Determination of Magnetic Mineral Crystal Structure Using X-Ray Diffraction (XRD) on Igneous Rock from Ogolowe and Bajugan Village, Toli toli District Central Sulawesi

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Abstract

Study of igneous rocks derived from Ogowele Village and Village Toli-Toli Bajugan has been conducted to determine the magnetic minerals contained in the igneous rocks, as well as determine the crystal system, lattice constants and field diffraction by comparison sieve 60 mesh and 80 mesh. Process characterization and analysis using X-Ray Diffraction (XRD). Characterization and analysis of the results showed that the compound was detected both rock samples Fe3O4, SiO2, Al2O3 and MnO2. Igneous rocks derived from Ogowele village is dominated by compounds SiO2 (quartz) by 52% and rocks from Bajugan village dominated by the compound Fe3O4 (magnetite) by 40%. The crystal structure is cubic and hexagonal compound to compound Fe3O4, SiO2, Fe3O4 compound cubic lattice constants are a = b = c is 8.375 Å. To compound the hexagonal SiO2 ie a = b of 4.898 Å and c of 5.385 Å. Field diffraction on Fe3O4 compound is (3 1 1) and the SiO2 compound that is (1 0 1).

Keywords: X-Ray Diffraction, Fe3O4 Compound, SiO2 Compound, cubic, hexagonal

INTRODUCTION

The mining sector in Indonesia is one of the sectors which are the mainstay of government in generating foreign exchange. This is because Indonesia is one country that has many mineral resources. One area in Indonesia, Central Sulawesi, especially Toli-Toli is an area of huge potential for mining materials such as igneous rock which contains magnetic minerals. The spread of igneous rocks almost in 10 subdistricts in Toli Tol, including in the village and village Ogowele Bajugan (Department of Industry and Energy and Mineral Resources Kab.Toli-Toli, 2006).

Magnetic minerals in fact there is always naturally in rocks, soil, or sediments, despite the abundance quantitatively quite small at around 0.1% of the total mass of rock or sediment (Bijaksana, 2002). Magnetic minerals are minerals that have high magnetic properties. The magnetic mineral properties, the type and morphology varied depending on source (Hunt and Moskowitz, 1995). Igneous rocks (from Latin: ignis, ”fire”) is a rock that resulted from the freezing process of magma (Sipatriot, 2013). Basically, the majority (99%) igneous rock...
composed of main elements, namely: Oxygen, Silicon, Aluminum, Iron, Calcium, Sodium, Potassium and Magnesium. These elements form the main silicate minerals: Feldspar, Olivine, Piroksen, amphibole, quartz and mica. These minerals occupy more than 95% by volume of igneous rocks, and became the basis for the classification and explain the origin of magma (Graha, 1987).

Due to the lack of studies of magnetic minerals in igneous rocks in Toli-Toli it is necessary to identify more of the magnetic minerals contained in igneous rocks. Igneous rocks derived from Ogowele Village and Village Toli-Toli Bajugan can draw objects that contain magnets then chances are igneous rocks that have a fairly high Fe content. For it will be the characterization of magnetic minerals contained in the igneous rocks using X-Ray Diffraction (XRD) which includes the formation of compounds, crystal system, lattice constants and fields of diffraction of the magnetic minerals of igneous rocks.

The objectives of this study is to determine the magnetic minerals contained in igneous rocks of the Ogowele and Bajugan village Toli-Toli District and determine the crystal system, lattice constants, and the diffraction plane of the magnetic minerals of igneous rocks.

The XRD Characterization results in the formation of compounds, crystal systems, lattice constants, and diffraction fields.

**EXPERIMENTAL SECTION**

Research for the characterization of magnetic minerals of igneous rocks using XRD performed on two laboratories, namely: Laboratory of Soil Science, Faculty of Agriculture UNTAD and Microstructure Laboratory of Physics, State UNM, Makassar. The timing of the study is from March to August 2013.

In the preparation phase materials used in the form of powder igneous rocks. Making the test material using the method of variation of grain size of 60 mesh and 80 mesh. At this stage of characterization using X-Ray tool Diffraction (XRD) to determine its content and its compounds and crystal system of the sample.

**RESULT AND DISCUSSION**

Characterization using XRD is characterization process that aims to determine the crystal structure of igneous rock samples that include several parameters, i.e.: the crystal structure, lattice constants, and the field diffraction (Sartono, 2006) The results of XRD characterization of igneous rock samples can be seen in Table 1 to 4 and Figure 2 to 5.

Based on the XRD results obtained for samples of igneous rocks from the village Ogowele with a size of 60 mesh looks compound FeO4 (magnetite) has a 21.6% weight percent, SiO2 (quartz) of 52.2%, MnO2 (pyrolusite) by 9, 22%, and 17% Al2O3. It is clear that the compound has the highest weight percent compound SiO2 (quartz). As for the compound FeO4 very small. FeO4 compound has a cubic crystal structure or isometric, based on the lattice constant of a = b = c = 8.375 Å with crystallographic angle $\alpha = \gamma = 90^\circ$. SiO2 and Al2O3 compound has a hexagonal crystal structure with lattice constants $a = b \neq c$ and crystallographic angle $x = \beta \neq \gamma = 120^\circ$. While the compound MnO2 seen that the lattice constant $a = b = 4.492$ Å Adan $c = 2.924$ and has a crystallographic angle $\alpha = \beta = \gamma = 90^\circ$ so that the compound MnO2 has a tetragonal crystal structure.

Different results shown by the results of the characterization of the rock sample size of 80 mesh which FeO4 by 22%, 53% compound SiO2, MnO2 by 8.6% and 17.1% Al2O3. The difference in results is due to the sample size. The finer the sample, the more accurate the phases were detected.

Based on the XRD results it can be said that the rock came from the ogowele village is classified as alkaline igneous rocks (andesite) because it is dominated by high SiO2 compounds.

In igneous rock samples from the village Bajugan 60 mesh size was detected only 3 compounds which amounted to 39.7% FeO4, 32.7% SiO2, and Al2O3 compounds by 28%. While the sample size of 80 mesh detected four compounds, namely by 40% FeO4, SiO2 compounds by 33%, Al2O3 24.9% and 2.1% MnO2 compound. Igneous rock samples Bajugan village also has a crystal structure similar to igneous rock samples Ogowele village because the resulting compound is also the same. FeO4 compound has a cubic crystal structure / isometric, based on the lattice constant of $a = b = c = 8.385$ Å the angle is $\alpha = \beta$ crystallography $= \gamma = 90^\circ$.
diffraction [311]. SiO$_2$ and Al$_2$O$_3$ compound has a hexagonal crystal structure with lattice constants $a = b \neq c$ and crystallographic angle $\alpha = \beta \neq \gamma = 120^\circ$ having SiO$_2$ diffraction field is [101] and Al$_2$O$_3$ is [100]. While the compound MnO$_2$ seen that the lattice constant $a = b = c = 5,886\,\text{Å}$ and $2,954\,\text{Å}$ and has a crystallographic angle $\alpha = \beta = \gamma = 90^\circ$ and the field diffraction [211] so that the compound MnO$_2$ has a tetragonal crystal structure.

Table 1. Compound with crystal system of XRD result of Ogowele rock 60 mesh size.

| No | Compound | Content (%) | $2\theta$ ($^\circ$) | d-Value (Å) | Int (cps) | Crystal Structure | crystallographic angle | Lattice Contant | Diffraction field |
|----|----------|-------------|---------------------|------------|----------|------------------|-----------------------|----------------|------------------|
| 1  | Fe$_3$O$_4$ | 21,6        | 35,530              | 2,5246     | 218      | Cubik            | $\alpha = \beta = \gamma = 90^\circ$ | $a = b = c$    | (3 1 1)          |
| 2  | Fe$_3$O$_4$ | 30,228      | 2,9542              | 47         |          |                  |                       |                |                  |
| 3  | Fe$_3$O$_4$ | 43,157      | 2,0944              | 74         |          |                  |                       |                |                  |
| 4  | Fe$_3$O$_4$ | 62,61       | 1,4825              | 150        |          |                  |                       |                |                  |
| 5  | SiO$_2$    | 52,2        | 26,726              | 3,3328     | 1387     | Hexagonal        | $\alpha = \beta \neq \gamma = 120^\circ$ | $a = b \neq c$ | (1 0 1)          |
| 6  | SiO$_2$    | 20,945      | 4,2378              | 319        |          |                  |                       |                |                  |
| 7  | SiO$_2$    | 39,609      | 2,2735              | 51         |          |                  |                       |                |                  |
| 8  | SiO$_2$    | 60,048      | 1,5394              | 167        |          |                  |                       |                |                  |
| 9  | MnO$_2$    | 9,2         | 28,053              | 3,1781     | 498      | Tetragonal       | $\alpha = \beta = \gamma = 90^\circ$ | $a = b \neq c$ | (1 1 0)          |
| 10 | MnO$_2$    | 36,627      | 2,4514              | 62         |          |                  |                       |                |                  |
| 11 | MnO$_2$    | 57,048      | 1,6132              | 99         |          |                  |                       |                |                  |
| 12 | Al$_2$.66$.O$_4$ | 17  | 37,49                | 2,397      | 43       | Cubik            | $\alpha = \beta = \gamma = 90^\circ$ | $a = b = c$    | (4 0 0)          |
| 13 | Al$_2$.66$.O$_4$ | 45,939    | 1,9739              | 130        |          |                  |                       |                |                  |
| 14 | Al$_2$.66$.O$_4$ | 68,405    | 1,3703              | 125        |          |                  |                       |                |                  |

Table 2. Compound with crystal system of XRD result of Ogowele rock 80 mesh size.

| No | Compound | Content (%) | $2\theta$ ($^\circ$) | d-Value (Å) | Int (cps) | Crystal Structure | crystallographic angle | Lattice Contant | Diffraction field |
|----|----------|-------------|---------------------|------------|----------|------------------|-----------------------|----------------|------------------|
| 1  | Fe$_3$O$_4$ | 22          | 30,142              | 2,9624     | 312      | Cubik            | $\alpha = \beta = \gamma = 90^\circ$ | $a = b = c$    | (3 1 1)          |
| 2  | Fe$_3$O$_4$ | 35,463      | 2,5292              | 389        |          |                  |                       |                |                  |
| 3  | Fe$_3$O$_4$ | 62,54       | 1,4839              | 181        |          |                  |                       |                |                  |
| 4  | SiO$_2$    | 53          | 20,890              | 4,2488     | 560      | Hexagonal        | $\alpha = \beta \neq \gamma = 120^\circ$ | $a = b \neq c$ | (1 0 1)          |
| 5  | SiO$_2$    | 26,674      | 3,3392              | 650        |          |                  |                       |                |                  |
| 6  | SiO$_2$    | 36,57       | 2,455               | 117        |          |                  |                       |                |                  |
| 7  | SiO$_2$    | 39,459      | 2,2818              | 66         |          |                  |                       |                |                  |
| 8  | SiO$_2$    | 50,16       | 1,8173              | 104        |          |                  |                       |                |                  |
| 9  | MnO$_2$    | 8,6         | 22,082              | 4,022      | 136      | Orthorombik      | $\alpha = \beta = \gamma = 90^\circ$ | $a \neq b \neq c$ | (1 1 0)          |
| 10 | MnO$_2$    | 24,236      | 3,6692              | 81         |          |                  |                       |                |                  |
| 11 | MnO$_2$    | 43,01       | 2,101               | 96         |          |                  |                       |                |                  |
| 12 | MnO$_2$    | 56,94       | 1,6158              | 99         |          |                  |                       |                |                  |
Figure 2. XRD result of igneous rock samples Ogowele village 60 Mesh size

Figure 3. XRD result of igneous rock samples Ogowele village 80 Mesh size

Figure 4. XRD result of igneous rock samples from Bajugan village 60 Mesh size

Figure 5. XRD result of igneous rock samples from Bajugan village 80 Mesh size
Table 3. Compound and crystal system of XRD result of Bajugan rock 60 mesh size

| No | Compound   | Content (%) | 2θ (°) | d-Value (Å) | Int (cps) | Crystal Structure | crystallographic angle | Lattice Constant | Diffraction field |
|----|------------|-------------|--------|-------------|-----------|-------------------|------------------------|-------------------|------------------|
| 1  | Fe₃O₄      | 39,7        | 30,14  | 2,962       | 125       | Cubic             | α = β = γ = 90°       | a = b = c         | (3 1 1)          |
| 2  | SiO₂       | 32,7        | 26,739 | 3,313       | 285       | Hexagonal         | α ≠ γ ≠ 120°          | a = b ≠ c         | (0 1 1)          |
| 3  | SiO₂       | 28          | 33,300 | 2,6883      | 156       | Hexagonal         | α ≠ γ ≠ 120°          | a = b ≠ c         | (0 1 2)          |

Based on the above results it is clear that the composition of rock samples from Bajugan village dominated by the Fe₃O₄ compound. With a high content of the Fe₃O₄ compound then rocks from the Bajugan village very useful as a main raw material of iron / steel.

**CONCLUSION**

Based on the analysis and XRD characterization in both the rock samples indicate that the detected magnetic minerals are compounds Fe₃O₄ (Magnetite). Where the igneous rocks from the village Ogowele have Fe₃O₄ content of 22%, while rocks from Bajugan village has a fairly high Fe₃O₄ content of about 40%.

From the results of XRD and proof theory calculations for the two rocks is known that the compound Fe₃O₄ from each sample has a cubic crystal structure / isometric with diffraction field or index field is [3 1 1] and has a lattice constant a = b = c. In a sample size of 60 mesh stone Ogowele Fe₃O₄ obtained compound with the results of XRD lattice constant values are a = b = c = 8.375Å whereas the theoretical calculation that a = b = c = 8.372 Å. While the rock sample size of 60 mesh Village Bajugan lattice constant values obtained XRD results are a = b = c = 8.385Å while the results of theoretical calculations are a = b = c = 8.372 Å.
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