DETERMINATION OF MASS ATTENUATION COEFFICIENTS FOR SEVERALNATURAL MINERALS IN MALAYSIA

SITI SARAH BINTI YUSOF

UNIVERSITI TEKNOLOGI MALAYSIA

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Special dedicated

For my beloved father and mother

Yusof Bin Sulaiman & Noraini Binti Deris

Thank for all the sacrifice and love that you give to me.

For all my friend, I want to thank for your cooperation and our friendship is meaningful experience for me.

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ABSTRACT

Mass attenuation coefficient (μ_m) is an important parameter in both fundamental and applied mineral studies. The purpose of this study is to determine the values of mass attenuation coefficients of several natural minerals from various mining areas in Malaysia. Four types of minerals were chosen which are hematite, tin ore, xenotime and monazite. The samples were prepared in pallet form by mixing 7g of each sample with 3g of wax. The dimension of the pallet was 3mm in thickness and 40 mm in diameter. The element compositions of the samples were determined by using X-ray fluorescence (XRF) spectroscopy. The gamma attenuation spectra were obtained by irradiating the sample in the energy range of 50-1500 keV with hyper pure germanium (HPGe) detector. The data were analyzed using Lambert-Beer's law to obtain experimental mass attenuation coefficient values. The theoretical mass attenuation coefficients were calculated using WinXcom software based on the concentration of elements and oxides from XRF data. The result showed that for tin ore, the experimental mass attenuation coefficients fitted well to the theoretical value with the average values of 2.382, 1.840 and 0.095 g cm^{-3} for the energy range of 50-300, 300-1000 and 1000-1500 keV respectively. On the other hand, the results from other three types of samples showed a slight less consistency between experimental and theoretical values.

ABSTRAK

Pekali pengecilan jisim (μ_m) merupakan parameter penting dalam bidang kajian asas dan gunaan mineral. Tujuan kajian ini adalah untuk menentukan nilai pekali pengecilan jisim bagi beberapa jenis mineral semula jadi yang diambil dari lombong yang berbeza di Malaysia. Empat jenis mineral telah dipilih iaitu bijih besi, bijih timah, xenotim dan monazit. Setiap sampel disediakan dalam bentuk pellet dengan mencampurkan 7g setiap sampel denagn 3g lilin. Dimensi setiap pellet adalam 3mm tebal dan 40mm diameter. Komposisi unsur bagi setiap sampel telah dianalisis dengan menggunakan spektroskopi pendarfluor sinar-X (XRF). Dengan menggunakan pengesan Hyper Germanium tulen (HPGe), spektrum pengecilan gamma telah diperolehi dengan menyinarkan sampel pada julat tenaga dari 50 keV sehingga 1500 keV. Kemudian, data di analisis dengan menggunakan hukum Lambert-Beer bagi mendapatkan nilai eksperimen pekali pengecilan jisim. Nilai teori pekali pengecilan jisim telah dikira menggunakan perisian winXcom dengan memasukkan nilai kepekatan unsur dan oksida yang diperolehi daripada analisis XRF. Hasil kajian menunjukkan nilai eksperimen pekali pengecilan jisim bagi bijih timah bersesuaian dengan nilai teori dengan nilai purata pekali pengecilan jisim masing-masing adalah 2.382, 1.840 dan 0.095 g cm^{-3} untuk julat tenaga 50- 300, 300-1000 dan 1000-1500 keV. Manakala, bagi tiga jenis sampel yang lain, terdapat sedikit pengurangan konsisten antara nilai teori dan eksperimen.

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CHAPTER 1

INTRODUCTION

1.0. Introduction

"Mineral are the inorganic chemical compounds from which all rocks are formed, they must have originated through natural than man-made processes (Andrew Clark, 1984, 7)". Mineral can be identifying based on the physical and chemical properties. The properties can be identified by examination of the specimen using microscope and other scientific equipment. There a few physical properties usually used to identify the type of mineral. First by colour, it was the easiest way to identify the type of mineral. This is because some colours are always associated with certain mineral group. Mineral also can be clarified based on the streak. Streak refers to the colour of the powder of mineral. The colour of the streak is characteristic of the mineral and it also a good diagnostic test. The hardness of the mineral also important physical properties in distinguishes the type of mineral. The other physical properties are cleavage. Many minerals show cleavage and it indicates the tendency of crystals to break or crack along certain crystallographic plane. For the chemical properties, it basically based on composition of the mineral.

Nowadays mineral has been used widely in daily. Therefore, in Malaysia the major business contributor for economic, social and industrial is mineral industry. This statement is further strengthened by the increases of minerals produced in Malaysia from 2006 to 2007 about 15 per cent (Malaysianminerals, 2009). "Among these identified mineral resources, we have developed and exploited a greater fraction of reserves of barite, bauxite, bentonite, clays, copper, gold, iron ore, limestone, silica, and tin and its associated minerals".

In line with the growth of minerals, many scientific studies have been conducted to look at the consequences in more detail about the properties of mineral. There are a lot of parameters which, important to understand the behaviours of the mineral. One of the parameters is mass attenuation coefficient. Mass attenuation coefficient of a substance or chemical element is a measure of the absorption or scattering of wavelengths per unit mass. The intensity decreases when radiations travel through the matter. These attenuation properties of radiation suggest that how much shielding is needed and how much dosage is received. Mass attenuation coefficient of the natural minerals can be calculated manually using Lambert-Beer's law. By using exponential attenuation equation, it shows the parallel beam of monoenergetic X-ray and/or γ-ray photons is attenuated in matter:

1.1. Background of the study

Mass attenuation coefficient, μ_m is an important parameter to understand the physical properties of the material, which is vital in fundamental physics and many applied fields. The accurate μ_m values had been calculated for x-rays and gamma rays in several materials are essential to understanding the basics of many fields like nuclear and radiation physics, radiation dosimetry, biological, medical, agricultural, environmental and industrial areas. Many experiments have been performed to

determine the μ_m and related parameters for various materials (elements, compound, tissue equivalent compounds, mixtures, alloys, crystal, superconductor and semiconductor, mineral, glasses), radiation shielding materials, building material, biological material by using the different photon energies. Much research has been carried out, but there are no such studies regarding natural minerals in Malaysia. Therefore, this research is proposed to identify the value of mass attenuation coefficient in Malaysian natural mineral.

1.2. Statement of the problem

Mass attenuation coefficient (μ_m) is an important parameter in applied science. Hence this research work, investigates the values of mass attenuation coefficients of natural minerals in Malaysia. In this experiment, the quantity of other elements in the natural mineral is also determined.

Therefore, the outcomes of this work will provide information regarding the other impurities in the natural minerals. These results will be beneficial not only to academicians but also the mining companies. The physical properties of the natural mineral are also figured out in this research. Finally, the natural minerals will be identified and analysed.

1.3. Objective

The objectives of this study are:

1. To determine the value of mass attenuation coefficient of natural mineral.

2. To identify the amount of other elements in natural mineral.

3. To compare the experimental results with the theoretical computed results.

1.4. Scope

This is an experimental as well as a theoretical study. The samples are collected from different mining areas in Malaysia. Mineral such as tin ore, monazite, xenotime and hematite have high industrial potential. In this research, we use the same thickness samples as a constant variable to study the mass attenuation coefficient for each sample at a different energy level. Therefore, we can compare the result using the value of mass attenuation coefficient when the radiations go through the same thickness of different sample. By using hyper pure germanium detector, the value of mass attenuation coefficient will be estimated. Besides that, for the material characterization X-ray diffraction analysis and X-ray fluorescence spectrometer also will be used in this experiment. X-ray diffraction is used to identify the amount of another element that occurs in samples. Meanwhile, X-ray fluorescence spectrometer used for analyzing surface pattern of the sample to determine whether it is crystalline or not.

1.5. Significance of the study

From this research, the mass attenuation coefficient of natural minerals can be measured. Beside this, the physical properties of the minerals can be identified. We also can identify the amount of other elements in minerals to investigate the level of safety of using them in our daily life. This is because minerals have been used widely in our life. So, when we know the mass attenuation coefficient of the minerals, we can understand the physical properties of the minerals. Therefore from this research, we can get the data for natural minerals in Malaysia.

1.6. Overview

In Chapter 1, we focus on the background of the study, the problem statement, scope of the study, objective, and significant of the study. The details about the natural mineral and the gamma interaction with a photon through the matter are discussed in Chapter 2. This chapter also discusses the previous research, which has been used as a reference for this study. The methodology of the study is written in Chapter 3. In this chapter, we explain about the experimental setting, and different other types of the analysis that has been used in this study. The details about the sample also have been discussed in this chapter. In Chapter 4, we also discuss the calculation of mass attenuation coefficient. The mass attenuation coefficient has been calculated using the Lambert laws equation. In this research we focus on the mass attenuation coefficient for the different energy only. The thickness of the samples has been fixed as 0.3 cm for each sample. The X-ray fluorescence analysis has been used to identify the composition of the sample. The mass attenuation coefficient can be calculating using WinXcom software with the composition data. The detail about the calculation is discussed. Finally, in Chapter 5, we conclude the result of this study.

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