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Composition and Liberation Size of Agbaja Iron Ore Kogi State North Central Nigeria.

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ABSTRACT: This research work focused on the Determination of the Elemental Composition and Liberation Size of Agbaja iron ore deposit kogi state Nigeria. The techniques involved in the study were sample collection and preparation, sieve analysis and chemical analysis of the field sample. The chemical analysis of the field sample was conducted on a scanning electron microscope which produce iron (Fe) to be the dominant metal in the list of element detected with an elemental percent composition of 35.48 % which makes it a low grade iron ore deposit. There is also phosphorus element present at 1.8 %. The presence of phosphorus in the ore makes it unique when compared to other iron ore deposits found in Nigeria.The mesh of grind was found to be 875 µm and the liberation size was established to be less than250 µm sieve size having the highest percentage of elemental iron composition of 36.59 and 35.91% iron content. The study recommended further investigation on the separation of the iron ore using 250 µm and other lesser sieve sizes.

Keywords: Comminution, Liberation Size, Ore, Mesh of Grind, Composition

I. INTRODUCTION

The enormous growth of industrialization from the eighteenth century onward led to dramatic increases in the annual output of most mineral commodities, particularly metals. Iron is one of the most common elements on earth. Nearly every structure put on by man contains at least a little iron. It is also one of the oldest metals and was first fashioned into useful and ornamental objects about 3,500 years ago (Lambert and Mark, 1988). Minerals by definition are natural inorganic substances possessing definite chemical compositions and atomic structures. Many minerals exhibit isomorphism, where substitution of atoms takes place without affecting the atomic structure (Wills, 2006). Other minerals exhibit polymorphism; different minerals having the same chemical composition but markedly different physical properties due to a difference in crystal structures. One of the most important determining factors for establishing Iron and steel plants is the availability of iron ore deposit with good geological, mineralogical and metallurgical properties. There are two fundamental operations in mineral processing namely; the release or liberation of the valuable minerals from their waste gangue minerals and separation of these valuables from the gangue, this latter process being known as concentration. The liberation of the valuable minerals from the gangue is accomplished by comminution and one of the major objectives of comminution is the liberation of the valuable minerals from the associated gangue minerals at the coarsest possible particle size. If such an aim is achieved, then not only is energy saved by the reduction of the amount of fines produced but any subsequent separation stages become easier and cheaper to operate. If high grade products are required then good liberation is essential in the process (Wills and Atkinson, 1993). Iron as in the case of most minerals are finely disseminated and intimately associated with gangues, which must be unlocked before separation can be undertaken. This is achieved by comminution, in which the particle size of the ore is progressively reduced until the particles of mineral can be separated by such methods as are available (Knecht, 1994). Comminution in the mineral processing plant takes place as a sequence of crushing and grinding processes carried out until the mineral and gangue are substantially produced as separate particles (Flavel, 1978).

Crushing is the first mechanical stage in the process of comminution in which the main objective is the liberation of the valuable minerals from the gangue (Lewis et al, 1976). Crushing is accomplished by compression of the ore against rigidly constrained motion path. This is contrasted

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with grinding which is accomplished by abrasion and impact of the ore by the free motion of unconnected media such as rods, balls or pebbles.

Grinding is the last stage in the process of comminution, in this stage the particles are reduced in size by a combination of impact and abrasion, either dry or in suspension in water. It is performed in rotating cylindrical steel vessels which contain a charge of loose crushing bodies. (The grinding medium) which is free to move inside the mill, thus comminuting the ore particles. According to the ways by which motion is imparted to the charge, grinding mills are generally classified into two types: tumbling mills and stirred mills (Wills 2006). Size analysis of the various products after comminution of a concentrator constitutes a fundamental part of laboratory testing procedure. It is of great importance in determining the quality of grinding and in establishing the degree of liberation of the values from the gangue of various particle sizes (Barbery, 1972).

This is done, primarily to establish that particle size at which the various grains in an ore happened to be free of each other, thus setting the stage for effective and efficient separation process. This particular particle size is referred to as liberation size, which also should be at the coarsest possible size to avoid energy waste through over grinding and hence saves a great deal of cost.

II. LOCATIONAND GEOLOGY OF THE STUDY AREA

Agbaja is a locality of large iron ore deposit in Kogi State, North Central Nigeria. The iron ore deposit is located on a plateau of latitude 7° 58'58.7"N and longitude 6° 38' 59.6"E (Aluko etal. 2018) which is also 26.4 km from Lokoja the state capital. Agbaja iron ore is a channel iron ore deposit (CID) located within the sub-horizontal to very shallow east dipping late cretaceous Agbaja formation which is made up of an upper unit hosting ferruginous sandstone and oolite/pisolite material (laterite unit) as shown in the geologic map of the study area in Fig. 1.

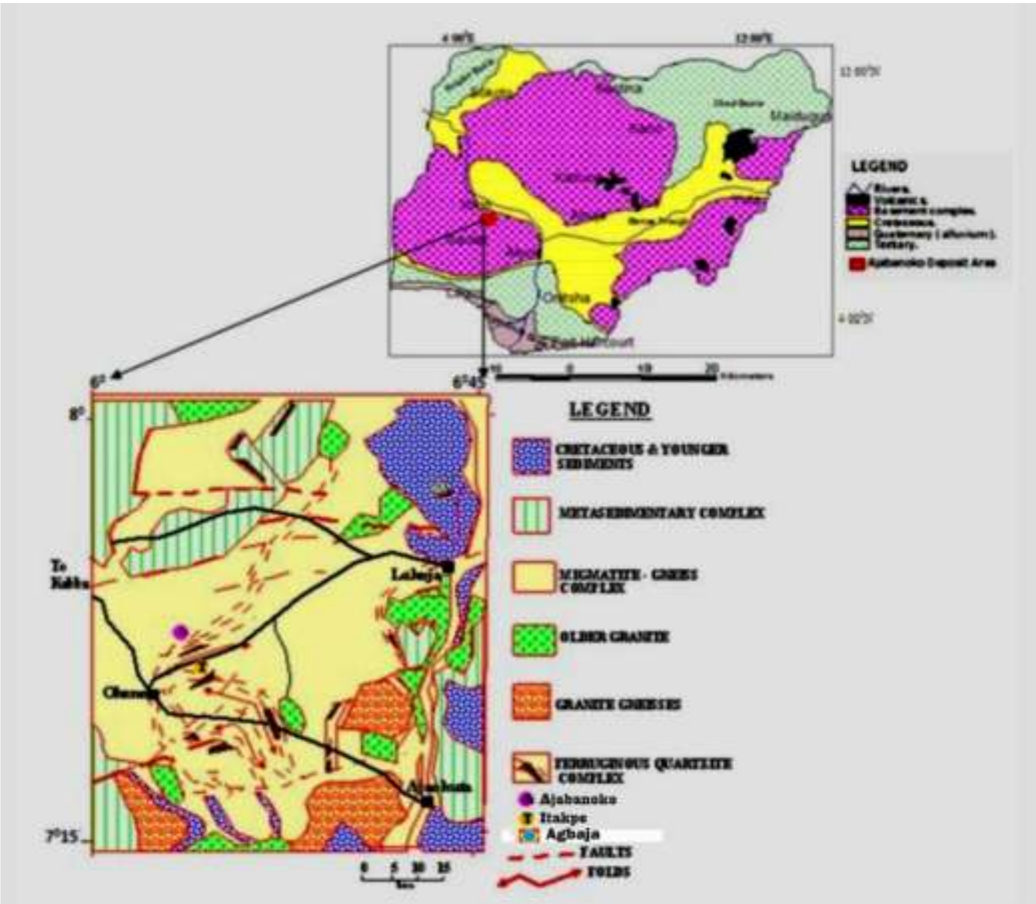

Fig 1 A geologic map of Nigeria showing the study area

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III. METHODOLODY

A. Sampling Method

Random sampling method was used to obtain bulk iron ore samples from agbaja deposit. Lump sizes of the ore are collected from the face of the deposit at intervals of about 10 m apart.

B. Sample Preparation

The lump sizes of the ore collected were broken into sizes that can be fed into a laboratory size jaw crusher using a sledge hammer. The samples were weighed for crushing and sieving and the oversize produced was ground in a ball mill characterized to rotate at 60 r.p.m. Sieve analysis is then carried out on the ground sample.

C. Mineralogical Composition

Scanning Electron Microscope SEM model JEOL 840 was used to analyze the sample for its mineral constituent. All the samples were carbon coated in order to make the mineral surface conductive and then mounted for analyses. Qualitative chemical analyses of minerals were carried out using SEM/EDS to produce back scattered images (BSI). The result of the field sample is shown in Table 1.

D. Sieve Analysis

Ten sets of sieves ranging from 2360 µm to 150 µm were used to carry out sieve analysis of the crushed and ground ore sample. The mesh of the top sieve was loaded with 2.5 kg of the crushed and ground ore and allowed to vibrate for 20 minutes. During the shaking, the undersize material falls through successive sieves until it is retained on a sieve having apertures which were slightly smaller than the diameter of the particles. After a successful operation each size fraction retained on each sieve was collected weighed and value recorded.

IV. RESULT ANALYSIS AND DISCUSSION

A. Results Analysis

The results of various laboratory experiments carried out are analyzed and presented as follows;

Table 1. Elemental Composition of Field Sample

Element	C	O	Al	Si	P	Mn	Fe	Cu	Ir
% Elemental Composition	3.61	52.50	3.94	2.70	1.28	0.07	35.48	0.07	0.35

Table 2. Result of Sieve Analysis of Crushed Ore Sample

Sieve Sizes (µm)	**Weight Retained (g)**	**Weight Retained (%)**	**Cumulative % Weight Retained**	**Cumulative % Weight Passing**
2360	1150.03	46.03	46.03	100.00
1700	331.46	13.26	59.29	53.97
850	458.55	18.35	77.64	40.71
600	156.21	6.25	83.89	22.36
425	110.60	4.42	88.31	16.11
300	76.48	3.06	91.37	11.69
250	36.70	1.46	92.83	8.63
180	47.88	1.91	94.74	7.17
150	23.68	0.94	95.68	5.26
-150	106.42	4.26	99.94	4.32

Table 3. Result of Sieve Analysis of Grinded Ore Sample

Sieve Sizes (µm)	**Weight Retained (g)**	**Weight Retained (%)**	**Cumulative % Weight Retained**	**Cumulative % Weight Passing**
2360	854.60	34.19	34.19	100.00
1700	401.69	16.07	50.26	65.81
850	285.16	11.40	61.66	49.74

600	189.82	7.59	69.25	38.34
425	150.79	6.00	75.25	30.75
300	131.51	5.26	80.51	24.75
250	112.05	4.48	84.99	19.49
180	124.78	4.99	89.98	15.01
150	91.06	3.64	93.62	10.02
-150	158.07	6.32	99.94	6.38

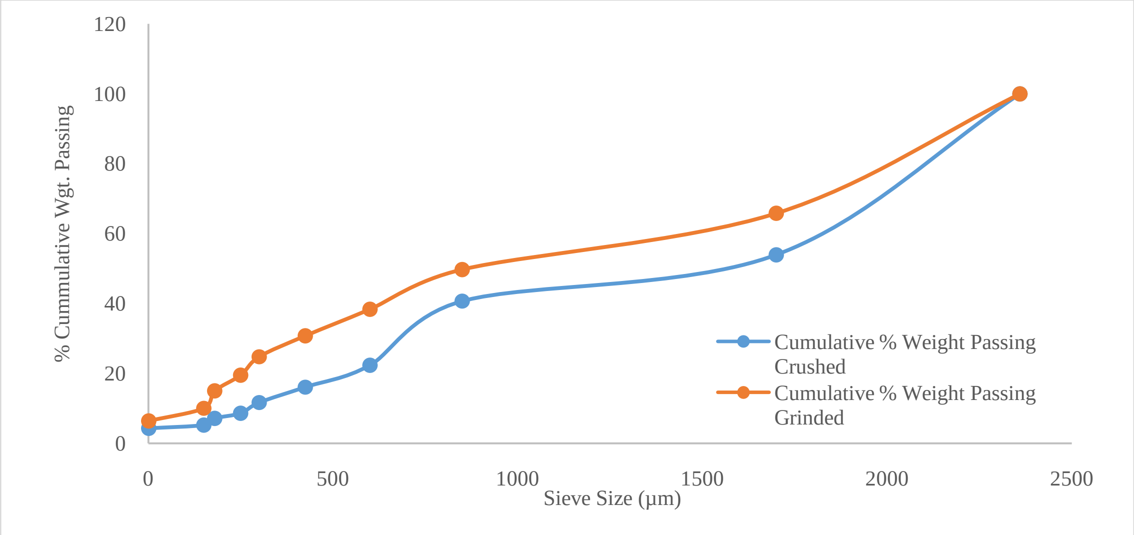

Fig 2. Particle distribution curve for sieve analysis of crushed and ground ore

Table 4. Elemental Composition of Sieved Ore Sample

Sieve Size (µm)	**% Elemental Composition**								
	C	**O**	**Al**	**Si**	**P**	**Mn**	**Fe**	**Cu**	**Ir**
2360	3.02	50.11	3.75	2.33	1.02	0.09	25.41	0.08	0.33
1700	3.13	51.95	3.92	2.71	0.98	0.12	29.39	0.05	0.17
850	3.43	52.30	3.70	2.72	1.11	0.05	34.38	0.01	0.23
600	3.13	51.86	3.84	2.63	1.48	0.09	33.61	0.02	0.17
425	3.23	52.41	3.89	2.75	1.09	0.03	32.92	0.06	0.13
300	3.33	53.49	3.77	2.48	1.22	0.21	34.38	0.06	0.30
250	3.62	52.70	3.93	2.65	1.17	0.09	36.59	0.07	0.35
180	3.57	52.30	3.18	2.93	1.08	0.11	35.91	0.10	0.48
150	4.01	50.16	3.32	3.15	0.06	0.34	35.64	0.28	0.11
Pan	4.03	51.58	3.35	2.98	1.30	0.45	32.36	0.21	0.09

B. Discussion

The chemical analysis of the field sample was conducted on a scanning electron microscope which produce the result in its elemental form indicated iron (Fe) to be the dominant metal in the list of element detected with an elemental percent composition of 35.48 % which makes it a low grade iron ore deposit. There is also a significant amount of the phosphorus element present at 1.8 %. The presence of phosphorus in the ore makes it unique when compared to other iron ore deposits found in Nigeria.

Tables 2 and 3 of sieve analysis show the performance of the communition process of crushing and grinding. It can be observed from Table 3 that the smaller the aperture of the sieve, the lower the weight % of the iron ore retained. The aperture range of 2360 µm has the most retained weight% followed by 850 µm and then 1700 µm respectively. But the value of % weight retained by the 2360 µm would reduce by the regrinding process and thereby increase the weight retained by the lower size sieves.

The valuable quantity which can be determined from the distribution curve is the median size of the sample which refers to the midpoint in the size distribution or 50 % passing or retained. The value obtained from the distribution curve of crushing shows that the 50% passing size is about 1575 µm while it is about 875 µm in the grinding distribution curve. This implies that 50 % of the particles sieved are finer than 1575 µm and 50 % is coarser than this size for crushing while 50 % of the particles sieved are finer than 875 µm and 50 % is coarser than this size for grinding. Also the energy consumed to produce particles of 1575 µm is the same energy consumed to reduce the particle size to about 875 µm.

The chemical analysis of the sample conducted on all the product of sieves is shown in Table 4. The result of the compositional analysis in elemental form indicated that 250µm, 180 µm and 150 µm contains the valuable mineral (Fe) in higher percentages of 36.59 %, 35.91 % and 35.64% respectively. This result shows that more of the iron (Fe) particles are liberated at the ≤ 250µm. Therefore, the comminution plant should be designed in closed circuit so as to liberate more iron minerals from the coarse meshes of the particle series in Table 4.

V. CONCLUSION

In conclusion the research established that the Agbaja iron ore is a low grade deposit with 35.48 % Fe content in the field sample tested in a scanning electron microscope and also confirms the iron ore to be a goethite mineral with the presence of 1.8 % phosphorus which makes it unique amongst other iron ore deposits in Nigeria. The liberation size was determined by sieve analysis to be 250µm having the highest percent elemental composition of 36.59 % with 50 % passing size in grinding of 875 µm.

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