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

Musfirah Cahya Fajrah[1,*], Alia Mapesso [2,], and Sandra Kasim [3]

[1]*Physics Departement, Faculty of Mathematics and Natural Science, Institut Sains Dan Teknologi Nasional, Jakarta, Indonesia*
[2,3]*Physics Departement, Faculty of Mathematics and Natural Science, Universitas Tadulako, Central Sulawesi, Indonesia*

**Corresponding Author: fira.toana@gmail.com*

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 Fe_3O_4, SiO_2, Al_2O_3 and MnO_2. Igneous rocks derived from Ogowele village is dominated by compounds SiO2 (quartz) by 52% and rocks from Bajugan village dominated by the compound Fe_3O_4 (magnetite) by 40%. The crystal structure is cubic and hexagonal compound to compound Fe_3O_4 SiO_2. Fe_3O_4compound 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 Fe_3O_4compound is (3 1 1) and the SiO2 compound that is (1 0 1).

Keywords: X-Ray Diffraction, Fe_3O_4 Compound, SiO_2 Compound, cubic, hexagonal

Abstrak (Indonesian)

Telah dilakukan penelitian terhadap batuan beku yang berasal dari Desa Ogowele dan Desa Bajugan Kabupaten Toli-Toli untuk mengetahui mineral-mineral magnetik yang terkandung pada batuan beku tersebut, serta menentukan sistem kristal, konstanta kisi dan bidang difraksi dengan perbandingan ayakan 60 mesh dan 80 mesh. Proses karakterisasi dan analisis menggunakan *X-Ray Diffraction* (XRD). Hasil karakterisasi dan analisis menunjukkan bahwa pada kedua sampel batuan terdeteksi senyawa Fe_3O_4, SiO_2, Al_2O_3 dan MnO_2. Batuan beku yang berasal dari Desa Ogowele didominasi oleh kandungan senyawa SiO_2 (kuarsa) sebesar 52 % dan batuan yang berasal dari Desa Bajugan didominasi oleh senyawa Fe_3O_4 (*magnetite*) sebesar 40 %. Struktur kristal yang terbentuk yaitu kubik pada senyawa Fe_3O_4 dan heksagonal pada senyawa SiO_2. Konstanta kisi senyawa Fe_3O_4 kubik yaitu a = b = c adalah 8,375 Å. Untuk senyawa SiO_2 heksagonal yaitu a = b sebesar 4,898 Å dan c sebesar 5,385 Å. Bidang difraksi pada senyawa Fe_3O_4 yaitu (3 1 1) dan pada senyawa SiO_2 yaitu [1 0 1]

Kata kunci: X-Ray Diffraction, Senyawa Fe_3O_4, Senyawa SiO_2, kubik, heksagonal

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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 Toli, 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.

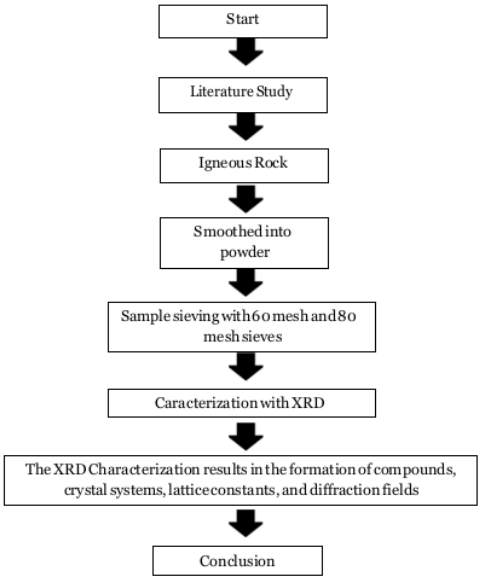

Figure 1 Research Flow Chart

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 Difraction (XRD) to determine its content and its compounds and crystal system of the sample.

Research flow chart showed;

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 Fe_3O_4 (magnetite) has a 21.6% weight percent, SiO2 (quartz) of 52.2%, MnO_2 (pyrolusite) by 9, 22%, and 17% $Al_2.66O_4$. It is clear that the compound has the highest weight percent compound SiO2 (quartz). As for the compound Fe_3O_4very small. Fe_3O_4 compound has a cubic crys3l structure or isometric, based on the latti3e constant of $a = b = c = 8.375$ Å with crystallographic angle $\alpha = \beta = \gamma = 90°$. SiO^2 and Al_2O_3 compound has a hexagonal crystal structure with lattice constants a = b ≠ c and crystallographic angle α = β ≠ γ = 120o. While the compound MnO2 seen that the lattice constant a = b = 4.492 Å Adan c = 2.924 and has a crystallographic angle α = β = γ = 90 ° 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 Fe_3O_4 by 22%, 53% compound SiO_2, MnO_2 by 8.6% and 17.1% Al_2O_3. 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% Fe_3O_4, 32.7% SiO_2, and Al_2O_3 compounds by 28%. While the sample size of 80 mesh detected four compounds, namely by 40% Fe_3O_4, SiO_2 compounds by 33%, Al_2O_3 24.9% and 2.1% Mn_3O_4 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. Fe_3O_4 compound has a cubic crystal structure / isometric, based on the lattice constant of a = b = c = 8,385 Å the angle is α = β crystallography = γ = 90odan field

diffraction [311]. SiO_2 and Al_2O_3compound has a hexagonal crystal structure with lattice constants a = b ≠ c and crystallographic angle α = β ≠ γ = 120° having SiO_2 diffraction field is [101] and Al_2O_3 is [100]. While the compound MnO_2 seen that the lattice constant a = b = c = 5,886Å and 2,9,54Å and has a crystallographic angle α = β = γ = 90 ° and the field diffraction [211] so that the compound MnO2 has a tetragonal crystal structure.

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

No	Compound	Content (%)	2θ (°)	d-Value (Å)	Int (cps)	Crystal Structure	crystallographic angle	Lattice Contant	Diffraction field
1	Fe_3O_4	21,6	35,530	2,5246	218	Cubik	α=β=γ=90°	a=b=c	(311)
2			30,228	2,9542	47				
3			43,157	2,0944	74				
4			62,61	1,4825	150				
5	SiO_2	52,2	26,726	3,3328	1387	Hexagonal	α=β≠γ=120°	a=b≠c	(101)
6			20,945	4,2378	319				
7			39,609	2,2735	51				
8			60,048	1,5394	167				
9	MnO_2	9,2	28,053	3,1781	498	Tetragonal	α=β=γ=90°	a=b≠c	(110)
10			36,627	2,4514	62				
11			57,04	1,6132	99				
12	$Al_2.66.O_4$	17	37,49	2,397	43	Cubik	α=β=γ=90°	a=b=c	(400)
13			45,939	1,9739	130				
14			68,405	1,3703	125				

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

No	Compound	Content (%)	2θ (°)	d-Value (Å)	Int (cps)	Crystal Structure	crystallographic angle	Lattice Contant	Diffraction field
1	Fe_3O_4	22	30,142	2,9624	312	Cubic	α=β=γ=90°	a=b=c	(311)
2			35,463	2,5292	389				
3			62,54	1,4839	181				
4	SiO_2	53	20,890	4,2488	560	Hexagonal	α=β≠γ=120°	a=b≠c	(101)
5			26,674	3,3392	650				
6			36,57	2,455	117				
7			39,459	2,2818	66				
8			50,16	1,8173	104				
9	MnO_2	8,6	22,082	4,022	136	Orthorombik	α=β=γ=90°	a≠b≠c	(110)
10	$Al_2.O_3$	17,1	24,236	3,6692	81	Hexagonal	α=β≠γ=120°	a=b≠c	(012)
11			43,01	2,101	96				(113)
12			56,94	1,6158	99				(116)

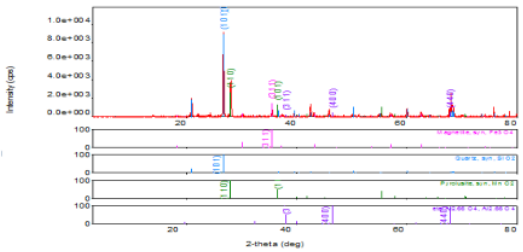

Figure 2. XRD result of igneous rock samples Ogowele village 60 *Mesh* size

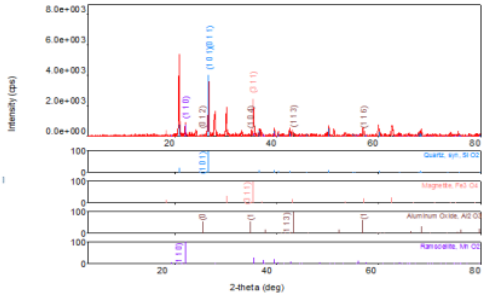

Figure 3. XRD result of igneous rock samples Ogowele village 80 *Mesh* size

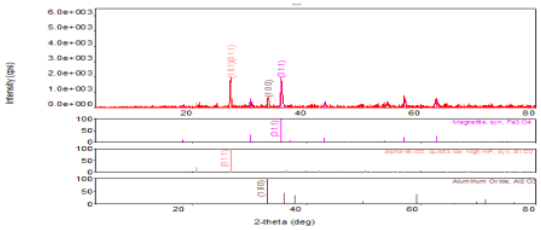

Figure 4. XRD result of igneous rock samples from Bajugan village 60 *Mesh* size

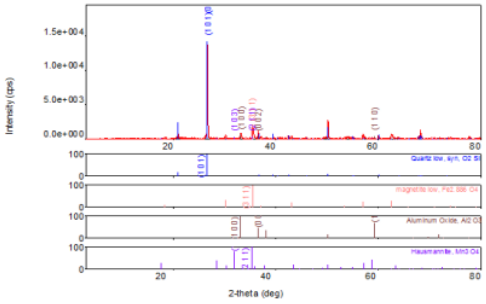

Figure 5. XRD result of igneous rock samples from Bajugan village 80 *Mesh* size

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 Contant	Diffraction field
1	Fe_3O_4	39,7	30,14	2,962	125	Cubic	α=β=γ=90°	a=b=c	(3 1 1)
2			35,529	2,5247	550				
3			57,04	1,6132	216				
4			62,61	1,4824	225				
4	SiO_2	32,7	26,739	3,3313	285	Hexagonal	α=β≠γ=120°	a=b≠c	(0 1 1)
5			54,12	1,6931	216				
6	Al_2O_3	28	33,300	2,6883	156	Hexagonal	α=β≠γ=120°	a=b≠c	(0 1 2)

Table 4. Compound and crystal system of XRD result of Bajugan rock 80 *mesh* size

No	Compound	Content (%)	2θ(°)	d-Value (Å)	Int (cps)	Crystal Structure	crystallographic angle	Lattice Contant	Diffraction field
1	Fe_3O_4	40	30,214	2,9555	110	Cubic	α=β=γ=90°	a=b=c	(3 1 1)
2			35,472	2,5285	552				
3			43,12	2,0962	84				
4			62,60	1,4828	250				
5	SiO_2	33	20,981	4,2305	199	Hexagonal	α=β≠γ=120°	a=b≠c	(1 0 1)
6			26,679	3,3386	1871				
7			42,520	2,1243	57				
8			50,215	1,8153	368				
9			67,81	1,3809	36				
10	Mn_3O_4	2,1	53,98	1,697	182	Tetragonal	α=β=γ=90°	a=b≠c	(2 1 1)
11			56,96	1,6154	167				
12	Al_2O_3	24,9	33,20	2,696	168	Hexagonal	α=β≠γ=120°	a=b≠c	(1 0 0)

Based on the above results it is clear that the composition of rock samples from Bajugan village dominated by the Fe_3O_4 compound. With a high content of the Fe_3O_4 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 Fe_3O_4 (Magnetite). Where the igneous rocks from the village Ogowele have Fe_3O_4 content of 22%, while rocks from Bajugan village has a fairly high Fe_3O_4 content of about 40%.

From the results of XRD and proof theory calculations for the two rocks is known that the compound Fe_3O_4 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 Fe_3O_4 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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