Mineral Identification of South Aceh Marble by Using X-Ray Diffraction Method

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Abstract. The purpose of this study was to identify the mineral content of South Aceh marbles. Marbles were collected from three selected areas: GunungKerambil, Meukek, and AlurKering. The samples were analysed mineralogical using X-Ray Diffraction (XRD) method. X-Ray Diffraction (XRD) analysis revealed that marble from these three regions showed the same diffraction pattern. All samples contain carbonate ions. The carbonate phase of this sample predominantly consists of calcite (CaCO₃). The phases identified on the marbles from GunungKerambil are dominated by calcite, while the phases identified from the marbles from Meukek and AlurKering are calcite and graphite.

1. Introduction

X-ray Diffraction (XRD) is one of the most important methods for mineral phase identification. The XRD method has been used to analyse several inorganic minerals such as metals, alloys, soils, minerals and rocks [1-8]. Marble is natural rocks derived from limestone metamorphism due to heat and pressure increased within the earth. Since the last decades, marble has been used for many decoration and construction applications. The availability of marble deposits offers the feasibility for economic growth with the potential applications.

South Aceh is one of the areas that well known for its marble deposits in Indonesia. The marble has been locally fabricated into many valuable products in Marble Production Unit located in Tapaktuan [9-10]. Most of the fabricated marble are generally come from GunungKerambil, Meukek, and AlurKering. It varies from white to dark colours. Basically, physical characteristic of any mineral sample can be determined by the colour. However, it cannot identify characteristic of the mineral specifically. A standard method is needed.

The characteristics of marble are significantly influenced by its mineral composition. Many studies have reported mineral composed in marble from different areas such as Pakistan [11-12], Greek [13], Pohorje Montain [14], Thassos island [15], Nigeria [16-17], Moroccan [18-19], and Göktepe (Muğla, Turkey) [20]. In general, mineral identifications were conducted by using X-ray Diffraction (XRD) method. The results show that the marbles from those areas are mainly formed by calcite or...
dolomite mineral. Some impurities such as silicate, oxides, sulphides and graphite may present depending on the geological formation of an area. On the other hand, the information regarding mineral composed in marble from South Aceh is limited. Therefore, identification of mineral formed the South Aceh marble by using a standard method is of great importance. This paper presents the mineral identification of South Aceh Marble by using X-Ray Diffraction method.

2. **Materials and Methods**

This research includes sample preparation, mineral identification and data analysis as shown in Figure 1.

![Sample Preparation](image1.png)  ![Mineral Identification](image2.png)  ![Data Analysis](image3.png)  

**Figure 1.** Research flow

2.1. **Sample Preparation**

Marble stone, which was obtained from GunungKerambil (GK), Meukek (M), and AlurKering (AK) were prepared in the Marble laboratory of Polytechnic of Aceh Selatan, Tapaktuan, South Aceh. The samples used for XRD analysis were in powder form. The stones that were taken to the laboratory were crushed and mashed into powder form (Figure 2). The powder samples were placed into glass sample cups and stored in a plastic bag.

![GK Sample](image4.png)  ![M Sample](image5.png)  ![AK Sample](image6.png)  

**Figure 2.** Marble Sample

2.2. **Mineral Identification**

Mineral content of South Aceh marbles was identified by using Shimazu x-ray diffractometer XRD-7000 with a CuK alpha radiation. The identification was conducted in the laboratory of material physics of Mathematics and Science Faculty in Syiah Kuala University, Banda Aceh. Samples were placed into a diffractometer. X-rays were set focused on a sample. The intensities of the diffracted sample were measured, recorded and plotted against the rotation angles of the sample. The result was shown in term of the X-ray diffraction pattern of the sample. Data obtained in the form of distance between fields (d), intensity (I) and diffraction angle (2θ). The mineral determination was carried out based on the diffraction patterns.

2.3. **Data Analysis**

Diffraction patterns of sample analysis using a computer device equipped with mineral diffraction databases. Diffraction patterns were matched with data in the database. The data obtained were analysed to determine the mineral content in marble.
3. Results and Discussions

3.1. South Aceh Marble

This research was conducted to identify minerals of marble from South Aceh. Marble samples were taken from three different areas; Gunung Kerambil (GK), Meukek (M), and Alur Kering (AK). The appearance of the samples is shown in Figure 3.

![Figure 3. The appearance of South Aceh Marble Sample](image)

It can be seen that the colour of marble varies with the location. Marble from Gunung Kerambil (GK) basically has a white colour with some black fibres inside. Marble from Meukek (M) has a grey colour with some white and orange fibre inside. In addition, marble from Alur Kering (AK) has a dark (black) colour with some white dots appeared. The differences of marble colour are strongly influenced by mineral composed within the marble.

3.2. Diffraction Pattern

X-ray diffraction (XRD) was used to detect mineral contained in the material. Each element or compound has a certain diffraction pattern. The diffraction pattern consists of spectra peaks with different intensities. The diffraction pattern produced in each marble stone from South Aceh is shown in Figure 4.

In the figure, the diffraction pattern of each sample is distinguished by colour. The green colour is interpreted as marble stone from Gunung Kerambil (GK), the red colour is interpreted as marble stone from the Alur Kering (AK), and the black colour is interpreted as marble stone from Meukek (M) area. The position of diffraction peaks in the diffraction pattern indicates the compounds and crystal structures identified from the sample.

![Figure 4. Diffraction Patterns of South Aceh Marble Sample](image)
3.3. XRD Data

The three highest peaks appeared in each diffraction pattern are tabulated in Table 1.

| Location | Diffraction angle 2θ (°) | d (Å)   | FWHM (°) | Intensity |
|----------|--------------------------|---------|----------|-----------|
| GK       | 29.5029                  | 3.0252  | 0.12750  | 5059      |
|          | 26.5997                  | 3.34844 | 0.11600  | 1283      |
|          | 47.5996                  | 1.90884 | 0.13800  | 503       |
| AK       | 29.5363                  | 3.02187 | 0.17000  | 1652      |
|          | 26.6338                  | 3.34423 | 0.16220  | 431       |
|          | 39.5632                  | 2.27606 | 0.19920  | 259       |
| M        | 29.4789                  | 3.02762 | 0.15680  | 1928      |
|          | 26.5781                  | 3.35136 | 0.13790  | 501       |
|          | 48.5972                  | 1.87197 | 0.17650  | 318       |

From the data, it can be seen that the highest peaks in the samples from the three regions are shown at diffraction angles (2θ) 29.5029, 29.5363, and 29.4879 with an average diffraction plane of 3.02 Å. According to mineral diffraction database, the mineral phase identified in South Aceh marbles are dominantly composed of Calcite (CaCO3). Calcite are the main minerals that form limestone or marble. Marble with calcite content are white, colourless and slightly yellow coloured. The highest content of calcite is shown on the marble stone from GunungKerambil(GK) with a white physical appearance. Meukek(M) marble stone possesses a grey colour with a composition of calcite and graphite minerals. On the other hand, marble stone from AlurKering (AK) has a distinctive black colour appearance. It consists of calcite and graphite. Several impurities such as Boron, Oxygen, and Magnesite are present within the marble.

3.4. Crystalline Size

Based on the data in Table 1, the crystalline size within the sample can be calculated using the Scherrer equation [10]. The results are tabulated in Table 2. It is determined by widening of the X-ray diffraction peaks (FWHM).

\[
D = \frac{K\lambda}{\beta \cos \theta}
\]  

(1)

where, D is average crystal size (nm), K is Scherrer constant (0.9), \( \lambda \) is X-ray (Å) wavelength is Diffraction angle (ø), and B is Maximum half height (radians) (FWHM).

The crystal size calculated from calcite in marble stone is 12.49 nm, 9.37 nm, and 10.19 nm. Peak width is inversely proportional to the size of the crystal. The larger the size of the crystal, the smaller the width of the diffraction peak that appears and vice versa.
4. Conclusion

In this study, the identification of mineral composition of South Aceh marble was carried out. From the results, it can be concluded that characteristics of marble from an area differ from others. It depends on its mineral composition. In general, South Aceh marbles are mainly composed of calcium carbonate, namely calcite (CaCO3). The phases identified on the marbles from GunungKerambil are dominated by calcite, while the marbles from Meukek and AlurKering consist of calcite and graphite mineral.

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