Characterization And Beneficiation of Bassa-Nge Iron Ore, Kogi State, Nigeria

Edoka Romanus[1] and Saliu, A. Mumuni[2]

[1]*Department of Technical Education, Kogi College of Education (Technical), Kabba, Nigeria.*
[2]*Department of Metallurgical and Materials Engineering, Kogi State Polytechnic Lokoja, Nigeria.*

Abstract: **The ore samples were sourced from Bassa-Nge village, Bassa Local Government Area of Kogi State. Characterization and Beneficiation of Bassa-Nge iron ore deposit, Kogi State, Nigeria was carried out using XRF, XRD, SEM and petrological microscope. The XRF result revealed that the ore contained 48.16 % Fe_2O_3 and 24.17 % SiO_2 as major constituents, 15.73% Al_2O_3 with 7.23%K_2O, 1.48%MgO, 2.02TiO_2, 1.51P_2O_5 and 1.10%MnO as minor constituents. The XRD result revealed that the mineral phases of the ore as Quartz (SiO_2), Hematite (Fe_2O_3) and Biotite $K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$ which are also the major minerals phases. The SEM and petrographic examination revealed that the ore matrix is an assemblage of inter-layered different minerals crystals with different shapes, sizes and angles of orientations and separated by grain boundaries. Low intensity magnetic separator was used to separate the ore into concentrate and tailing. Both the concentrate and tailing were weighed and analyzed using XRF machine. Beneficiation of the iron ore indicated that the iron (Fe) of the ore can be upgraded from 48.03% to 51.57%Fe using low intensity magnetic separation technique.**

***Keywords*: Chemical, Mineralogical, Characterization, Beneficiation, Bassa-Nge iron ore**

I. INTRODUCTION

Nigeria is blessed with all the raw materials required for steel development including iron ore, coal, natural gas and limestone (Elijah, 2013).It has been proven that Nigeria is endowed with lots of solid minerals including but not limited to precious metals, stones and industrial minerals. The Federal Ministry of Mines have found over five hundred (500) locations of mineral deposits in the country and identified nine (9) that they would want to concentrate and promote, and these include coal , tin ore, gold, bitumen, iron ore, columbite –tantalite, lead-zinc, Wolframite and industrial minerals (Allen, 2017).

Nigeria has the potentials of becoming a regional economy hub in the West African sub-region, but the economy of the country cannot be strong and vibrant without growth in its iron and steel sector or without the use of iron and steel in the manufacturing sector among others (Agbu, 2007).

Iron is the major component in steel production; usually over 90 percent, at present there is no satisfactory substitute for steel even in modern industrialized societies, the supply of iron will therefore remain an important fundament to industrial development in the twenty-first century (Jens and Nicolas, 2003).

The most important economical iron oxides are those occurring within the Okene magnetite complex in North Central Nigeria. The largest of several similar deposits in the district is hematite-magnetite quartz body, which is a ferruginous quartz (Oyedele *et. al.,* 2016). Work to date has outlined mineral reserves of 111,400,000 tonnes grading about 35% Fe which is easily upgraded and is now being developed for open pit mining to provide feed for the Ajoakuta and Delta Steel Companies (Salawu, 2015).

Upgrading of valuable mineral from their naturally occurring ores can be termed in different ways as “ore dressing” “mineral dressing” and “mineral beneficiation”. Beneficiation is an important intermediate step in the transformation of naturally occurring ore to pure metal (Abubakre *et al*., 2014)

Characterization of iron ore is a very important step required before beneficiation and for iron production to takes place. In this procedure, the quantity, grade or quality, densities, shape, and physical characteristics are determined to allow for appropriate application of technical and economic parameters to support production planning and evaluation of the economic viability of deposits (John *et al.,* 2015).

Previous studies on Nigeria iron ores

Asuke, (2014) has also worked on the dephosphorization of KotonKarfe iron ore by acidic leaching and concluded that the phosphorous content of KotonKarfe iron ore can be reduced by acidic leaching technique. Oloche *et al.* (2001), also worked on Muro hill, Nasarawa State and reported that within a hitherto is schist belt, a banded iron oxide quartz rock which is associated with dolomite rock.

Odusote *et al*., (2019) carried out a preliminary characterisation of iron ores for steel making usiung Jaruwa and Agbaja deposite, based on the findings, Jaruwa deposit can be classified as high grade hematite iron ore while Agbaja deposit can be classified as lean grade, although both can serve as feedstock for production of iron through direct reduction route.

Agava *et al*., (2016) investigated on upgrading of ochokochoko iron ore using gravity and magnetic

concentration methods, the results obtained from the two different concentration tests inferred that Ochokochoko iron ore deposits can be upgraded using both Gravity and Magnetic separation technique to produce concentrate suitable for pig iron production by conventional blast furnace route.

Oladunni *et al.*, (2016) carried out a research on froth flotation of Ajabanoko iron ore deposit in Kogi State The results obtained from the work fell short of this standard, hence, the use of floatation reagents is not advisable for upgrading low grade Ajabanoko iron ore.

This study, therefore, is aimed at developing a process route for the Characterization and Beneficiation of the Bassa-Nge iron ore deposit located in Bassa, Kogi State for its possible utilization in Ajaokuta and Delta Steel Plants. To the best of my knowledge, there is no reported work on the Bassa-Nge iron ore. Bassa-Nge iron ore is a source of iron ore deposit that can be beneficiated and exploited in the nation's iron and steel industries.

II. EXPERIMENTAL PROCEDURE

A. Materials collection, equipment and preparation

The outcropped iron ore samples that were characterised in this study were collected from Bassa-Nge village in Bassa Local Government Area of Kogi State (7^0 42´N and 7^0 59´N). The equipment used in this research were Laboratory sledge hammer, Jaw crusher, Ball mill, Xray florescence (XRF) Machine, X-ray diffractometer (XRD) Machine, Magnetic separator, Petrological microscope and Scanning electron microscope (SEM). Samples of the iron ore were collected from 8 points on the deposit located at Bassa-Nge village located, in Bassa local government area of Kogi State. Grab method of sampling was used in assembling the samples. Ore samples were collected at interval of 250m apart and 7m depth, the lump sizes of the ore samples were crushed and ball milled. The major raw material for this research is the as-sourced iron ore (Figure 1).

Figure1: Bassa-Nge iron ore (As-sourced)

B. Characterization and beneficiation techniques

The representative samples were taken and analysed using X ray Florescence (XRF) machine to determine the elemental composition of the ore. The mineralogy of the ore was determined using X-ray diffraction (XRD) machine, the thin section of minerals and rocks were examined with the mineral fragment using petrological microscope and the microscopic features of the ore using scanning electron microscope. 200g of the iron ore was reduced to the liberation size of the ore (-355+250µm) using ball milling machine before separation. Low intensity magnetic separator was used to separate the ore into concentrate and tailing. Both the concentrate and tailing were weighed and analyzed using XRF machine.

III RESULTS AND DISCUSSION

A. Results and discussion of the analysis of Bassa-Nge iron ore

Table 1 present the result of the chemical analysis of Bassa-Nge iron ore using XRF in weight percentages. The result shows that the ore contained 48.16 % Fe_2O_3 and 24.17 % SiO_2 as major constituents, 15.73% Al_2O_3 with 7.23%K_2O, 1.48%MgO, 2.02TiO_2, 1.51P_2O_5 and 1.10%MnO as minor constituents**.**

Table 1: Chemical analysis of the oxide composition Bassa-Nge iron ore

Chemical Compound	Assay(%)
Fe_2O_3	48.16
SiO_2	24.17
Al_2O_3	15.73
K_2O	7.23
MgO	1.48
TiO_2	2.02
P_2O_5	1.51
MnO	1.10

200g of the iron ore was reduced to the liberation size of the ore (-355+250µm) using ball milling machine before separation. Low intensity magnetic separator was used to separate the ore into concentrate and tailing. Both the concentrate and tailing were weighed and analyzed using XRF machine.

Table 2 presents the mineralogical composition of the ore sample, it could be observed from Table 2 that the ore contained quartz (SiO_2), hematite (Fe_2O_3), and biotite ($K(Mg,Fe)_3AlSi_3O_{10}(OH)_2$) as the major mineral phases.

Table 4: XRD analysis result of the composite sample

Mineral Name	Chemical Name	Chemical Formula
Quartz	Silicate	SiO_2
Hematite	Iron Oxide	Fe_2O_3
Biotite	Potassium.IronMagnesium Aluminum Silicate Hydroxide	$K(Mg,Fe)3AlSi_3O_{10}(OH)_2$

Table 3 shows the composition of the concentrate and the tailing after magnetic concentration, the chemical analysis shows that the concentrate produced contained 56.32%Fe and 15.90% SiO_2, while the tailing gave 43.09% Fe_2O_3 and 32.83% SiO_2, the results showed that the iron bearing mineral (hemaetite) is liberated from its associated minerals (silica, alumina etc.).

Table 3: Composition of the concentrate and the tailing after magnetic concentration

Compounds	Concentrates	Tailings
SiO_2	15.90	32.83
Al_2O_3	0.43	7.27
CaO	5.11	5.42
TiO_2	3.31	15.27
V_2O_5	0.17	0.14
K_2O	7.21	0.061
MgO	0.39	0.11
Fe_2O_3	56.32	43.09
BaO	0.23	< LOD
P_2O_5	1.15	0.13
MgO	< LOD	3.0

The metallurgical balance of Bassa-Nge iron ore (Table 4) shows that the concentrate produced contained 51.57%Fe with recovery of 74.4%Fe. This means that there is an upgrade in the iron content from 48.03%Fe in the feed to 51.57%Fe in the concentrate after magnetic separation.

Table 4: Percentage distribution of material after the magnetic concentration and recovery

product	Weight	% Assay		Unit		% Recovery	
		Fe	SiO_2	Fe	SiO_2	Fe	SiO_2
Feed	200	48.03	21.50	12820	4065	100	100
Concentrate	132.5	51.57	18.20	9817.11	2021.26	74.4	43.82
Tailings	51.20	28.63	27.23	1989.04	2042.12	12.23	46.31
Loss	16.30	-	-	-	-	13.37	9.87

From the SEM examination (Figure 2), it is observed that the minerals are separated by grain boundaries, no interlocking of minerals and the mineral particles vary in sizes. The iron minerals have relatively smaller grains and smooth boundaries that created segregations between the iron and other minerals.

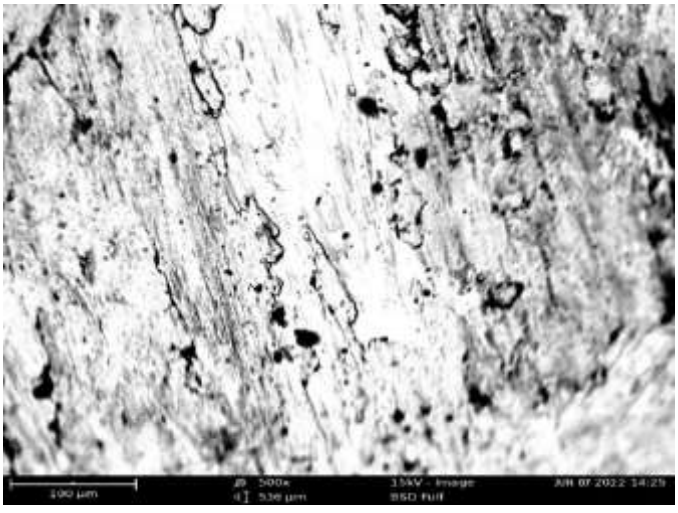

Figure 2: SEM micrograph of Head Sample

Petrographic microscopy of Bassa-Nge iron ore in Figure 3 shows A whitish portion the quartz minerals, brown portion which is the area partially replaced by hematite and the dark portion is the biotite. This phenomenon enhances easy liberation of valuable minerals from the gangues% SiO_2.

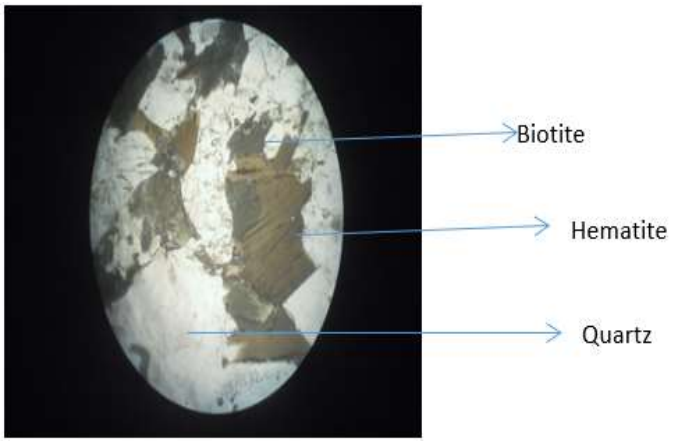

Figure 3: Petrographic microscopy of Bassa-Nge iron ore

From Figure 4, dominant mineral phases in the iron ores are; hematite, quartz and biotite with other associated mineral phases.

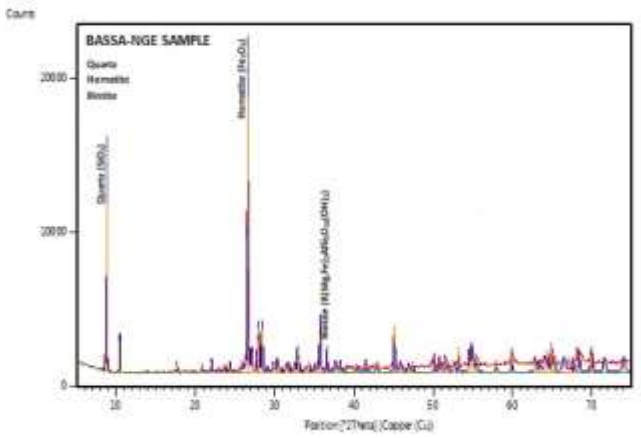

Figure 4: XRD pattern of the Bassa-Nge iron ore

IV. CONCLUSIONS

The following conclusions were drawn

1. The result shows that the ore contained 47.82% Fe_2O_3 and 24.1% SiO_2 as major constituents, with,11.43%K_2O, 0.24%MgO, 4.61TiO_2, 2.744P_2O_5, 0.23%PbO and 1.45%Al_2O_3 as minor constituents and thus can be regarded as medium grade iron ore.
2. The mineralogical analysis of the ore revealed that the iron bearing minerals are mainly Biotite, Hematite and Quartz.
3. The SEM and petrography analysis results revealed that the iron bearing minerals are separated from other minerals contained in the ore by smooth grain boundaries.
4. Beneficiation of the iron ore indicates that the iron (Fe) of the ore can be upgraded from 48.03% to 51.57%Fe using low intensity magnetic separation technique.
5. From the results gotten, Bassa-Nge iron ore is a medium grade iron ore deposit that can be explored and exploited for usage in iron and steel production.

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