



## CHEMICAL COMPOSITION OF SOLID MINERALS FROM LOKOJA AND JOS IN NORTH CENTRAL NIGERIA

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### ABSTRACT

The structural, qualitative and quantitative analysis of grained rock samples were carried out with the view to establishing the mineral components present in the samples. Two samples were collected from a mining site in Jos, Plateau State as well as from another mining site in Lokoja, Kogi State. The two samples were prepared for XRD analysis using a backloading preparation method and done with X-ray diffractometer. The analysis confirmed the presence of minerals such as Cassiterite ( $\text{SnO}_2$ ), Ilmenite ( $\text{FeTiO}_3$ ), Zircon ( $\text{SiO}_4$ ), Columbite (Fe), Manganooxide in the sample from Jos as a result of the matching of the peaks with the database  $2\theta$  values. The percentage area integration of the various phases which correlated to the quantity of the various minerals in the sample revealed that Cassiterite (Tin Oxide) of 65.9% value was from Jos and is a Tin Ore. The grain sizes for Cassiterite ( $\text{SnO}_2$ ), Ilmenite ( $\text{FeTiO}_3$ ), Zircon ( $\text{SiO}_4$ ), Columbite (Fe), Manganooxide are 17.674, 35.348, 37.208, 70.695, 20.199 in nm respectively. The samples from Lokoja showed the presence of Magnetite ( $\text{Fe}_3\text{O}_4$ ), Quartz ( $\text{SiO}_2$ ), Hematite ( $\text{Fe}_2\text{O}_3$ ) and Goethite ( $\text{FeO}(\text{OH})$ ) and confirmed the grain sizes of 28.278, 35.348, 28.278, 17.673 and 23.565 in nm respectively. The constituents of Lokoja samples, all of which contained Iron Oxide also indicate that the sample is an Iron Ore. These findings confirm the fact that the mineral resources that are present in these regions of the country are economically viable and have the potential to boost economy and industrial development.

**Keywords:** *Solid mineral, XRD, grain size, Mineralogy.*

**INTRODUCTION**

Nigeria as a nation is naturally enriched with a huge amount of solid minerals widely distributed across the different geographical belts of the country. Prior to the early crude oil booms of the 1970s and 1980s, solid mineral such as Coal, Tin and Columbite contributed largely to the economy buoyancy of Nigeria (Akongwale, *et al.*, 2013). As reported by the Nigerian Geological Survey Agency, Nigeria has some 34 known major mineral resources deposit distributed in locations across the country. Exploration in Nigeria for solid minerals such as Tin, Niobium, Lead, Zinc, and Gold can be traced back for more than 90 years (Alabi *et al.*, 2013).

According to Onuiri *et al.*, 2015, Mineral resources are referred to as non-living naturally occurring matters which comprises of solid inorganic matter or petrified organic substance including industrial mineral, valuable metals, which can be discovered both in and on the earth's crust in such form and quantity and of such a grade or quality with realistic expectations for cost-effective extraction. The term "Mineral Resource" is also referred to as any category of naturally occurring solid inanimate elements with a distinctive crystalline form (having the nature of a solid formed by the hardening or solidification of chemicals) and a homogeneous chemical composition.

Solid minerals in rocks are formed due to planetary accretion and differentiation. Tin, which is a useful metal of commerce since the Bronze Age, has long been sought and mined. Most tin of commerce is smelted from concentrates that contain a high proportion of tin in cassiterite, many other valuable metals are recovered during the mining and concentration of tin ores (Sainsbury, 1969).

Most sedimentary rocks contain significant quantities of iron, and there is a complete range up to those of ore grade. Sedimentary iron ores can broadly be considered as occurring in three major classes: bog iron ores, ironstones, and (banded) iron formations. This also is the increasing order of their economic importance. Its ore minerals comprise: massive magnetite, banded-granular haematite-magnetite, and schistose haematite (Anike, 1987). According to MMSD, 2010, two broad types of iron ore occur prominently in Nigeria. They are: Banded iron formation and the Cretaceous sedimentary (oolitic) iron deposits

The Nigerian economy is largely dependent on oil; non-oil minerals have relatively weak roles. However, the current global economic downturn, in particular oil price volatility in the international

market, has compelled the Nigerian government to reduce the risk of over dependence on oil by paying considerable attention to solid mineral development (Murtala, 2011). Nigerian mining has a vast potential for the economic development.

This work is for quantitative and structural analysis of natural mineral present in the samples considered and to consider the economic potential of these minerals to alleviate the economy challenges confronting the nation Nigeria and for advancement in industrialization.

**MATERIALS AND METHODS**

Two Samples were collected from a mining site in Jos, Plateau State, Nigeria (Lat. 9.8965°N, Long. 8.8583°E) while another one was collected from another mining site in Lokoja, Kogi State, Nigeria (Lat. 7.8023°N, Long. 6.7333°E).

**Possible Locations of the Samples A and B in Nigeria**

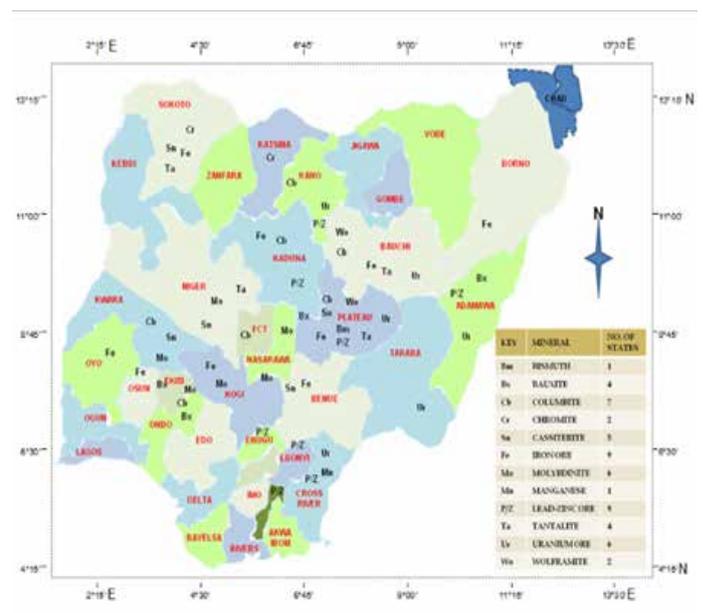


Fig 1: Source: Ajaka and Oyathelemi, (2010).

The samples were crushed separately into particulate form and fine appropriately enough for X-ray diffractometry analysis. The samples were prepared for XRD analysis using a backloading preparation method and they were analysed with a *PANalytical Empyrean diffractometer* with PIXcel detector and fixed slits with Fe filtered Cu-K $\alpha$  radiation. The phases were identified using X'Pert High score plus software. The relative phase amounts (weight %) was estimated using the Rietveld method (PANalytical Highscore4+).

RESULTS AND DISCUSSION

The grain (particle) size was estimated using Debye-Scherrer’s equation: 
$$g = \frac{k\lambda}{\beta \cos\theta} \text{ ----(1)}$$

Where  $\lambda$ , B, and  $\theta$  represent the wavelength of the X-ray source, the full width at half maximum (FWHM), and the Bragg angle, respectively (Alabi *et al.*, 2013).

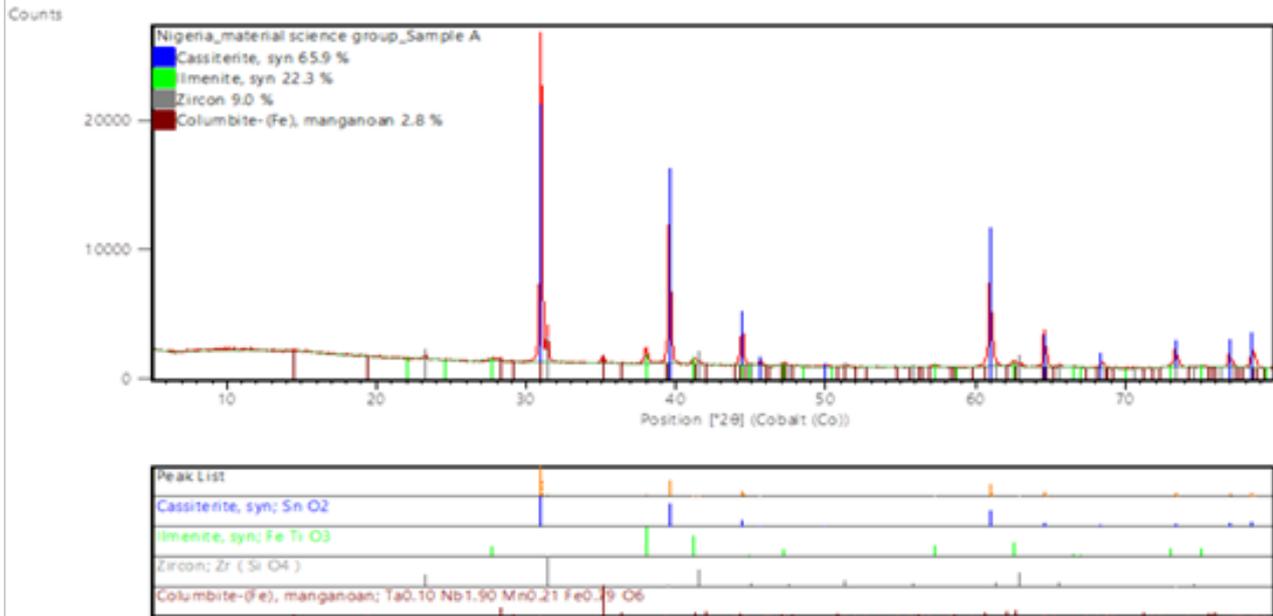


Fig. 1: XRD Pattern for Sample from Jos

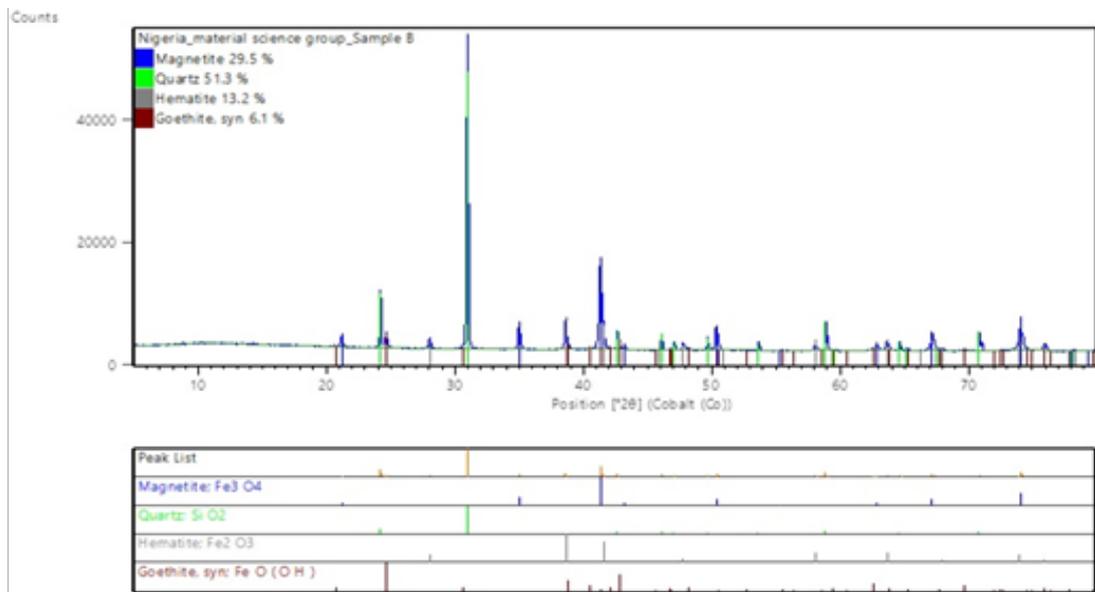


Fig. 2: XRD Pattern for Sample from Lokoja

Table 1: Values of Grain sizes for samples A and B.

S/N	2θ (Degrees) FOR SAMPLE A	FWHM (β)	Grain sizes, g (nm)	Constituent present	S/N	2θ (Degrees) FOR SAMPLE B	FWHM (β)	Grain sizes, g (nm)	Constituent present
1	31.0	0.80	17.674	SnO <sub>2</sub>	1	41.3	0.5	28.278	Fe <sub>3</sub> O <sub>4</sub>
2	38.0	0.40	35.348	FeTiO <sub>3</sub>	2	31.0	0.4	35.348	SiO <sub>3</sub>
3	41.1	0.38	37.208	SiO <sub>4</sub>	3	38.7	0.5	28.278	Fe <sub>2</sub> O <sub>3</sub>
4	35.0	0.2	70.695	Fe	4	24.5	0.8	17.673	FeO(OH)
5	61	0.7	20.199	SnO <sub>2</sub>	5	74	0.6	23.565	Fe <sub>3</sub> O <sub>4</sub>

The average grain sizes for samples A and B, based on the expected dominant resources in each, are 18.937nm and 25.922nm respectively.

The X-ray diffractograms identified the following minerals; Cassiterite, ilmenite, Zircon, Columbite, manganooan in Sample A. On the basis of the peak area of the first order reflections of the respective minerals (Fig 1),Cassiterite appears to predominate in the Jos sample while other associate minerals in the deposits are ilmenite, Zircon and manganooan as inclusions.

Results of the X-ray diffraction indicate that the sample from Jos is dominated by cassiterite with the highest percentage and lowest value of columbite (Fe). The percentage concentration of cassiterite, Syn SnO<sub>2</sub> is estimated to be 65.9% while columbite is 2.8% (Fig. 3).

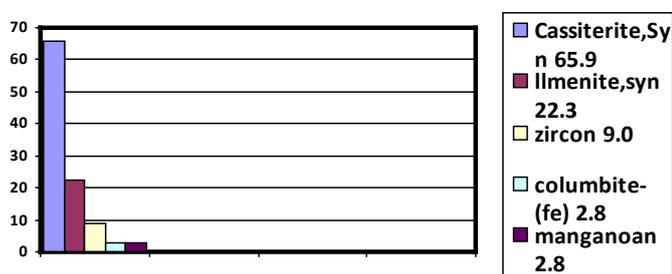


Fig. 3: Mineral percentage composition from Jos

In sample B, the X-ray diffractograms identify the following minerals; Magnetite, Quartz, hematite, Goethite. On the basis of the first order reflection minerals (Fig. 2), magnetite appears to predominate in the sample from Lokoja, other associate minerals in the deposits are Quartz, Hematite as inclusions.

Result of the X-ray diffraction indicates that the Lokoja’s sample is dominated by magnetite with the highest percentage on the peak list and lowest value of Goethite. The percentage concentration of magnetite Fe<sub>3</sub>O<sub>4</sub> is estimated to be 29.5% while Goethite, Syn is 6.1% (Fig. 3.4)

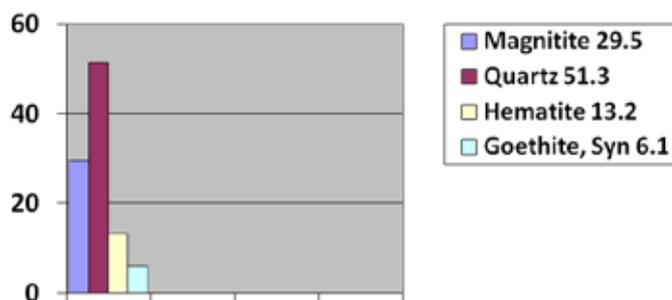


Fig 4: Mineral percentage composition in Lokoja Sample B

The factors influencing the intensity of a peak include, Mineral structure, Mineral abundance, Preferred orientation of sample and order of reflection.

One of the most fascinating aspects of mining is the search for and discovery of mineral deposits. (Naturally concentrated or localized occurrences of useful minerals). This is termed Prospecting (Ajeigbe *et al.*, 2014).

Cassiterite is the best-known tin mineral and it has been used as the chief ore of tin from early history throughout the ages and remains so even today. It is an economically important mineral, being the primary ore of the metal tin and is used as a collector of mineral with the transparent forms being highly desired. Cassiterite is occasionally used as a minor gemstone, being faceted mostly for collectors. Magnetite in sample from Lokoja when used as the aggregate portion of a concrete mix increases the density of the concrete to twice that of standard concrete. This is called “heavy concrete.” It has become a common building material in nuclear plants as well as (in brick form) for the mitigation of radiation in x-ray facilities. Magnetite can be added as a very fine powder to the plastic mix to increase the weight.

Magnetite is an excellent source of iron for the production of iron-based chemicals like ferric chloride and ferric Sulphate, which are used as alternatives to aluminum hydroxide.

Magnetite is also an important material component of power plants as it is used to generate electricity. Magnetite, owing to its magnetic properties, is widely used in compasses and other navigation devices. Magnetite also serves as an excellent abrasive which is a cleaner and has way lower toxicity than abrasives that have a silica base. The most significant use of magnetite lies in its status as an ore of iron and its industrial importance in manufacturing steel.

**CONCLUSION**

It has been confirmed from this study that Tin occurs in Nigeria in the form of Casiterite with varying amounts of associated minerals. The major sources of ore bearing cassiterite in Nigeria are the alluvial and eluvial deposits from the biotite granites within the jurassic alkaline ring complex of the Jos Plateau, which confirms the location of the sample. More so, less than 5 % of the total production has been recovered from the pegmatites within the largely Precambrian basement complex consisting of magnetites, columbites but with the rapidly depleting reserves. It was also confirmed from the Lokoja sample that it is an ore of iron containing majorly Magnetite and Goethite as the mineral composition.

The X-ray Diffractometry analysis revealed that the samples are Tin ore and Iron ore and the two samples contained Ilmenite, Zircon, Quartz, and Hematite as inclusions.

The Grain sizes of the samples were

determined using the Debye-Scherrer's formula and it was observed to vary based on preferred orientation and crystallite size effects.

It was also discovered that the sharp and narrow diffraction peaks are observed at very high counts of between 10000 and 40000 in both samples. The weakest peak from the peak list is the plane and peak of Columbite and Goethite in both samples making

it more difficult to obtain the particle sizes. With the affirmative information from the investigation of the substantial percentage composition of the minerals present in the two samples considered, the ray of hope is so bright for diversification of the nation's economy from crude oil, provided mining of these natural mineral resources (and even others) will be effectively taken care of and their judicious use is of utmost priority.

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