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ENERGY DISPERSIVE X-RAY FLUORESCENCE ANALYSIS (EDXFA) OF TIN CONTENT IN CASSITERITE OBTAINED FROM RAY-FIELD MINING SITE, JOS

U.A. Uduma[1], Jacob, A.G[1] and Maria, B.Uduma[2].

[1]Department of Applied Chemistry, Federal University Dutsin-Ma, Katsina State, Nigeria.
[2]Department of Biology, Federal College of Education Kano, Kano State, Nigeria.
Corresponding Author's email/phone number: udumas96@gmail.com+2348038866244

Abstract
A rapid and precise method was used for the determination of tin in cassiterite from the Ray-field mining site, Jos, using energy dispersive x-ray fluorescence spectrometry, following standard procedures.Theapplication of the technique is very precise when compared to solution methods of analysis.Sampling was conducted by collecting thirty cassiterite samples from ten cassiteriteheaps at the mining site, placed into labeled polyethylene container in triplicates. The samples were dried under laboratory condition for two weeks, ground, sieved and 4g homogenous sample representative was mixed with 1g lithium tetraborate binder and pressed into pellets, dried at 110^0C and analyzed. The average percentage of tin in the cassiterite was 19.57%. Other constituents of the cassiterite as analyzed include: Fe(13.70%), Ti(15.90%), Si(23.81%), Zr(8.44%), Al(8.55%),Nb(6.30%), Ta (1.59%), Ca(0.79%), Mn (0.53%), Cr (0.32%), V(0.35%), and Zn(0.15%). Silicon is the predominant element in the cassiterite. Tin is assessed because it is extensively used in many modern high-tech industrial applications, supper-alloys and electronics industry. The EDXRF technique can also provide a rapid evaluation of the economic potential of a geological deposits thereby providing its value both to the miningindustry and to the community impacted by the geological exploitation activities.

Keywords: *Cassiterite, Tin,Jos Ray-Field, Energy Dispersive X-ray Fluorescence Analysis, pellet*

Introduction

Cassiterite is made up of various minerals with different tin content and tin oxidation states, and gangue and or tailing minerals that are of no commercial value. The most prominent tin minerals arecassiterite and complex sulphides. Tin is used for plating in food containers and food- processing equipment, in alloys, and as pigments in the ceramic and textile industry. The knowledge of the mineralogy, in particular the oxidation state of the tin oxides has direct influence on the commercial value of the ore and on processing of the ore (Enders, 2005).

Evaluation of economicpotential of geological materials associated with mining practices can be facilitated by accessible and effective tools and techniques such as Energy Dispersive X-Ray Fluorescence spectrometry (EDXRFs). The technique is also an effective method for rapid quantification of the economic potential in Nigeria's mineral resources. EDXRFs ispowerful technique in analytical chemistry.

EDXRFs are rapid, relatively non-destructive chemical or elemental analysis of rocks, minerals, sediments, fluids and soils (Fisher *et al.,* 2014). Its purpose is to identify the elemental abundances of the sample. It is used in a wide range of applications, including mining, metallurgy, soil surveys, cement production, ceramics and glass manufacturing, petroleum industry, field analysis in geological and environmental studies, and research in igneous, sedimentary and metamorphic petrology etc. (Fitton, 1997, Jurado-Lopez*et al.,* 2006). EDXRFs can also sometimes be used to determinethe thickness and composition of layers and coatings (Thomas, 1982). The method is fast, accurate, non-destructive and usually required only a minimum of sample preparation.

The mining industry is one of the oldest industries in the world, and its importance to human development becomes evident when one considers the naming of the pre-historic age after mined products such as: Stone age, Bronze age and Iron age (Jennings, 1999). Mining generally is the extraction of valuable mineral resources or other geological materials from the earth, usually from an ore body, vein or seam (Encarta Encyclopedia, 2001).

Over the years, mining evolved all over the world to include various minerals such as the mining of Malachite at Maadi by ancient Egyptians, Gold and Iron at Wales by the Romans and Turquoise in pre-Columbian America. Mining in Nigeria started as far back as the eighteenth century. Over 500 occurrences and deposits of different minerals are known so far to exist within the country with the exploitation of some of them being on a small scale (Adegbulugbe, 2007). One of the major cases of mineral exploration and exploitation that boomed within Nigeria has been that of tin in Jos, Plateau State. Tin is said to be one of the oldest mineral resources known to man as its strategic importance was recognized as far back as 300 years ago when its hardening effects on copper was discovered (Adegbulugbe, 2007). Since then, tin ore has been mined in several parts of Nigeria including Zaria, Kano, Bauchi,, Ilesha and Plateau provinces, with over 80% of the production coming from the Jos Plateau (Ajaegbu et al., 1992). The production of tin in Jos Plateau in the colonialera started with about 1.5 metric tons in 1914 andthen began to increase until peak production of 17.740 metric tons was reached in 1943, Nigeria became the 6^{th} world producer of tin. In 1970 however, tin mining declined rapidly due to market forces and a diversion of interest in Nigeria towards crude oil production and export (Patterson, 1986). With tin mining activities going on in various sites in the Jos Plateau at informal levels, the social and economic impacts on the mining communities comes readily to mind.Mining activities bring about diversification of the economy, increase in income, job creation/increase employment, intense migration, population growth and provision and maintenance of social amenities.

However, the Jos Ray-Field is a new mining site and as such has little or no existing literature.

The aim of this study is to demonstrate the application of EDXRFs to determine the tin composition of cassiterite samples collected from Jos Ray-Field mining site of Plateau

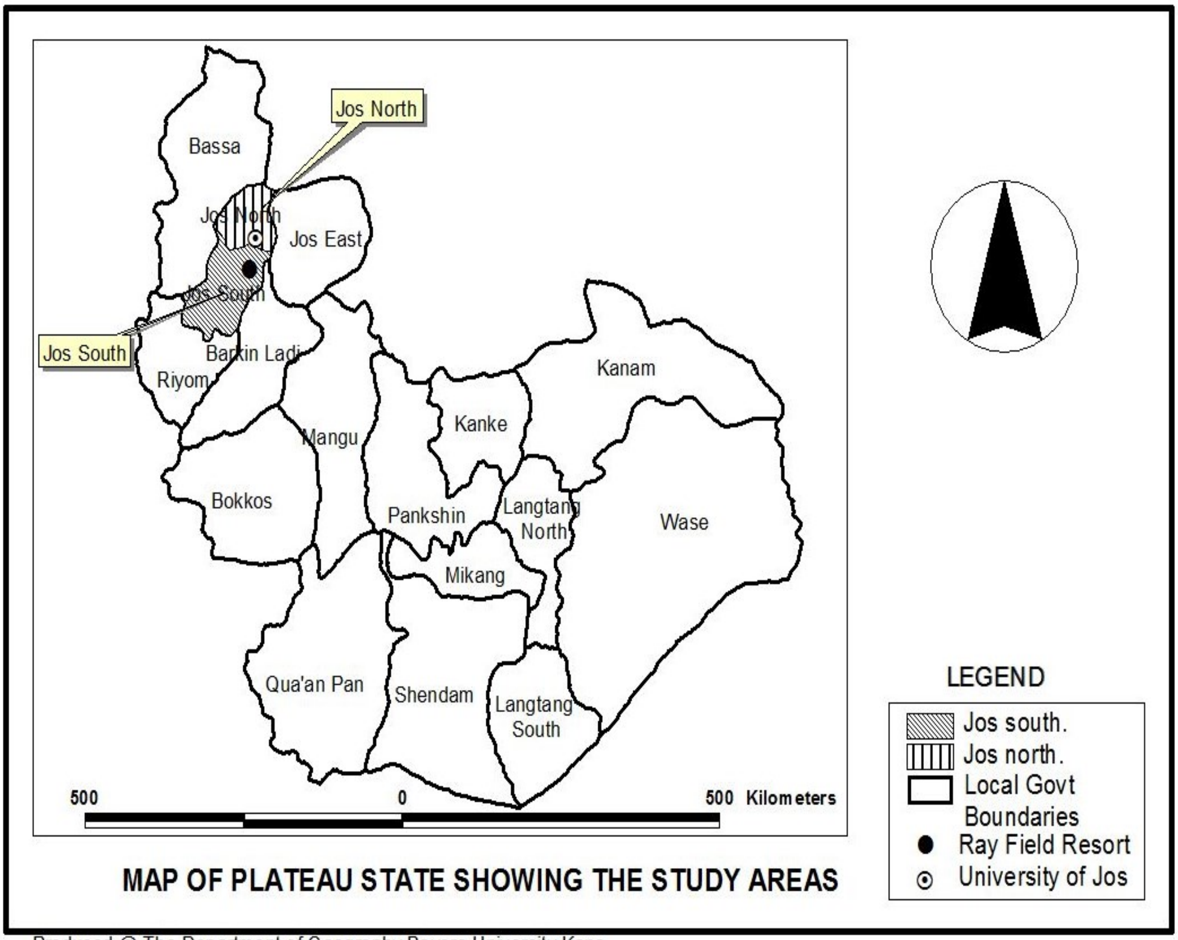
State and evaluate theeconomic diversification of Nigeria's national resources through tin mining. This will create job opportunities for our teaming unemployed youths, eradicate poverty, criminality, insecurity and increase the Gross Domestic Product (GDP) of Nigeria, which justifies this study.

Materials and Methods

Sample Collection and Pre-Treatment

The cassiterite samples used for this study were collected from Jos Ray-Field mining site in Jos South Local Government Area (Fig. 1, map of Plateau state showing the study area), PlateauState, North Central, Nigeria. Sampling was conducted by collectingthirtycassiterite samples fromtencassiterite heaps, one each from the top, middle and bottom, and same were placed into labeled polyethylene container, and mixed thoroughly to obtain sample representative of the entire sampling interval. The cassiterite samples were air dried under laboratory conditions for two weeks before analysis.

Fig. 1: Map of Plateau State Showing the Study Area



Produced @ The Department of Geography Bayero University Kano

Sample Analysis

The air dried cassiterite samples were ground in agate mortar and pestle and sieved to 75µm particle size. Four grammes (4g) of the sieved homogeneous sample representatives were intimately mixed with 1g of lithium tetraborate binder (Li2 B4 O7) and pressed in a mold under a pressure of 10-15 tons/in^2 to a pellet. The pellets in triplicate were dried at 110^{o}C for 30minutes in an oven to get rid of absorbed moisture and then stored in a desiccators for analysis. The analysis was carried out using EDXRF spectrometer model Lelyweg1, 760ZEA, Almelo, Netherland. EDXRF measurements were performed using an annular 25mci 109Cd as the excitation source that emits Ag-K X-rays (22.1KeV) in which case all elements with lower characteristic excitation energies were accessible for detection in the samples. The system consists further more of a Si(Li) detector with resolution of 170eV for the 5.90keV line coupled to a computer controlled analog to digital converter (ADC) card (Iwanczyk*et al.,* 1996). The Mo target serves as a source of monochromatic X-rays which are excited through the sample by primary radiation and then penetrate the sample on the way to the detector. In this way, the absorption factor is experimentally determined which the program used in the quantification of concentration of the elements. In addition, the contribution to the Mo-K peak intensity by the Zr-K is subtracted for each sample (De Boer, 1999).

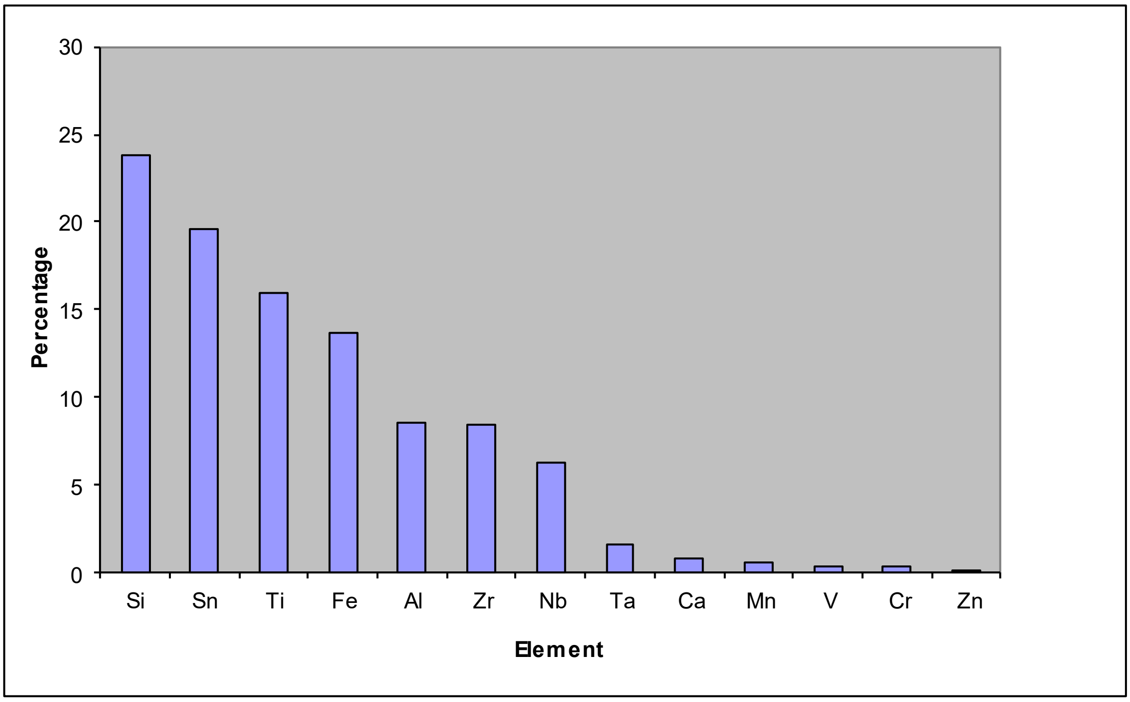


Fig. 2: Elemental Composition of Jos Ray-Field cassiterite

Results and Discussion

The studied area is shown in Figure 1. Figure 2, shows the average elemental composition of the cassiterite as analyzed. The average percentage of tin in the cassiterite was 19.57%. Other constituents of the cassiterite as analyzed include: Fe (13.70%), Ti (15.90%), Si (23.81%), Zr (8.44%), Al (8.55%), Nb (6.30%), Ta (1.59%), Ca (0.79%), Mn (0.53%), Cr (0.32%), V (0.35%), and Zn (0.15%).The percentage of Sn found in the cassiterite samples in this study is not surprisingly high because the principal ore of tin, cassiterite, is found in many parts of Plateau State.The analytical result provides the level/percentage of tin in the Jos Ray-Field cassiterite and the economic bases for its exploitation, job/wealth creation, diversification of the economy and curbing of insecurity.

Generally, mining has the potential to shape and affect economies directly and indirectly. Mining brings employment, government revenues and opportunities for economic growth and diversification (WBIFC, 2002).

Conclusion

This study demonstrates the application of the EDXRFs based spectro-chemical analytical technique to obtain fast and accurate level/percentage of tin in cassiterite. The EDXRFs is a cost-effective, rapid and eco-friendly technique for analysis of tin concentrates.

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