EVALUATION AND PROCESSING OF ANDALUSITE MINERAL FROM TERENGGANU, MALAYSIA

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EVALUATION AND PROCESSING OF ANDALUSITE MINERAL FROM TERENGGANU, MALAYSIA

by

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LIST OF ABBREVIATION

An	Andalusite
ATM	American Testing Materials
Crd	Corundum
DMS	Dense Media Separation
EDX	Energy dispersive X-ray
ENE	East North-East
FOB	Free on board
Ha	Halite
ISMI	International Sematic Manufacturing Initiative
JMG	Minerals and Geoscience Department
L.O.I	Loss on Ignition
Mz	Monazite
NNW	North North-West
NS	North-South
PPL	Plane-polarized light
Ru	Rutile
SEM	Scanning Electron Microscope

SG	Specific Gravity
SSE	South South-East
TPA	Tonnes per annum
XPL	Cross-polarized light
XRD	X-ray Diffraction
XRF	X-ray Fluorescence

LIST OF SYMBOLS

%	percentage
°C	degree Celsius
km	kilometer
km^2	kilometer cube
m	meter
mm	millimeter
cm	centimeter
µm	micrometer
g	gram
g/cm^3	gram per centimeter cubed
rpm	round per minute
Wt%	weight percentage
Al_2O_3	Aluminum oxide
Fe_2O_3	Magnetite
Al_2SiO_5	Sillimanite Mineral (Andalusite, Kyanite and sillimanite)
SiO_2	Silicon dioxide
ρ	density

Kbars	kilobars
GHz	gigahertz
MHz	megahertz
kW	kilo watt
kv	kilovolt
mA	miliampere

PENILAIAN DAN PEMPROSESAN MINERAL ANDALUSIT DARIPADA TERENGGANU, MALAYSIA

ABSTRAK

Dalam penyelidikan ini sampel daripada dua kawasan iaitu Sungai Cerul dan Kemasik, Terengganu telah dikaji. Mineral andalusit dalam bentuk kristal jelas dapat dilihat dalam julat saiz 2 cm to 5 cm tertanam atau tersimen bersama filit dalam sampel yang diperolehi dari Sungai Cerul. Manakala kehadiran mineral andalusit sukar untuk dilihat dalam sampel yang diperolehi dari Kemasik. Gred mineral andalusit dalam sampel Sungai Cerul menunjukkan ia mengandungi lebih kurang 49.13% Al_2SiO_5 manakala analisa ke atas gred kristal andalusit mendapati ia mengandungi sehingga 73.35 % Al_2SiO_5. Disebabkan peratusan andalusit yang tinggi, deposit ini mempunyai potensi untuk dieksploitasi. Sampel yang diperoleh dari Kemasik terjadi dalam persekitaran geologi yang sama dengan sampel dari Sungai Cerul namun andalusit tersebar di dalam filit sebagai batuan perumah. Walau bagaimanapun, kejadian mineral andalusit di Kemasik telah terjejas oleh luluhawa yang tinggi serta perubahan sekeliling. Sampel dari Kemasik, tiada bentuk kristal andalusit yang tertentu terdapat di dalam batuan perumah dan gred Al_2SiO_5 yang terkandung adalah kira-kira 40.81 %. Di samping itu, ciri-ciri fizikal andalusit yang secara perbandinganya sukar untuk diproses secara fizikal maka mendapan ini dikategorikan sebagai tidak berpotensi buat masa ini. Eksperimen pengisaran yang dilakukan, menggunakan sampel andalusit dari Sungai Cerul, menunjukkan bahawa kelajuan putaran rod yang optimum bagi membebaskan mineral andalusit dari batuan perumah adalah pada kelajuan 20 putaran per minit (rpm) selama 40 minit. Pembebasan dan pemisahan andalusit dari batuan perumah berjaya meningkatkan gred andalusit sekitar 13.14% Al_2SiO_5. Dengan rawatan gelombang mikro, pembebasan telah bertambah baik dan meningkat sehingga 17.44 % Al_2SiO_5. Selain peningkatan gred andalusit, masa pengisaran juga berkurangan dari 40 minit ke 15 minit dengan peningkatan pembebasan daripada 60% kepada 70%. Di samping itu, rawatan gelombang mikro dengan suhu yang rendah dalam keadaan basah menunjukkan hasil yang baik bagi pemecahan antara muka.

EVALUATION AND PROCESSING OF ANDALUSITE MINERAL FROM TERENGGANU, MALAYSIA

ABSTRACT

In this research, two andalusite bearing rock samples from Sungai Cerul and Kemasik, Terengganu areas were studied. Coarse andalusite crystals in range of 2 cm to 5 cm in length were found embedded or cemented with phyllite in sample from Sungai Cerul. Whereas, the presence of andalusite crystal in the andalusite bearing rock sample from Kemasik was hardly to be observed. Grade of andalusite bearing rocks from Sungai Cerul indicated that it is contain approximately 49.13% Al_2SiO_5 and analysis on the andalusite crystal found that it contains up to 73.35% Al_2SiO_5. Due to the high percentage of andalusite, this deposit has the potential to be exploited for its value. The samples from Kemasik occurred in similar geological environment as in Sungai Cerul which is disseminated in phyllite as host rock. Though, the occurrence of andalusite mineral in Kemasik was affected by high weathering and alteration. Compared to samples from Sungai Cerul, the andalusite bearing rock from Kemasik have no specific andalusite crystal shape in host rock and the grade of Al_2SiO5 is about 40.81% Al_2SiO_5. Due to the physical properties of andalusite from Kemasik is comparatively difficult to be processed by physical methods this deposit was considered not viable for the time being. The experimental works on grinding performance on andalusite bearing rock from Sungai Cerul indicated that the optimum rotational speed of the rod mill to liberate the andalusite mineral from the host rock is at 20 rpm for 40 minutes. The liberation and separation of andalusite from the host rock managed to improve the grade of andalusite approximately 13.14 % Al_2SiO_5. With the microwave treatment, the liberation has been improved and increased the grade of andalusite up to 17.44 % Al_2SiO_5. Grinding time was also reduced from 45 minutes to 15 minutes with better liberation from 60% to 70% when microwave treatment was applied. In addition, the microwave treatment with low temperature in wet condition show a good result of the breaking the andalusite crystal interface.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Sillimanite group mineral (Al_2SiO_5 or $Al_2O_3.SiO_2$) such as andalusite, kyanite and sillimanite is a hope of new material for industrial mineral. The most important mineral that use in the production of advanced refractory material was the orthorhombic crystal andalusite (Burt and Ross, 2006). When firing these minerals at 1380 °C its will transform to mullite (3 $Al_2O_3.2SiO_2$) with low expansion (5%) (Beuvelet et al., 1996). These mineral become an interested material for many reasons:

- Provide high thermal stabilities due to low thermal expansion
- Low resistance to creep, and low of deformation in high temperature under load.
- Perform a good resistance to the action of molten metal and good resistance to slag.

South Africa had been known as the world largest reserve and the biggest andalusite production in the world which is concentrated in various localities around the Bushveld Complex (Botha, 2010). Other than South Africa, the countries that also produce andalusite are France, China, Peru, the United States and Spain (Simandl et al., 1995a, Feytis, 2011).

1.2 Malaysia Prospective on Andalusite

Andalusite consider as new mineral to Malaysia which is no exploitation yet. Every years Malaysia imported a significant value of sillimanite group mineral such as andalusite, kyanite, and sillimanite to support the demand of industries. In 2005 the quantity of import is 653 060 tons and continue increase to 1 240 520 tons in the year 2008. In 2009 the amount of import decrease in 2009, however the demand increase again in 2010 up to 1 444 782 tons and 1 006 000 tons in 2011. Figure 1.1. shows quantity and price of sillimanite mineral imported from 2005 to 2011. Since 2005 the value of imported who gradually increase from US$ 200 000 to US$ 700 000 in the years 2010. However, the value slightly decreased to US$ 500 000 in the year 2011 (UNComtradeDatabase, 2011).

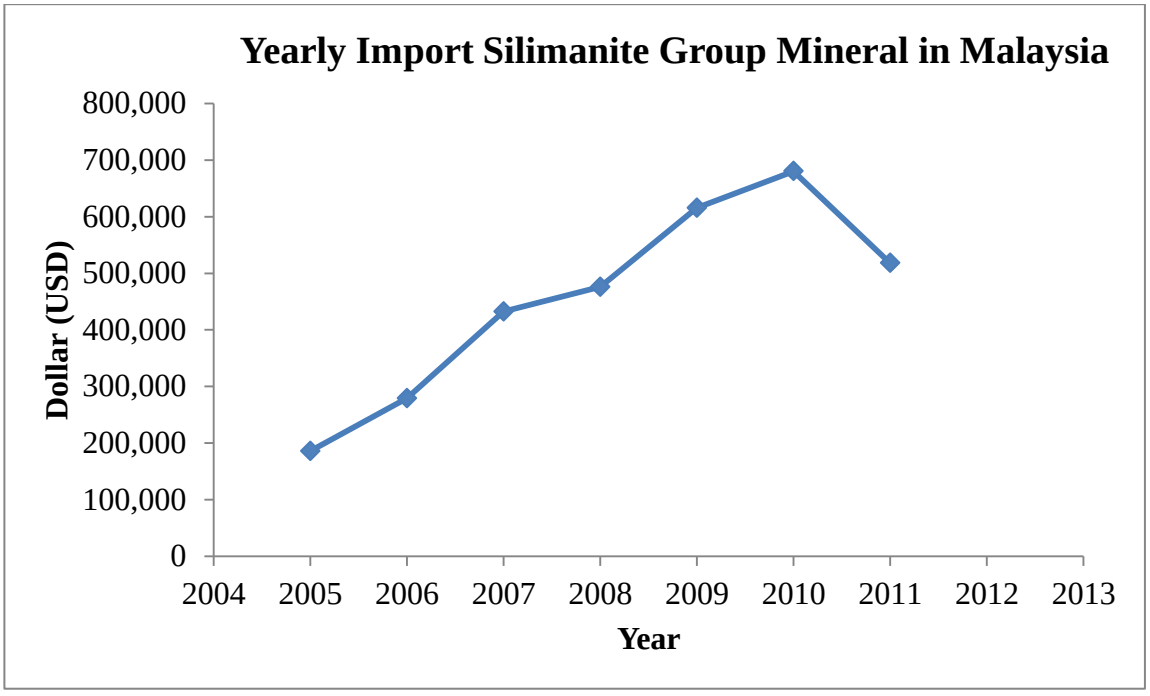

Figure 1.1: Yearly import andalusite. kyanite, and sillimanite in US dollar (UNComtradeDatabase, 2011).

1.3 Problem Statement

Andalusite is one of the best natural resources of mullite among aluminosilicate material, which is formed at comparatively low temperature. Based on the huge advantage of this mineral for industrial application, andalusite becomes a crucial mineral for exploration and exploitation. Although, numerous research papers published about andalusite occurrence, mining and processing worldwide, but the information of this mineral in Malaysia very limited. Base on the existing report in south-east Asia (Sa and Boom, 2003), there are abundant of andalusite, group of sillimanite mineral occurrence in Terengganu area. However, comprehensive report or recent study to evaluate and process this mineral scientifically in the aspect of economic evaluation to identify its quality and uses is not yet done by anybody in Malaysia. Therefore, this study is importance to give some input and idea about the qualities and beneficiation methods that can be used to prepared final product. This will save Malaysia money on importing andalusite from foreign country worth US$ 158 201 (in the year 2011) (UNComtradeDatabase, 2011).

1.4 Objective of Studies

The aims of this project are to provide scientific information regarding the characterizations and the beneficiation of Malaysian andalusite. The main objectives of this research are:

i. To characterize the quality of Malaysian andalusite

ii. To evaluate the potential of Malaysian andalusite

iii. To determine the beneficiation of the andalusite ore to produce clean andalusite concentrate.

1.5 Overview of the Thesis

This thesis has been divided into five parts. Chapter one, provide general information related to problem statement and the objective of this research.

Chapter Two, present several information and knowledge related to andalusite around the world and in Malaysia such as geological occurrence, production, price, industrial application and the advantage of microwave treatment assisted grinding. According to the numerous advantage of andalusite, this mineral is a key factor to support Malaysian economy.

The methodologies and equipment used in this research revealed in Chapter Three. In this research samples were collected from two different locations in Terengganu. The characterization of this samples was investigated on mineralogical study by using thin section, X-ray diffraction, scanning electron microscopy, and chemical composition analysis by using X-ray fluorescence. The primary liberation included crushing, grinding and sieving. Furthermore, microwave treatment method had been applied for improving the liberation and separation.