[1.] Suleiman I. SALAWU, [2.] A.M. SALIU

CHARACTERIZATION AND BENEFICIATION OF OBAJANA IRON ORE, KOGI STATE, NIGERIA

[1.]Department of Mechanical Engineering, Kogi State Polytechnic, Itakpe, NIGERIA
[2.]Department of Metallurgical and Materials Engineering, Kogi State Polytechnic Itakpe, NIGERIA

Abstract: The ore sample was sourced from Obajana (oyo) village, Lokoja Local Government Area of Kogi State. Characterization of Obajana iron ore deposit, Kogi State, Nigeria was carried out using XRF, XRD, SEM and petrological microscope. The XRF result revealed that the ore contained 0.38%P, 15.91K, 2.48%Ca, 39.24%Fe, 1.02%Mg, 3.54%Al and 25.56%Si. 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
Keywords: Chemical, Mineralogical, Characterization, Beneficiation, Obajana iron ore

INTRODUCTION

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 commonly used iron minerals include; hematite, Fe_2O_3 (70% Fe); magnetite, Fe_3O_4 (72% Fe) and of much less importance: limonite, $Fe_2O_3{\cdot}3H2O$ (60% Fe); siderite, $FeCO_3$ (48.3% Fe); and pyrite, FeS_2 (46.6% Fe) (Biswas, 2005).

Characterization of iron ore is a very important step required before beneficiation and iron production 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). Iron ore deposits have not been fully explored and exploited in Nigeria and if fully exploited can serve as foreign exchange for the country (Danmola and Abba, 2013).

Agbado Okudu iron ore deposit has been worked on by Agava (2006). Who reported that the iron ore contained, on the average, total iron content of 38.82% and mineralogical analysis revealed that the iron bearing minerals are predominantly magnetite and haematite.

Agava *et al.* (2016) determined the chemical, mineralogical and liberation size of Ochokochoko iron ore. They reported that the ore is predominantly magnetite, hematite, calcite, alumina, and silica, they also reported that the ore can be classified as medium grade and liberated at -180+125 μm sieve size. Salawu (2015) investigated the chemical and mineralogical characterization of Gujeni iron ore deposit Kaduna State, Nigeria and the findings showed that the ore contained majorly hematite, goethite, rutile while, manganese oxide, zincite, zirconium and silicate minerals were present in minor quantities. Table 1 shows the iron ore deposits in Nigeria

EXPERIMENTAL PROCEDURE

— Materials collection, equipment and preparation

The outcropped iron ore samples that were characterised in this study were collected from Obajana (oyo) village about 5km from Obajana cement company (7^0 45´N and 6^0 67´N) shown in figure 1 and equipment used in this research were Laboratory sledge hammer, Jaw crusher, Ball mill, Xray florescence (XRF) Machine, X-ray diffractometer (XRD) Machine, Petrological microscope and Scanning electron microscope (SEM). Samples of the iron ore were collected from 3 points on the deposit located at Obajana (oyo) village located, in Lokoja Local Government Area of Kogi State. Grab method of sampling was used in assembling the samples. 35kg of the samples were collected at interval of 180m apart and 4m depth, the lump sizes of the ore samples were crushed and ball milled.

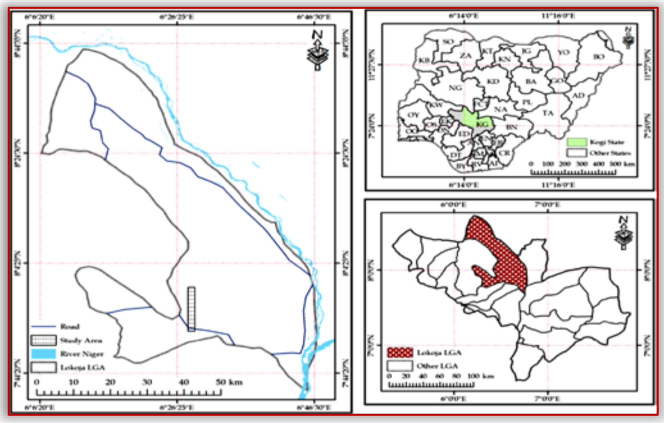

Figure 1: Location map of the study area inset on Lokoja map, north central Nigeria (Olasunkanmi N.K. *et al.*, 2017)

— Characterization and beneficiation techniques

The representative sample was 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 micrroscope. 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 1: The Nigerian iron ore deposits and their proven reserves (in million tonnes)

S/NO	State	Location	Iron content	Proven reserves
1	Kogi	Bassa-Nge	43-49%	400 million tonnes
2		Agbado Okadu	38-48%	60 million tonnes
3		Ajabanoko	40%	60 million tonnes
4		Jatti	40%	-
5		Koton Karfe	43-53%	428 million tonnes
6		Itakpe	36-38%	200 million tonnes
7		Chokochoko	30-40%	14 million tonnes
8		Akoina	41-47%	-
9		Tajimi	39-58%	200 million tonnes
10		Ero	Under investigation	-
11		Ebiya	Under investigation	-
12		Obanaja	Under investigation	-
13		Agbaja	43-49%	2 billion tonnes
14		Kakun (Kabba)	38-42%	-
15		Ubo-Toso	Under investigation	-
16	Kaduna	Kagara (Kubacha)	58-63%	-
17		Birni Gwari	30-35%	-
18	Ondo	Akunu (Ikare)	Under investigation	-
19	Bauchi	Reshi	10-19%	-
20		Ayiwawa	6-23%	-
21		Gamawa	40-45%	-
22	Plateau	Veketuwo	40-50%	-
23	Nasarawa	Toto Muro	25-38%	3.8 million tonnes
24	Kebbi	Dakingari	37%	-
25	Anambra	Nsude Hill	43-50%	40.6 million tonnes

Source: (Uwadiale, 1989; Thomas, 2002)

RESULTS AND DISCUSSION

Table 2 present the result of the chemical analysis of Obajana iron ore using XRF in weight percentages. The ore contains 39.24 % Fe and 25.56 % Si as major constituents; with 15.91 % K, 3.5 % Al, and P is the least with 0.38% while Table 3 shows the chemical analysis of the oxide composition Obajana iron ore.

The result shows that the ore contains 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. Figure 2 shows the XRF pattern of the ore.

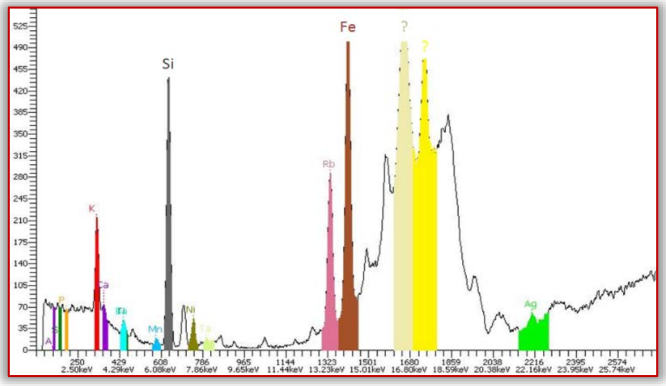

Figure 2: XRF pattern of the obajana iron ore

Table 2: Chemical analysis of the elemental composition Obajana iron ore

Element number	Element symbol	Element name	Atomic conc.	Weight conc.
14	Si	Silicon	25.56	20.84
13	Al	Aluminium	3.54	5.97
19	K	Potassium	15.91	18.80
26	Fe	Iron	39.24	33.30
39	Y	Yttrium	1.35	3.64
41	Nb	Niobium	1.29	3.61
47	Ag	Silver	1.09	3.56
20	Ca	Calcium	2.48	3.00
17	Cl	Chlorine	1.36	1.46
22	Ti	Titanium	1.00	1.44
6	C	Carbon	3.19	1.16
16	S	Sulphur	1.11	1.07
11	Na	Sodium	1.48	1.03
12	Mg	Magnesium	1.02	0.75
15	P	Phosphorus	0.38	0.36

Table 3: Chemical analysis of the oxide composition Obajana iron ore

Chemical Compound	Assay (%)
SiO_2	24.1
Al_2O_3	1.45
K_2O	11.43
CaO	7.2
TiO_2	4.61
V_2O_5	0.08
MgO	0.24
Fe_2O_3	47.82
CuO	0.067
PbO	0.23
BaO	0.10
P_2O_5	2.744
Na_2O	0.049

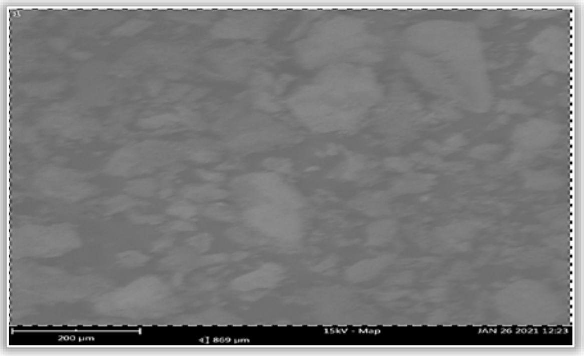

Figure 3: SEM micrograph of Head Sample

Table 4 presents the mineralogical composition of the ore sample, it could be observed from table 4 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. From the SEM examination (figures 3), it is observed that the minerals are separated by grain boundaries, no interlocking of minerals and the mineral particles vary in sizes.

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 Iron Magnesium Aluminum Silicate Hydroxide	$K(Mg,Fe)3AlSi_3O_{10}(OH)_2$

The iron minerals have relatively smaller grains and smooth boundaries that created segregations between the iron and other minerals. Petrographic Microscopy of Obajana Iron Ore in

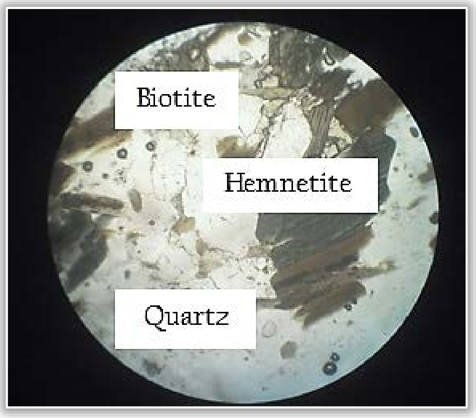

Figure 4: Petrographic Microscopy of Obajana Iron Ore

Table 5: 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

Figure 4 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. 200g of the iron ore vs. 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 5 shows Composition of the concentrate and the tailing after magnetic concentration. The chemical analysis shows that the concentrate produced contained 56.32%Fe and 15.9% SiO_2, while the tailing gave 43.09% Fe_2O_3 and 32.83% SiO_2.

CONCLUSIONS

The following conclusions were drawn:

≡ The result shows that the ore contains 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.

≡ The mineralogical analysis of the ore revealed that the iron bearing minerals are mainly Biotite, Hematite and Magnetite.

≡ The SEM analysis results revealed that the iron bearing minerals are separated from other minerals contained in the ore by smooth grain boundaries.

≡ From the results gotten, Obajana iron ore is a deposit that can be explored and exploited for usage in iron and steel production.

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