INDUSTRIAL MINERALS IN WEST KALIMANTAN AND THEIR UTILIZATION FOR CERAMIC PRODUCTS

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ABSTRACT

The Province of West Kalimantan has abundant source of industrial minerals such as kaolin, ball clay, quartz and zircon that can be utilized as ceramic raw materials. These materials are spread out in Regencies of Sambas, Singkawang, Bengkayang, Sanggau and Sintang. From various industrial minerals found in West Kalimantan, only clay and kaolin have been utilized by the ceramic industries in West Kalimantan, West Java, Central Java, East Java and Bali. The other industrial minerals such as bauxite, zircon, ilmenite, quartz still have not been utilized for ceramics commodity.

Therefore to empower all industrial mineral types from these areas as ceramic raw materials, it is necessary to do a circumstantial and comprehensive study of those minerals based on the result of preliminary research related to ceramic raw materials, whether by using them directly for ceramic products or through processing beforehand. From this study, it is expected that the industrial minerals in West Kalimantan can be empowered to be optimally utilized for white or coloured ceramic bodies, glaze, refractory and other ceramic products.

Keywords : Industrial minerals, ceramic, West Kalimantan

1. INTRODUCTION

Industrial minerals or non-metallic minerals are all kind of mine materials type excluding metallic minerals and energy materials (petroleum, natural gas and coal) and element of radioactivity, which can be utilized for various industrial needs, among others is ceramics industry. According to the Government Regulation no. 27/1980 on Mining, the industrial minerals are grouped into mine materials of group C. Some industrial minerals such as quartz, feldspar, kaolin, ball clay, clay, limestone and toseki are usually applied for making ceramic product like floor tile, wall tile, tableware, sanitary and decorative or art ceramics (Suripto and Wenas, 2006).

The existence of industrial mineral deposits in West Kalimantan like quartz sand, ball clay, ilmenite, bauxite, kaolin and zircon sand, spread out in Regencies of Sanggau, Pontianak, Sambas, Singkawang, Ketapang, Sintang and Bengkayang. As illustratated in Table 1, there are some minerals deposit in Singkawang Regency such as kaolin, quartz sand and ball clay with total deposits of around 1,200,000 m^3, 930,000 m^3 and 1,790,000 m^3 respectively. Whereas in Regency of Bengkayang there are deposits of zircon sand, kaolin, quartz sand, clay and ball clay with the total amount of deposit around 4,980,000 m^3, 8,700,000 tons, 6,800,000 tons, 2,700,000 tons and 3,270,000 tons respectively (Anonymous, 2004).

The majority of industrial minerals as mentioned above still have not been commercially managed for the purpose of ceramic industry in this country, and only the minerals in Singkawang Regency which have been utilized by ceramics industry, for example clay from South Singkawang district in

Table 1. The type and total deposits of ceramic raw materials in West Kalimantan

Regency	Type of raw material	Total deposit
Bengkayang	Zirkon sand	4,980,000 m^3
	Quartz sand	6,800,000 tons
	Kaolin	8,700,000 tons
	Bauxite	2,700,000 tons
	Ball clay	3,270,000 tons
Sekadau	Zirkon sand	870,000 m^3
	Quartz sand	9,250,000 tons
	Clay	Million tons
Sintang	Zirkon sand	1,360,000 m^3
	Quartz sand	Million tons
	Manganese/pyrolusite	1,250,000 m^3
Melawi	Felspar	Hundred thousand tons
	Quartz sand	Million tons
Pontianak	Quartz sand	7,500,000 m^3
	Kaolin	9,200,000 m^3
	clay	12,400,000 tons
Landak	Quartz sand	10,600,000 m^3
	Kaolin	7,250,000 m^3
Ketapang	Quartz sand	172,000,000 tons
	Kaolin	7,450,000 m^3
	Bauxite	590,000,000 tons
	clay	8,600,000 m^3
Sanggau	Quartz sand	65,400,000 tons
	Kaolin	5,380,000 tons
	Felspar	1,790,000 tons
	Bauxite	420,600,000 tons
Singkawang	Quartz sand	930,000 m^3
	Kaolin	1,200,000 m^3
	Ball clay	1,790,000 m^3
Sambas	Quartz sand	4,250,000 tons
	Kaolin	49,800,000 m^3
	Felspar	9,000,000 m^3
	Dacite	9,900,000 m^3
Kapuas Hulu	Quartz	7,950,000 tons
	Kaolin	9,400,000 tons
	Shale	5,300,000 m^3

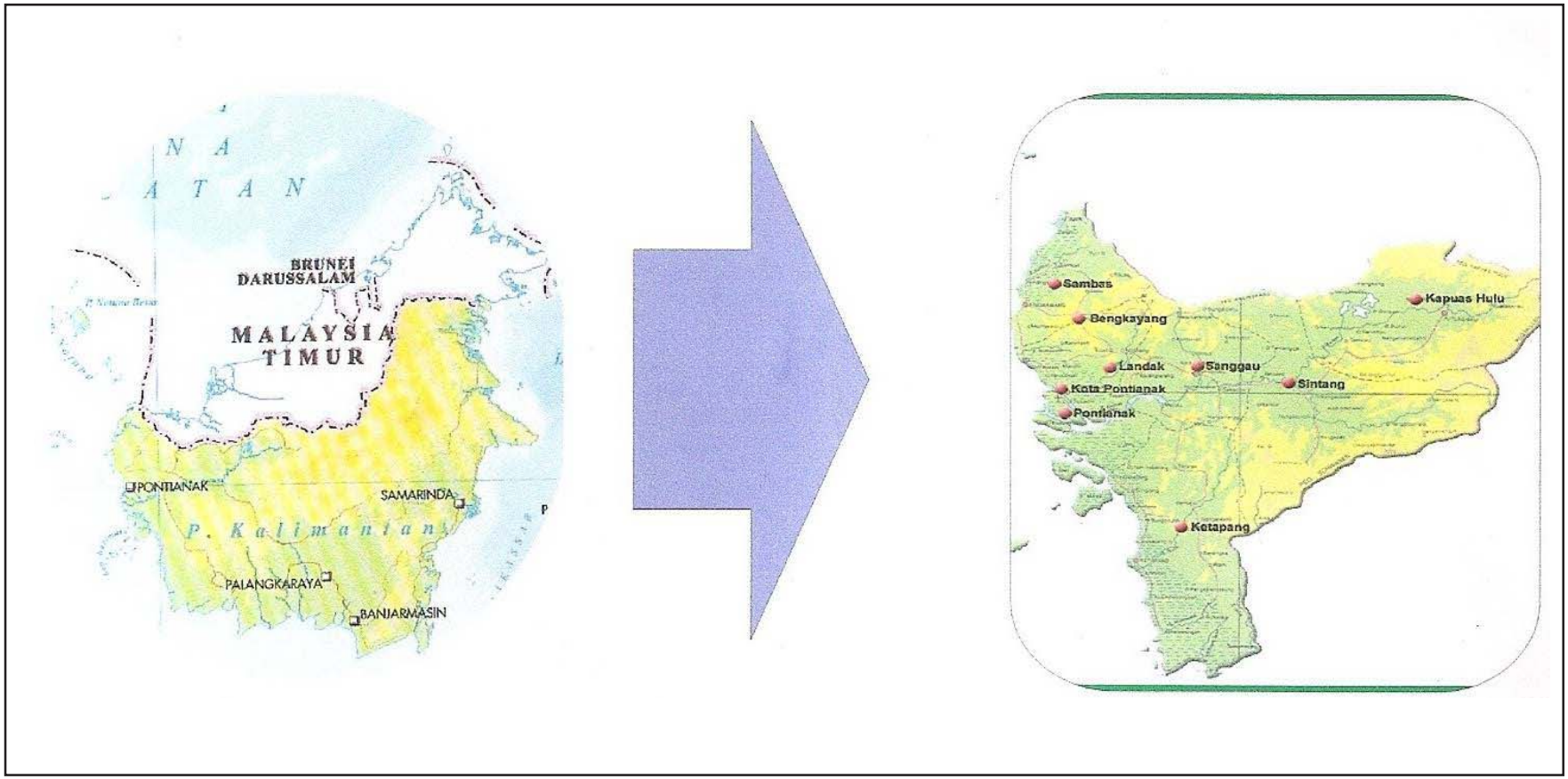

Figure 1. The map of potential ceramic raw material in West Kalimantan

Sedau village and vicinity area have been applied by ceramics industry for decorative ceramics and bricks. The ball clay from Capkala district which are the property of PT Sibelco Lautan Mineral have been used by the ceramic industries in the Province of West Java and East Java, and some minerals are exported to Malaysia, Korea and China. The deposit of zircon sand in the Regencies of Bengkayang, Sekadau and Sintang, which is known as placer deposit or alluvial is still be mixed with ilmenite sand, quartz sand and other minerals. Therefore to separate the zircon sand from other minerals, it needs beneficiation process by means of gravity concentration, magnetic separation or other methods depending on mineral characteristics.

2. METHODOLOGY

The method of this study is conducted by using primary and secondary data. The primary data consists of industrial mineral characteristics such as chemicals composition, physical properties of minerals and direct observation on the location of industrial mineral deposits. The secondary data consist of report of industrial mineral resources in West Kalimantan, obtained from literature study.

3. THE POTENCY OF INDUSTRIAL MINERALS IN WEST KALIMANTAN

The existence of industrial mineral deposits as source of potential ceramic raw materials in West Kalimantan such as quartz sand, ball clay, kaolin, clay and feldspar are spread out in several regencies as shown in Table 1.

4. THE UTILIZATION OF INDUSTRIAL MINERALS AS CERAMIC RAW MATERIALS

In regency areas of West Kalimantan Province which have a lot of potential sources of industrial minerals as ceramic raw materials, not all minerals are being optimally explored yet as ceramic products. Only clay from South Singkawang District and ball clay from Capkala District in Singkawang Regency are used as a single material for ceramics body.

Clay from South Singkawang District has been used for making decorative ceramics like jar, decorative jar and artistic vase by ceramic workers in that region, by hand made in lieu of slip casting method and its glaze material still uses waste battery or used accu which contains poisonous plumbum sulfide (PbS) (Anonymous, 2002). Therefore it has been tried to form the ceramic ware from single clay material by slip casting method and then be glazed by frit glaze materials which are nontoxic and not dangerous for health of the worker and environment (Subari et al, 2007). After investigating its utilization for ceramic products, the clay from Capkala District similar to ball clay, because its grain size particle below 2 micron (2 μm) is around 80.15 % and its plasticity index is above 25. Ball clay is categorized as secondary clay containing organic material, having high plasticity, wide range of vitrification, and having white or bright colour if it is heated at high temperature.

Besides ball clay in Capkala District owned by PT Sibelco Lautan Mineral is being used by the ceramic industry in Pontianak and Singkawang Regency, it also has been sold to ceramic industries in West Java like PT Inti Kemenangan Jaya, PT KIA and Mulia Keramik, and in East Java like PT Kuda Laut Mas and Kuali Mas Keramik, and has been exported to China, Korea, Japan and Malaysia. Another type of clay applied for making ceramic products is kaolin or china clay which has been used by PT Lucky Indah Keramik (tableware) in Tangerang and PT Sanagriya Lestari Keramik (ceramic tile) in Bekasi.

Generally, the deposit of kaolin might be divided into two kinds, that are:

1. Primary deposit, which occured due to the chemical decomposition of rock source where granitic/rhyolitic formed “in situ” and usually called as primary residual deposit. The primary deposit may also occur because of magmatic process (hydrothermal) which is usually formed at rock cracks, weakness zone or along the faulting rocks. Generally the primary deposit consist of coarse granulous.

2. Secondary deposit, formed by the transportation as an interaction result of atmosphere and hydrosphere of primary deposit or the granitic/rhyolitic rocks which were precipitated in cer-

tain area. The transported media may be water or wind because in general the secondary deposit are in the fine granulous. The deposit of kaolin in the area of Sei Pangkalan in Sambas Regency can be found in fine granule and there is no existence of sulfide minerals such as pyrite and galena, so it can be estimated as secondary deposit.

The mining activity of kaolin in Sei Pangkalan II (about 50 hectares) is usually done by strip mining (open pit mining). The first step is stripping off the overburden and then after seems to be the kaolin layer continued with digging activity by using excavator.

Zircon sand from Bengkayang regency and Sintang was owned by PT Wajok Inti Lestari Mineral. This company has beneficiation processing unit to process natural zircon sand mixed with other minerals such as quartz sand, ilmenite sand and hematite. From the beneficiation process of zircon sand, it can be obtained $ZrSiO_4$ in reddish brown colour containing ZrO_2 above 50%, and has not yielded yet as pure zircon. The zircon material was tried for making ceramic glaze as an additive material, added into frit glaze with composition of lead (Pb_3O_4) 46%, quartz 16%, borax 15%, boric acid 18%, kaolin 3% and ZnO 2%. The zircon material in glaze may function as opacifier, which can lessen the transparency value and increase its reflectance diffusion value.

5. INDUSTRIAL MINERALS OF WEST KALIMANTAN

5.1. Clay

Clay from South Singkawang District consists of two kinds, that are the yellow coloured clay and the white grey coloured clay. From the result of chemical analysis, each clay contained high alkalinity (K_2O and Na_2O), that are 1.67% and 1.59% respectively, while ferrous oxide grade (Fe_2O_3), alumina oxide (Al_2O_3) and silica oxide (SiO_2) between white grey clay and yellow clay indicating that the difference of grade value is significant. The concentration of Fe_2O_3, Al_2O_3 and SiO_2 for white grey clay are 0.64 %, 28.31 % and 58.24 % respectively, while the yellow clay contains Fe_2O_3 4.40 %, Al_2O_3 12.75 % and SiO_2 72.32 %. Based on the mineralogical analysis, the white grey clay consists of kaolinite, halloysite, quartz and feldspar, whereas yellow clay consists of illite, kaolinite, quartz, feldspar and limonite. According to the chemical and mineralogical analysis of white grey clay, it can be simply classified as ball clay and yellow clay similar to a plastic clay type. Furthermore, by firing at high temperature, the white grey clay gives white creamy colour, while the yellow clay gives reddish light brown colour.

Based on the chemical contents of Fe_2O_3 (4.40 %) and Al_2O_3 (69.13 %), it can be said that the characteristic of the yellow clay is relatively equal to the yellow clay from Zorka Nemetali Company in Cabac Yugoslavia.

As can be seen from mineralogy of Singkawang clay and yellow clay from Zorka Nemetali, both types of clay contain mineral of quartz. Thereby either clay Singkawang or yellow clay from Yugoslavia if fired at high temperature (above 800°C) can undergo sintering process, so the ceramic body will start to be massive. This yellow clay can be casted for ceramics product like tablewares by slip casting method and ceramic tile by drought press (Despotovic and Filipovic, 2006).

The clay from Capkala District, simply is categorized as plastic type clay until hardly plastic or can be categorized as ball clay. This is visible from the result of firing test at temperature 1250°C and 1350°C; the colour is originally creamy grey, after fired at 1250°C the colour turns into milky white and starts to sinter. If the clay is fired at 1350°C, it will melt with creamy white colour. Based on particle size analysis, the size particle under 2 μm is around 80.15 % and comply with Indonesian National Standard of ball clay for fine ceramics (SNI 06 – 0578 – 89).

Clay from South Singkawang District and ball clay from Capkala District are used for decorative ceramics of vase type formed by slip casting, and the result is good enough that the ceramic ware goods are not barst and easy to discharge from the gypsum mould. The product from the casting method shows that the level of viscosity, the thixotropy character and the specific gravity of the cast mass are suitable to the mould characteristic. Slip casting is a mixed ceramic raw materials, suspension mass of water with certain viscosity that

can form thin layer or thick after decanted into the dry gypsum mould. The good characters of slip casting are:

- The viscosity of its slip is enough to flow into the mould directly and quickly.
- The speed of permeate at gypsum mould must be fast
- Having ability for drying in the mould.
- Having stable properties in casting process.
- Quick dryed in the mould.
- Has low dry shrinkage and high dry strength after casted or formed.
- Free of air trap and the symptom of scumming.

In making ceramic products, the slip casting method will give uniform product with varying geometries compared to hand made (throwing). Therefore the ceramic small industries in Singkawang Regency are expected to be able to use slip casting method as an addition to throwing method.

5.2. Bauxite

The deposit of bauxite in West Kalimantan is located at Ketapang and Sambas regencies. However the bauxite has not been commercially managed, while the amounts of deposit is abundance. Based on the exploration data, the bauxite deposit here contains Al_2O_3 above 50 %, clay mineral, quartz (silica) and ferrous oxide. The bauxite ore contains mineral of aluminium hydroxide in the form of diaspore ($Al_2O_3.H_2O$) or gibbsite ($Al_2O_3.3H_2O$), kaolinite ($Al_2O_3.SiO_2.2H_2O$), and impurities mineral like hematite (Fe_2O_3), quartz (SiO_2) and anatase (TiO_2). The relative proportional amount of Al_2O_3/SiO2 can form the mullite mineral, if the bauxite contains alumina (Al_2O_3) above 65 % weight or its molar ratio is 2.55. The existence of mullite in this material gives resilience character of high thermal shock, good mechanical strength and high creep resistance. The characteristics of bauxite in West Kalimantan are relatively equal to the bauxite found in Istra area (Yugoslavia), which still be mixed with clay material and quartz. This bauxite must undergo washing process in drum scrubber equipment in order to obtaine washed bauxite, clay, quartz sand and other impurity (Hayden and Murray, 2001). This mud material contains mineral illite, disordered kaolinite, quartz (silica) and ferrous oxide that very plastic and has low vitrification temperature.

Clay resulted from washed bauxite is categorized as low quality clay and suitable for producing red bricks and ceramic tiles. The chemical components of the clay are SiO_2 51.99–66.47 %, Al_2O_3 11.23–18.15 % and Fe_2O_3 6.39–12.20 %, alkalinity (K_2O + Na_2O) 2.51–4.99 %, vitrification temperature 950–1150°C, water absorption value 6.32 % and the specific gravity 2.38 g/cm^3 (Pavlovic, et al, 1992).

Other impurities in the bauxite are titania oxide (TiO_2) and ferrous oxide (Fe_2O_3), that can reduce the fluxing point. The Fe_2O_3 has fluxing character lower than FeO. TiO_2 can be found in tialite ($Al_2O_3.TiO_2$) or rutile (TiO_2), where tialite melts at temperature of 1850°C. However, if the impurities contained in ferrous oxide are mixed with rutile, it will form Fe_2TiO_5 with fluxing point of 1300°C. Bauxite suitable for refractory has iron content less than 2.5% (Charles A. Schacht, 2004).

5.3. Zircon Sand

The deposit of zircon sand in West Kalimantan can be found in Sekadau, Sintang and Bengkayang regencies. The deposit of zircon sand here is placer deposit and still mixed with other minerals like ilmenite, hematite, rutile and quartz. To separate the zircon sand from the impurities mineral, it must be done by beneficiation process using gravity concentration, magnetic separation and electrostatic separation. The flow chart of the beneficiation process can be seen in Figure 2.

Rutile and limonite have higher level of electrical conductivity compared to zircon, so the minerals are easy to separate by high tension or electrostatic separator with electric field strength around 20–25 kv. To separate iron minerals (hematite, ilmenite) from zircon sand, it can be applied by magnetic separator (Pramusanto dan Fadli, 2006).

The technology of beneficiation process of natural zircon sand from West Kalimantan is similar to that of in Vietnam. However the percentage of beneficiated ZrO_2 is differs in West Kalimantan is around 49.5–50.2%, while in Vietnam is around 54.8–56.2 % (Dao DM., 1999).

In ceramic industry, the zircon raw material is applicable for making refractories, cutting tools, nozzle, automotive components (Wackman, J.B. 1999) and glaze materials which has function as opacifier for glazing sanitary products, tablewares

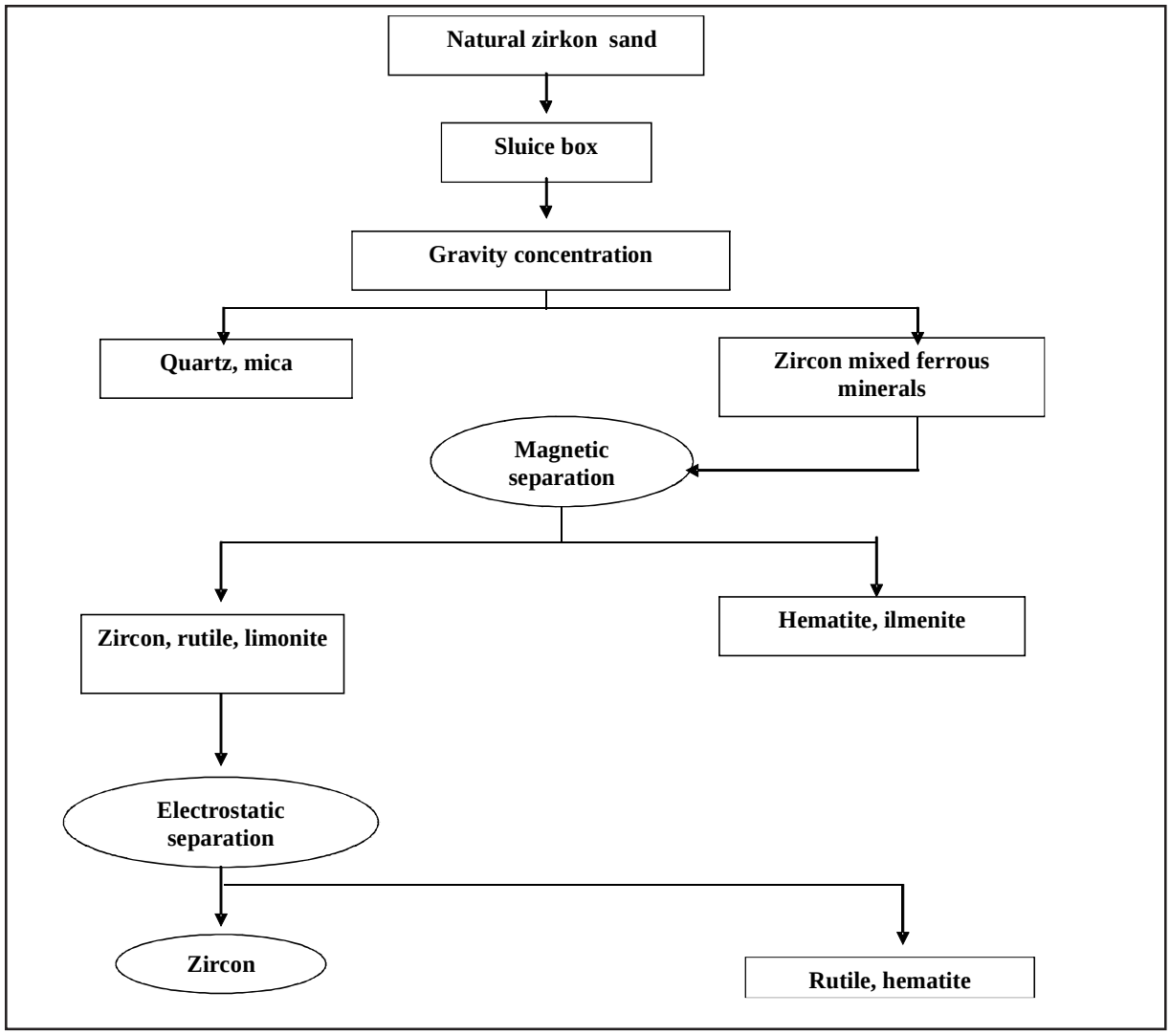

Figure 2. Beneficiation process of natural zircon sand

and ceramic tiles. Zircon material has an opaque property and good to colour effect, resistant incised and very stable at the difference of firing temperature. Therefore the material is recognized for glaze opacifier (Richardson, 1987).

To obtain ZrO_2 from zircon sand, it can be done by melting and leaching process as described in Figure 3.

5.4. Ilmenite sand

Ilmenite sand in West Kalimantan is formed altogether with zircon sand, quartz sand and other minerals. For making ceramic products of coloured body, the ilmenite material can be used as filler material to assists sintering process. Low grade ilmenite on ilmenite body can be used for substitution silica component. Body of ilmenite is more sophisticated and its character is better compared to the conventional ceramics body containing silica. Matured temperature of ilmenite body is lower than silica body. The chemical composition of ilmenite body is TiO_2 47.2%, Fe_2O_3 17.0 %, SiO_2 0,2 %, Al_2O_3 3.7 %. Ilmenite is used as substitution of silica material the making fine earthernware body. The composition of ilmenite body are ilmenite 20–70 %, feldspar 10–30 %, clay 20–50 %. The usage of ilmenite material is between 20–70%, sintered at firing temperature of 1150–1200°C. The porosity value of ilmenite body which is fired at 1200°C is smaller than 1.0 % on

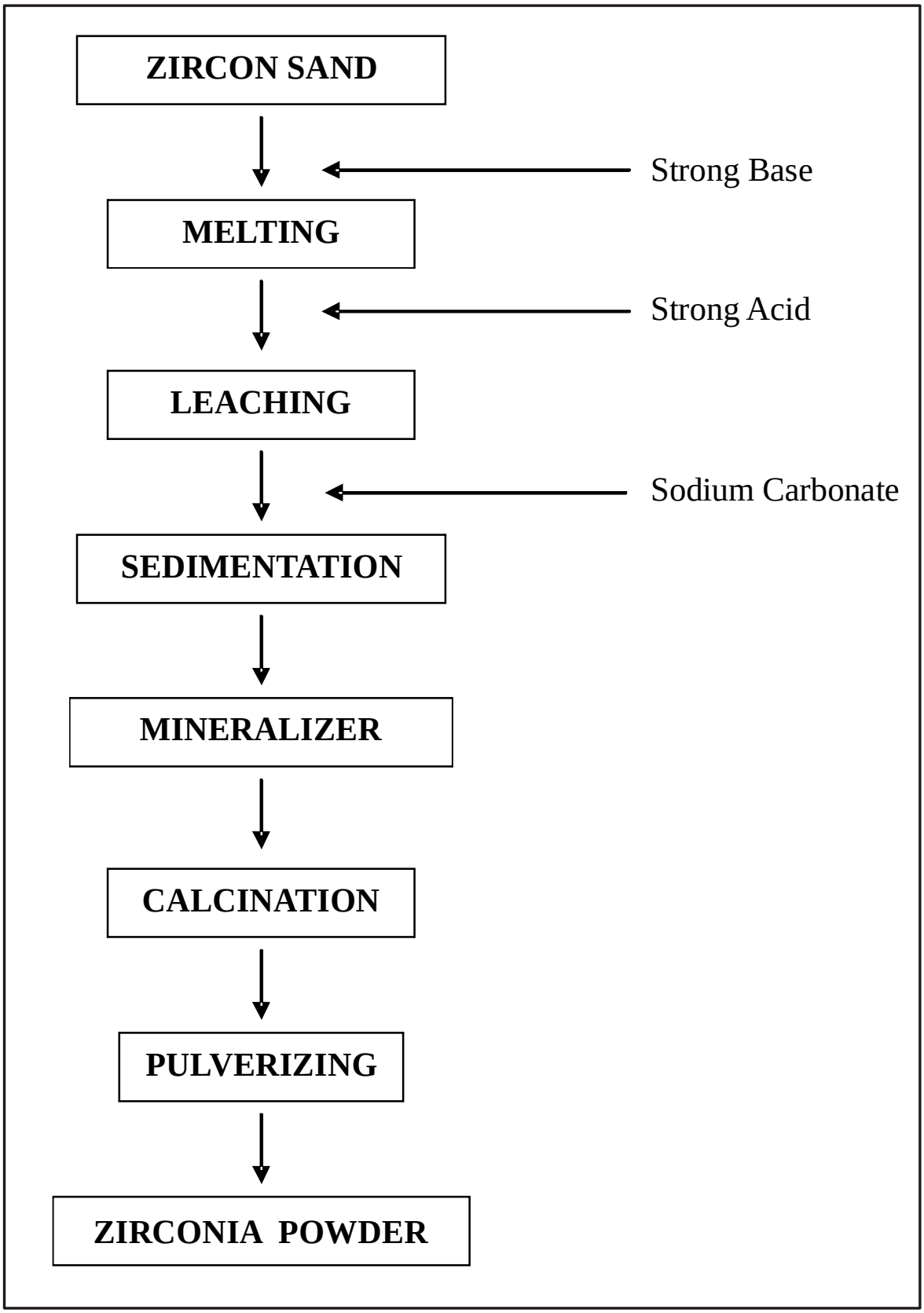

Figure 3. Flow chart of making zirconia powder

usage of ilmenite 60–70%. Its bending strength is bigger than silica body. The composition for ilmenite body and silica is shown in Tabel 2.

Tabel 2. The composition of ilmenite and silica body

Raw Material	Ilmenite Body, %	Silica Body, %
Kaolin	25	25
Ball clay	25	25
Feldspar	25	25
Ilmenite	25	-
Silica	-	25

According to Table 2, the bending strength value of silica body firing at 1200°C is 9,390 lb/in^2, while the bending strength of ilmenite body firing at 1150°C is 10,670 lb/in^2 (Fauber, et.al, 1980). The ilmenite sand can be beneficiated to get titania (TiO_2) by leaching using sulphuric acid solution to form titanyl sulphate ($TiOSO_4$) which will precipitate, and $TiO(OH)_2$ is hydrolysed at temperature 90°C.

Precipitate of $TiO(OH)_2$ is heated until 1000°C to form titania (TiO_2) as follows:

$$TiO(OH)_2 \longrightarrow TiO_2 + H_2O$$

In the ceramic industry, the titania can be used for colourant glaze with specific colour such as dried straw colour.

5.5. Feldspar

The deposit of feldspar found in West Kalimantan in Sanggau and Melawi Regencies with the total reserves of around 2,250,000 tons. Feldspar from Sanggau Regency especially contains alkalinity ($K_2O + Na_2O$) ranging from 3.8–7.2 % and ferrous oxide (Fe_2O_3) between 0.51-0.l85% (Adrian and Subari, 2003). Based on the chemical composition, the feldspar Sanggau is applicable for making ceramics glaze for stoneware and porcelain body (Anonymous, 1990) and for producing fine ceramics of pottery, sanitary and porcelain body (Anonymous, 1989). The mining activity in those regencies is done by a traditional way using bigfork and spade.

According to Center Bureau of Statistics (*Biro Pusat Statistik*), the national ceramic industries still import the feldspar material of amount 734,000 tons in 2006, where most of the raw material is destined as component of glaze. To overcome this feldspar import, the feldspar from West Kalimantan can be utilized optimally. Feldspar contains alkali (K_2O and Na_2O), silica (SiO_2) and alumina (Al_2O_3), that after firing at high temperature, this alkali component melting to form the glass phase. The glass phase will react with silica and alumina to form mullite mineral ($3Al_2O_3.6SiO_2$).

5.6. Kaolin

Kaolin is one of industrial minerals which structured by clay mineral of kaolinite type with low iron content, having white colour with chemical composition of hydrous alumunium silicate ($Al_2O_3.2SiO_2.2H_2O$) accompanied with some gange minerals (quartz, biotite, ilmenite). Kaolin occured as a result of wheathering the igneous rock containing feldspar or because of hydrothermal process at the crystalline rocks, especially having acid properties as granitic, diorite, dacite. The wheathering process of mineral feldspar becomes mineral kaolinite can be written as follows :

$$2KAlSi_3O_8 + 2H_2O \rightarrow Al_2(OH)_4(Si_2O_5) + K_2O + 4SiO_2$$

feldspar — kaolinite

The deposit of kaolin in West Kalimantan is around 82,930,000 m^3, in Sambas Regency is 49,800,000 m^3. The chemical composition of kaolin is SiO_2 57.40 %, Al_2O_3 27.46 %, Fe_2O_3 0.65 %, CaO 1.68 %, MgO 1.40 %, K_2O 0.78 % and Na_2O 1.10 %. Based on the chemical composition, the Sambas kaolin can be applied to produce fine ceramics of stoneware and sanitary types (Anonymous, 1990).

According to Director General of Agro and Chemical Industry, Ministry of Industry, Indonesia still import kaolin of around 757,900 tons in 2005 and 780,000 tons in 2006 (Bochari, 2007). To overcome the kaolin import, kaolin deposit from West Kalimantan can be managed optimally to anticipate the decrease of kaolin reserves in Bangka Belitung province and to lessen the kaolin import.

6. CONCLUSION

– The Province of West Kalimantan has abundant resources of industrial minerals which is potential to be utilized as component of ceramic raw materials such as quartz, kaolin, clay, ball clay, feldspar, bauxite and natural zircon sand, which spread out in the Regencies of Pontianak, Singkawang, Sambas, Sanggau, Ketapang.

– The ceramics raw material such as quartz, kaolin, ball clay, clay and feldspar can directly be used for making ceramic products such as decorative ceramics, sanitary, tableware and ceramic tiles. The zircon sand type, dacite and bauxite, firstly must be upgraded through the beneficiation process before applying them for making ceramic products and also for glaze materials.

– Ceramic raw materials is directly utilized for making ceramic products. By-product from the beneficiation process of natural zircon sand like ilmenite and from beneficiation process of bauxite like low grade clay, and also beneficiated materials (zircon and bauxite) are expected to be able to utilized optimally for producing ceramic products such as tableware, tiles, and decorative ceramics of white body type or coloured body, glaze materials, refractories and other ceramics.

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