a limited exploration area with three different regions and only one company for each region. The results of this calculation are also different because researchers only measured the cliff height of the asphalt excavation in one area that had been explored.

3.2. Asphalt Buton Density
In measuring density, samples are taken directly from the field (mine). Samples were taken randomly as many as 2 samples in each mining area, namely Kabungka, Lawele, and Sampolawa. For the Kabungka region, Sample 1 and sample 2 were taken in the Southwest position. In the Lawele region sample 1 was taken in the Northwest position and sample 2 was in the Southwest position. While for the Sampolawa region, sample 1 was taken in the southeast position and Sample 2 was in the North position. The density value for each sample is shown in table 2.

| Deposit               | Volum (ml) | Density (grams/ml) |
|-----------------------|------------|--------------------|
|                       | Sample 1   | Sample 2           | Sample 1   | Sample 2   |
| Kabungka (Tambang winto) | 16         | 17                 | 1.25       | 1.18       |
| Lawele                | 18         | 19                 | 1.11       | 1.05       |
| Sampolawa (Rongi)     | 15         | 14                 | 1.33       | 1.43       |

Table 2 shows that the average density of Buton asphalt ranges from above 1. Data obtained approaches tables 5 and 6 which show that the density of Buton asphalt is above 1. Each density of the two samples is different, as is the density of each deposit. The mass of the Lawele deposit is smaller than the density in deposit Kabungka and Sampolawa. This is also due to the bitumen content, water content or rock hydrocarbon composition which can be seen in table 7.

3.3. Characteristics of Buton asphalt
Based on its physical properties, Asphalt is a solid or half-solid bitumen with dark brown or black color that comes from petroleum or natural refineries. The petrographic analysis of Buton asphalt was found that Buton asphalt organic material for the formation of Sampalakosa and Tondo formation was dominated by lamalginite and bitumen and did not show the presence of liptinite or vitrinite. Whereas in the Winto formation it was found that the organic material contained lamalginite, vitrinite, liptinite, inertinite, and its derivatives [8]. In general, the element of bitumen content consists of carbon (C) of 82-88%, Hydrogen (H) of 8-11%, Sulfur (S) of 0-6%, oxygen (O) of 0-1.5%, and Nitrogen (N) of 0-1% [7]. Results of physical Buton asphalt and chemical testing of minerals from the extraction of Buton bitumen and asphalt minerals in Kabungka and Lawele are shown in tables 3 and 4 respectively.

| Type of Testing | Results of Testing |
|-----------------|--------------------|
| Asphalt Level (bitumen)% | Kabungka | Lawele |
| Penetration, 25°C, 100 gr, 5 seconds, 0.1 mm | 20 | 30.08 |
| Softening Point, °C | 101 | 59 |
| Solubility in C3HCl3,% | - | 99.6 |
| Flash-point, °C | - | 198 |
| Specific gravity | 1.046 | 1.037 |
Tabel 4. The chemical composition of Buton asphalt minerals in Kabungka and Lawele [7]

| Chemical compound | Name of chemical compound | Test Result |
|-------------------|---------------------------|-------------|
| CaCO₃, % (calcite) | Calcium carbonate         | 86,66       | 72,90       |
| MgCO₃, % (magnesite) | Magnesium Carbonate       | 1,431       | 1,281       |
| CaSO₄, %        | Calcium Sulphate          | 1,11        | 1,94        |
| CaS, %           | Calcium Sulfide           | 0,36        | 0,52        |
| H₂O, %           | Water                     | 0,99        | 2,94        |
| SiO₂, % (quartz) | Silicidioxide             | 5,64        | 17,06       |
| Al₂O₃, % + Fe₂O₃, % | Aluminum Oxide + Ferioxide | 1,52       | 2,31        |
| Residue, %       | Residue                   | 0,96        | 1,05        |

Table 3 shows that Buton bitumen contains good quality bitumen content to use. This can be seen from the data of the company PT. WIKA Bitumen which is shown in table 5 for deposit Kabungka (Winto mine) and Lawele deposit. Table 4 shows that Buton asphalt contains the composition of oil shale as in Green River which consists of quartz and carbonate (calcite and magnesite) as shown in table 6.

Tabel 5. The bitumen and the water content of Kabungka and Lawele deposit at the Winto mine [6]

| Sample number | Kabungka |  | Lawele |  |
|---------------|----------|  |        |  |
| 72            | 7,32     | 20,77 | 5,60   | 33,89 |
| 74            | 6,36     | 25,26 | S1     | 1,20  | 29,55 |
| 75            | 8,57     | 24,51 | S2     | 5,60  | 28,26 |
| 76            | 8,74     | 25,27 | S3     | 1,60  | 31,42 |
| 77            | 8,96     | 24,49 | S4     | 9,00  | 21,71 |
| 5             | 13,78    | 21,58 | S5     | 1,40  | 27,30 |

3.4. Characteristics of Oil Shale

The term oil shale generally refers to all types of sedimentary rocks containing solid bitumen material (called kerogen) which is released as a liquid such as petroleum through a heated chemical pyrolysis process [9]. Oil shale has specific gravity, which is around 1.77 to 2.08 [10]. The oil shale composition scheme in Green River is generally shown in table 6.

Table 6. The chemical composition of kerogen and mineral oil shale at Green River [7]

| Parameter | Oil shale |
|-----------|-----------|
| Nitrogen (N) | 2.4       |
| Sulphur (S)  | 1.0       |
| Oxygen (O)   | 5.8       |
| Carbon (C)   | 80.5      |
| Hydrogen (H) | 10.3      |
| Total        | 100       |
| Carbonates   | 48.0      |
| Feldspars    | 21.0      |
| Quartz (SiO₂) | 15.0  |
| Clays        | 13.0      |
| Analcite dan pyrite | 3.0  |
| Total        | 100       |
According to the study from Schmidt and Prien, the Green River formation has about 80% organic oil shale formations in Wyoming, Colorado, and Utah consists of organic shale or marlstone. Deposite oil shale in Green River in the Western United States and a number of eastern tertiary lacustrine deposits. Australia is lamosite and the Eastern Deposit United States is marinated [11].

Based on the characteristics between asphalt and oil shale, Buton asphalt can be categorized as oil shale. This is based on an investigation from Hardiyanto, asphalt/ tar sand on Buton Island is categorized as a solid/ semi-solid type of oil shale which occurs naturally in porous media or rock slits. From the results of the photography of organic minerals, Buton asphalt is categorized as lamosite and marinate oil shale containing lamalginite [8]. This is based on Tanjung that kerogen Buton asphalt is kerogen type II, which is a mixture of terrestrial materials (lacustrine) and marine material (marine) that produce soft oil [12] and based on Hardiwisatra that found fossils of marine life in each sedimentation formation [13].

3.5. Advantage of Oil Shale

Based on the characteristics of asphalt and oil shale in Buton Island can be converted into crude oil through a heating process with retorting. The temperature required in the retort process is 500-550°C, or 930-1020°F [11]. The mechanism is a more complex extraction process which consists of ex-situ and in-situ processes. Figure 1 shows the ex-situ process where oil shale is mined, crushed, and then undergoes a thermal process on the surface and in the second picture an in-situ process occurs where the oil shale in the form of fracture is heated underground.

![Figure 1. Steps for ex-situ and in-situ retorting [7]](image)

3.6. Advantage of Buton Asphalt in Learning

Learning can be done in nature, one of which is visiting natural resources so that they can get to know and increase knowledge about the natural resources of the area such as asphalt mines. Some simple practices in learning physics are shown in Figure 2.

Figure 2 shows that Buton asphalt can be used as an interesting source or media of physics learning so that it can improve students' skills and knowledge and also can introduce students to the potential of Buton as a natural resource of the region.
Figure 2. Figure (a) Measurement of building height using a simple clinometer, (b) determination of the direction of eye angina using a compass, and (c) measurement of asphalt density

4. Conclusion
The conclusions of this study are: (1) The density of each deposit obtained is equal to 1.05 grams/ml to 1.43 grams/ml. The density of each deposit varies where the greatest density is deposit Sampolawa and the smallest is at Lawele deposit; (2) Based on its characteristics, asphalt/tar sand on Buton Island is categorized as a solid / semi-solid type hydrocarbon oil shale; (3) The process of converting asphalt and oil shale into crude oil is through extraction consisting of ex-situ processes and in-situ processes; (4) Buton asphalt can be used as a source or media of physics learning for students such as building height measurements using a simple clinometer, determining the direction of eye angina using a compass, and measuring density using Buton asphalt.

The disadvantage of this study is that in determining the asphalt density, the researchers only used two samples and were not included with the measurement of the bitumen content and water content of the Buton asphalt, so the authors had difficulty in determining the cause of any Buton asphalt density. Therefore, further research is needed by using more samples and making measurements directly about the bitumen content and bitumen content.

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Acknowledgments
The author gives countless thanks and respect, especially to both parents, for all their prayers and sacrifices to be able to provide motivation and encouragement both morally and materially given to the author. Furthermore, deepest gratitude and appreciation, the author conveyed to PT Wika Bitumen and PT Metrix Elcipta which has helped many authors in completing this research and also to the Physics Laboratory Coordinator who has helped in providing tools to facilitate the author in retrieving experiment data.