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Analysis of oxide content in sand and rock found in public mining of west sumatra province using XRF test

Rindang Kembar Sari*

Faculty Member of IAIN Bukittinggi, Garegeh, Mandiangin Koto Selayan, Kota Bukittinggi, Sumatera Barat, Indonesia

*rindangkembarsari@gmail.com

Abstract. Indonesia is regionally located on two large plates, which are the Pacific plate in the north and the Australian plate in the south. Due to the geological activity of these two plates, it results in a complex tectonic pattern supporting the formation of mineralization. Therefore, Indonesia is considered as a country rich in various minerals and oxide sources. The purpose of this study is as a preliminary study to analyze the element of atom / oxide contained in rocks and sand found in public mining of West Sumatra Province. The initial identification done is to perform X-ray fluorescence test (XRF) on rock samples taken from *Jorong Bukit Harapan Darmasraya* Regency *and Manggani, 50 Kota* Regency. The sand samples are taken from *Kupitan* area *Sijunjung* Regency, *Pinti Kayu Gadang Muara Labuh* and *jorong pulai Sitiung Darmasraya* regency. XRF test results for rock and sand samples from these five areas indicate the presence of six dominant oxides with large percentage i.e. Al2O3, SiO2, P2O5, CaO, TiO2, Fe2O3 oxides. The content of SiO2, Al2O3, Fe2O3, CaO, TiO2, and P2O5 foundon rock samples is quite high 53.01-57.77%, 29.982-32.191%; 5.113-10.302%; 2.119-2.367%; 0.902-1.809%, and 0.685-0.968% respectively. Meanwhile, the sand samples indicate the content of SiO2, Al2O3, Fe2O3, CaO, TiO2, and P2O5 15.103-52.652%; 5.379-17.621%; 9.22-58.593%; 1.54-9.22%; 0.702-12.238% and 1.261-2.545% respectively.

1. Introduction

Indonesia is regionally located on two plates, Pacific Plates in the North and Australian Plate in the South. This plate collision results in the formation of volcanoes (volcanoes arc). Between these two plates, there is a fault line up and folds. Behind the back arc of subduction zone, they will form a series of magmatic and volcanic activities and various deposition basins. The collision between the Indo-Australian Plate and the Aurasia Plate produces the southern route of Java and the volcano in Sumatra, Java, Nusatenggara and other basins such as the basin of North Sumatra, Central Sumatra, South Sumatra and the North Java. Due to the activity of the movement of the two plates, it eventually results in a complete tectonic pattern. This geological condition supports the formation of mineralization in Indonesia as a gift of Allah SWT, including materials with oxide content, gold and other metals.

The formation of metal minerals closely links to the magmatic process. The area supporting for the formation of metal mineral is commonly found in the ones with volcanic rock. It is due to the magmatic process reaching the earth surface because of intensive erosion leaving small number of volcanic rocks. If the erosion occurs right on the mineralization zone, the metal mineral will be brought up to the surface and easier to obtain [1].

Mineralization process is one of benefits from the collision of the two plates that put Indonesia as a country rich with various mineral and other oxide sources. For example, the oxide material contained in mining rock and sand are (1) quartz sand with dominant content of oxide element of quartz (SiO_2), mostly used as the raw material of ceramic, glass, mirror, cement, plates, other chemical industries, with purity reaching 95 -97 %; (2) clay as a kind of rock which is dominantly composed of kaolinite mineral as the source of aluminium (Al_2O_3) mostly used in ceramic industry , with the purity reaching 40 % ; (3) limestone with dominant oxide content of calsite ($CaCO_3$)as the carbonate sediment which emits CO_2if mixed with chloride acide (HCl), mostly used in Portland cement, steel purification, paper industry, building material, paint and so forth with the purity reaching 98 % ; (4) trass as the mineral produced by vulcanic ashes contained silica oxide (SiO_2) that undergoes sedimentation into certain degree. If it is mixed with calcium oxide, it will produce cement with SiO_2content of 51.93 % - 57.35% dan Al_2O_3: 18.04 % - 20.57 % (5) dolomite is a kind of limestone whose part of its content is replaced by magnesium $CaMg(CO_3)_2$. It is used as the raw material of refractory and fertilizer, with the rate MgO 19,72 %, CaO 35,79 %. [2].

West Sumatera is Indonesian Province rich with natural resources. With this abundant resource, it brings the prosperity to its people. This province is located in both lowland and highland which is potential to have mineral mining.

According to the information from ESDM of West Sumatera [3] the potential mineral materials in the mining encompasses class of A, B, C. Mining material class A is coal in *Sijunjung* and *Sawahlunto*. Class B mining materials consisting of mercury, sulfur, iron sand, copper, lead and silver are in *Sijunjung*, *Solok*, *Lima Puluh Kota*, *Pasaman* and *Tanah Datar*. As for C class mining materials, it is foundthroughout the areas of West Sumatra, such as sand, stone and gravel as well as obsidian and andesite stones in *Padang Pariaman*. (http: //www.bi.go.id.profilsumbar).

In addition, West Sumatra is also famous for its largest quartz sand reserves in Indonesia. Quartz sand is formed from weathering rocks that drift and are deposited in the areas of the river, beach and lake. Quartz sand is a mining material consisting of crystals of silica (SiO2) and containing impurities carried over during the sediment process. Quartz sand is also known as white sand as the result of weathering rocks containing major minerals, such as quartz and feldspar. The result of weathering is then washed and carried away by water or wind deposited on the banks of rivers, lakes or seas. Quartz sand has a composite composition of SiO2, Al2O3, TiO2, CaO, MgO, K2O, clear white or any other color depending on the impurities. (www.tekmira.esdm.co.id, 2010).

The purpose of this study is as a preliminary study to analyze or identify the element of atom / oxide contained in rocks and sands in public mining of West Sumatra Province through X-Ray Flourescence test. Hopefully, this research can be used as the consideration for further research. Rock samples are taken from the area of*MangganiGunungOmeh* 50 Kota regency and *Bukit Harapan* / *SP3 Koto BaruDarmasraya*. Sand samples are taken from the area of *PulaiSitiungDarmasraya, PintiKayuMuaraLabuh and BatangKapehSijunjung*.

2. Theoritical Review

2.1. A Brief Overview of Mining and Mineral in Indonesia

Article 33 of the 1945 Constitution mandates that the earth, water and natural resources contained therein shall be controlled by the State and used for the greatest prosperity of the people. The mandate of the 1945 Constitution is the foundation of mining and energy development to exploit the potential wealth of resources, minerals and energy in support of sustainable national development. The mines, minerals and coal contained within Indonesian mining legal territory are non-renewable natural resources as a gift of Allah SWT which has an important role in fulfilling the livelihood and welfare of Indonesianpeople. Mining is an activity to extract precious and economically valuable precious materials from the earth's crust, either mechanically or manually on the earth's surface. The Government of Indonesia through Government Regulation No. 27 of 1980 divides the minerals into 3 groups, namely: (1). The strategic excavated material which is called quarry material of class A consists of: petroleum, liquid bitumen, frozen wax, natural gas, solid bitumen, asphalt, anthracite, coal, uranium, radium, thorium, other active radio excavated materials, nickel, cobalt, lead. (2). Vital quarry material which is also referred to as class B excavated material consists of iron, molybden, chromium, tungsten, vanadium, titan, bauxite, copper, timbale, zinc, gold, platinum, silver, mercury, arsenic, antimony, bismuth, yttrium, rhutenium, cerium and other rare metals, beryllium, corundum, zircon, quartz crystals, cryolites, fluorspar, barite, iodine, bromine, chlorine, sulfur. (3). Non-strategic and non-vital excavated materials, also known as Class C, consist of: nitrate, nitrite, phosphate, rock salt (halit), asbestos, talc, mica, graphite, magnesite, yarosit, leusit, alum, ocher, gems, quarsakaolin sand, feldspar, gypsum, bentonite, pumice stone, limestone, granite and others, other elements of with no content of class A and class B one the scale of mining economy.

2.2. X-Ray Flourencence

The analysis using XRF is based on identification and enumeration of X-ray from the effect of photoelectric event. The electric photo effect occurs because the electrons in the target atom (sample) are exposed to high-energy beams (gamma radiation, X-rays). If the light energy is higher than the electron binding energy in the orbit of K, L, or M of the target atom, then the target atomic electron will exit its orbit. Thus, the target atom will experience electron vacuum. This electron vacuum will be filled by electrons from the outer orbital followed by the release of X-ray energy. The schematic of the identification process with XRF is shown in Figure 1.

The resulting X-ray is a combination of continuous spectrum and a certain energy spectrum (discreet) derived from the target material overlapped with electrons. The type of discreet spectrum that occurs depends on the displacement of electrons occurring in the atoms of the material. This spectrum is known for its characteristic X-ray spectrum. XRF spectrometry utilizes X-rays emitted by a material which is then captured by a detector to analyze the content of the elements in it. The material analyzed can be massive solid, pellet, or powder. The elemental analysis is done both qualitatively and quantitatively. Qualitative analysis analyzes the types of elements contained in the material and quantitative analysis is performed to determine the concentration of elements therein. The X-rays generated from the event are captured by Silicon Lithium semiconductor (SiLi) detectors.

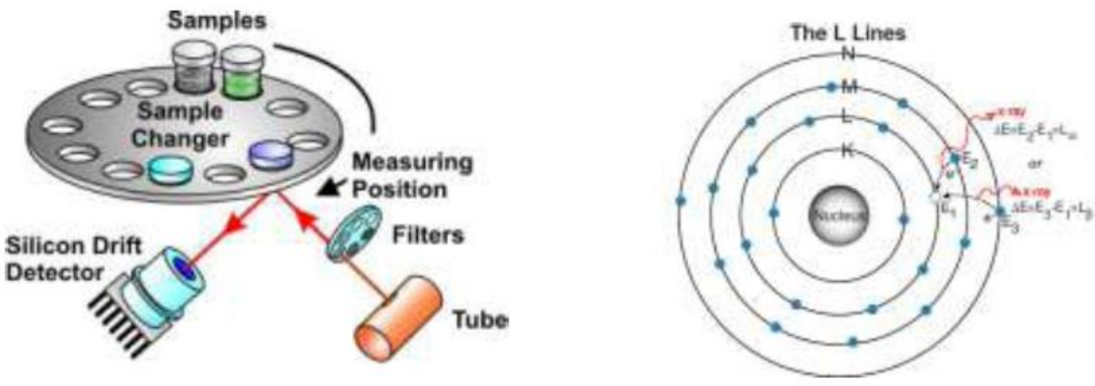

Figure 1.(a) principle of X-Ray Flourescence, (b) the electron vacuum on L line [4].

3. Research Method

3.1. Sample Selection

In this study, samples from natural materials in the form of rocks and sand are taken from *MangganiGunung Omeh.50 Kota, Bukit Harapan / SP3 Koto BaruDarmasraya* for rock samples and *PulaiSitiungDarmasraya, PintiKayuMuaroLabuh and BatangKapehSijunjung* for sand material. The natural material undergoes the process of selection and scouring in order to get the particles to be tested with XRF. Schematic stages in this study can be seen in Figure 2.

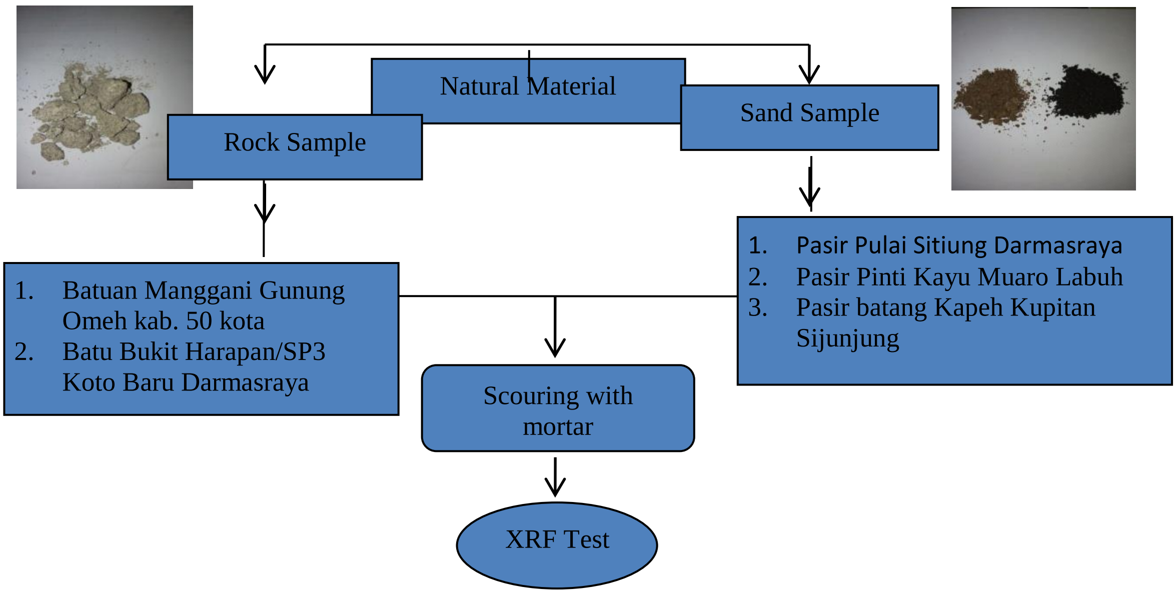

Figure 2. Sample Selection Process

3.2. Preparation of Sample Testing

Samples prepared from natural materials are rock and sand. The researcher took a small part of the sample to be processed into powder form. This powder was then inserted into the sample container. This research was conducted in Laboratory of Material Chemistry Instrument FMIPA UNP in June 2017. XRF test is generally used to analyze element in mineral / rock. The elemental analysis is done both qualitatively and quantitatively. Qualitative analysis is done to analyze the type of elements contained in the material while quantitative analysis is done to determine the element concentration in the material.

3.3. Results and Discussion

XFR test is conducted as the initial step to identify the expected presence of SiO_2, Al_2O_3, TiO_2, CaO, which later will be used for further research. XRF results from rock and sand samples are presented in the Table 1.

Table 1. XRF Results from Rock and Sand Samples

Element	**Sand**			**Rock**		**Oxide**	**Sand**			**Rock**	
	Pl	**Pi**	**Ku**	**Mg**	**Bh**		**Pl**	**Pi**	**Ku**	**Mg**	**Bh**
Al	5.713	3,843	14,633	28,102	25,725	Al_2O_3	7,900	5,379	17,621	32,191	29,982
Si	11.490	9,657	43,209	54,039	46,397	SiO_2	17,709	15,103	52,652	57,772	53,010
P	1.145	1,545	1,095	0,995	0,643	P_2O_5	1,853	2,545	1,261	0,968	0,695
K	0,141	0,347	1,547	0,789	0,616	K_2O	0,115	0,287	0,880	0,392	0,338
Ca	1,646	2,820	14,466	3,751	3,787	CaO	1,540	2,669	9,225	2,119	2,367
Ti	8,955	11,130	0,993	1,392	2,525	TiO_2	9,749	12,238	0,702	0,902	1,809
Fe	67,100	66,649	16,023	9,719	18,115	Fe_2O_3	58,020	58,593	9,220	5,113	10,301
V	0,426	0,390	0,042	0,048	0,113	V_2O_5	0,485	0,448	0,031	0,033	0,085
Cr	0,639	0,101	0,013	0,005	0,143	Cr_2O_3	0,606	0,097	0,008	0,003	0,090
Mn	0,457	0,740	0,220	0,061	0,107	MnO	0,361	0,597	0,116	0,029	0,056
Cu	0,022	0,032	0,017	0,017	0,014	CuO	0,016	0,023	0,008	0,007	0,006
Zn	0,127	0,084	0,031	0,031	0,032	ZnO	0,090	0,061	0,014	0,013	0,014
Sr	0,014	0,014	0,351	0,082	0,095	SrO	0,010	0,009	0,151	0,032	0,039
Ag	1,317	1,462	0,879	0,694	0,830	Ag_2O	0,962	1,082	0,448	0,308	0,403

Based on the characterization of five rock and sand samples from public mining of West Sumatera by XRF test, it shows that there are 14 identified oxides. Six of which have percentage above 0.5% i.e. oxides of Al_2O_3, SiO_2, P_2O_5, CaO, TiO_2 and Fe_2O_3. As for the content percentage of Al_2O_3, SiO_2, P_2O_5, CaO, TiO_2 and Fe_2O_3 in rock samples is SiO_2 53.01-57.77%; $Al_2O_3$29.982-32.191%; P_2O_5 0.685-0.968%; CaO 2.119-2.36%; TiO_2 0.902-1.809%; and $Fe_2O_5$5.113-10.302%. Meanwhile, for the sand sample the content percentage is SiO_2 15.103-52.652%; Al_2O_3 5.379-17.621%; P_2O_5 1.261-2.545%; CaO 1.54-9.225%; TiO_2 0.702-12.238% and $Fe_2O_3$9.22-58.593%.

4. Conclusion

The results of X-Ray Fluorescence test on rock and sand samples taken from West Sumatera show in the rock samples of *Manggani* the presence of oxides $SiO_2$and Al_2O_3higher than other oxides 57,772% and 32,191%. As for the sand samples from *Pulai Sijunjung* and *Pinti Muara Labuh*, oxide Fe_2O_3 has dominant percentage i.e. 58.593%. Oxides obtained from XRF test such as oxides of SiO_2, Al_2O_3, TiO_2 and CaO can be used for further research. To support the XRF test results, XRD test is needed to be done for these samples.

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