

# Liberation Studies of Composite Particles in Iperindo Gold-bearing Rock, Southwest Nigeria

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## To cite this article:

Adetula Yomi Vincent, Alabi Oladunni Oyelola, Ola-Omole Omoyemi Omole. Liberation Studies of Composite Particles in Iperindo Gold-bearing Rock, Southwest Nigeria. *American Journal of Nanosciences*. Vol. 5, No. 4, 2019, pp. 39-42. doi: 10.11648/j.ajnn.20190504.12

**Received:** October 22, 2019; **Accepted:** November 20, 2019; **Published:** November 25, 2019

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**Abstract:** The research investigates the liberation size of composite particles in Iperindo lode deposit at Ilesha goldfield in Osun state, Nigeria. The sample of the gold ore was sourced from Iperindo and 3 kilograms of gold ore was prepared by crushing and grinding to 100% passing 710 $\mu$ m sieve. 300 grams of the prepared ore was charged into set of sieves arranged in  $\sqrt{2}$  i.e from 500  $\mu$ m to -45  $\mu$ m mounted on automated sieve shaker and operated for 20 minutes. Atomic Absorption Spectrometry (AAS) and X-ray Fluorescence (XRF) were used to determine the elemental and chemical composition of the ore. The chemical analysis of the crude sample via X-ray Fluorescence Spectrometry (XRF) revealed that the crude sample contain high content of Fe, Ti, Mn and K. The traces of K, Ba and Rb, shows that composite particles in Iperindo gold-bearing rock ore was formed as a result of hydrothermal alteration and the characterization of the sieve fractions by Atomic Absorption spectrometry shows -63 $\mu$ m +45 $\mu$ m has the highest gold content when compare to other seive fraction. This indicates that the optimum liberation size of gold in Iperindo gold-bearing rock is 45 $\mu$ m. Processing of gold, which is economical viable from the ore deposit using froth flotation is desirable. Hence, efficient flotation of the mineral particle at the optimum liberation size of 45 $\mu$ m which lies favorably within the range of 10–150 $\mu$ m sighted from literature, will lead to good recovery of the gold particle.

**Keywords:** Iperindo Gold Ore, Liberation Size, Mineral Processing, Ilesha, Sustainable

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## 1. Introduction

Solid Minerals are an economic commodity, mined for their potential use or intrinsic value and they constitute a wide range of natural resources like galena, sphalerite, gold, columbite, tantalite, molybdenum, among others that provide a bulk of raw materials for industry [1]. Gold is a noble metal, an indispensable, social, political significance and non-substitutable strategic resource due to its broad applications in industries as well as national economy [2]. It is imperative to know that the world gold production has been on the increased since 2014 while in 2018, China became the world top gold producer for the twelfth consecutive year since 2006 with production of 440 tons of gold. Similarly, Australia produced 300 tons of gold which is the second largest gold producer while Russia became the third largest gold producing country with 255 tons. In the same vein, United States of America produced 245 tons of gold to be ranked the world's

forth producer of gold, South Africa is the seventh largest gold producer with gold production averaging 245 tons and Ghana ranked twelfth position with production of 90 tons of gold among others [3]. However, despite the occurrence of gold deposit in Nigeria, yet there is no official documentation of the country among comity of gold producing nations of the world. Fortunately, gold occurrence in economic quality has been reported in Ife-Ilesha area of Southern Nigeria and Iperindo gold-bearing rock is one of the few primary gold deposits known in Nigeria [4]. To selectively concentrate valuable mineral, the host rock (ore) needs to be crushed and ground to liberate the minerals of interest but it so unfortunate that 100% liberation is never achieved in practice [5] however, composite particles which comprise both liberated particles and particles of "locked" minerals and gangue [6-8], are produced. It is imperative to know that for efficient separation of valuable mineral to be achieved, the ore is ground finer to improve liberation, which automatically increase recovery rate and produce pure concentrate with little gangue [9]

However, fine grinding can lead to production of very fine and untreatable particles which may be lost to tailing and high cost of energy is inevitable during the process [10]. As a result of this grinding is therefore a compromise between liberation and particle size [11]. Froth flotation is one of the most important methods of mineral concentration, widely used in the mineral processing industry. It exploits the differences in the electrochemical properties of mineral surfaces, that is, between hydrophobic and hydrophilic surfaces, which either occur naturally or are artificially induced by chemical reagents [12]. It has been reported that efficient flotation of mineral particles occurs for particle diameters in the range of 10–150µm [13, 14].

Below the lower and upper limit of this size range, there is low or poor recovery of mineral particles because mineral flotation is a size dependent process; fine, intermediate and coarse particles show different flotation behavior [15]. The need to study the liberation size of Iperindo gold-bearing rock is imperative to the recovery of gold concentrate for further extraction processing.

## 2. Materials and Methods

### 2.1. Material

The material used for this research was three kilograms (3 kg) of Iperindo Lode ore sourced from Ilesha gold ore deposit site which is about 23 square kilometers. It lies within latitude 7°3' and 7°35' and longitude 4°30' in Osun State, Nigeria. Samples were randomly picked by to have a true fraction representation of the deposit while cone and quartering sampling method was used after crushing.

### 2.2. Method

Three kilograms (3 kg) sample was crushed using laboratory Jaw crusher and ground in a Ball mill. Three hundred grams (300 g) of the prepared sample was subjected to sieve analysis using a sieve range of +500 µm to -45 µm to determine the liberation size. The elemental analysis and chemical analysis of the crude gold samples was carried using Atomic Absorption Spectrometer (AAS) and X-ray Fluorescence (XRF)

#### 2.2.1. Atomic Absorption Spectrometer (AAS)

20g of Ilesha lode gold ore was analyzed to determine its metal content using atomic absorption spectrometer (AAS) at the Geoscience Laboratory, University of Lagos, Nigeria. The sample was treated with aqua regia (concentration of conc. Nitric acid (HNO<sub>3</sub>) and conc. Hydrochloric acid (HCl)) to dissolve the gold. It was heated at 870°C for 3 hours and was allowed to cool in a desiccator for 40 minutes. The digested ore sample was then analyzed using the AAS. AAS gold standard was prepared and the ore was allowed to absorb light. The sample was first atomized and a beam of electromagnetic radiation emitted from the excited gold atoms was allowed to pass through a vaporized sample. The elemental composition of the ore in part per million as

obtained is presented in Table 1 and Table 2 alongside other elements in each of the sieve sizes.

#### 2.2.2. X-ray Fluorescence (XRF)

Chemical analysis of the gold ore was carried out using the x-ray fluorescence (XRF) of the Venarum Mines Laboratory, Apapa, and Lagos State. The X-ray Fluorescence (XRF) which is a semi-quantitative analysis tool used to determine the chemical composition of the associated mineral in the ore. 2g of the gold ore was pulverized to the powder form, the powdered ore was thereafter fed into the sample holder of the XRF equipment.

## 3. Results and Discussion

*Table 1. Elemental Analysis of Iperindo Lode Gold Ore (Bulk assay).*

Bulk Assay	Mn	Cu	Au	Fe	S
(ppm)	29.97	6.88	4.1	4129.09	0.159

The elemental analysis carried out on the Iperindo gold-bearing rock ore as shown in Table 1 reveals that the ore contains 4.10ppm Au, 29.97 ppm Mn, 4129.09 ppm Fe, 6.88ppm Cu and 0.1059ppm S. The result shows that the Iperindo gold bearing rock ore has appreciable gold content. The 4.10 ppm obtained is above the minimum value 0.69-1.37ppm which [16] prescribed for an economically worthwhile extraction.

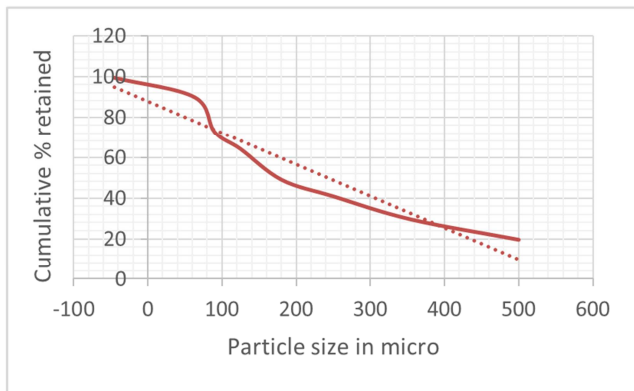
Table 2: shows the result for the chemical analysis of Iperindo lode ore using X-ray Fluorescence (XRF).

*Table 2. Chemical Analysis of Iperindo Lode gold ore Using XRF.*

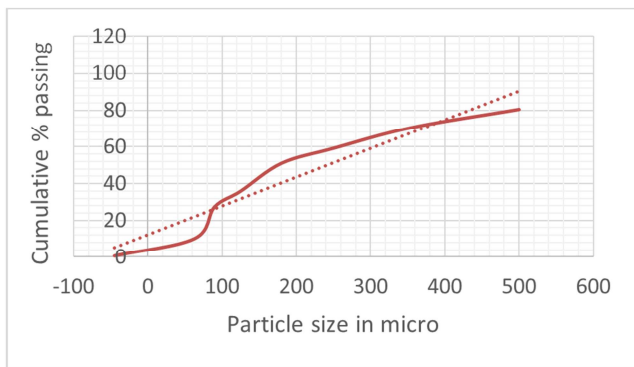
Element present	Composition (ppm)	Element present	Composition (ppm)
K	15562.52	As	256.13
Ca	3699.51	Se	157.11
Ti	56463.06	Rb	2631.15
V	492.07	Sr	78.78
Cr	1707.05	Mo	208.97
Mn	12096.46	Ag	0.56
Fe	282984.78	Au	103.98
Co	1374.97	Pb	1003.38
Ni	1374.97	Th	432.38
Z	4507.29	S	1549.76

The principal element present in the gold ore is iron which is shown in Table 1 and Table 2. From the result of the analysis, 282984.78 Fe was revealed in the Iperindo gold-bearing rock. This ore conforms to the assertion of [16] that gold occurs in ores as discrete particulates within sulphide minerals (mainly in pyrite and arsenopyrite). This also tallies with the observation of [17] that iron is present in a variety of oxide, hydroxide, sulfate, sulfide and silicate minerals. However, the traces of K, Ba and Rb, in the ore shows that the Iperindo gold-bearing rock ore is formed as a result of hydrothermal alteration.

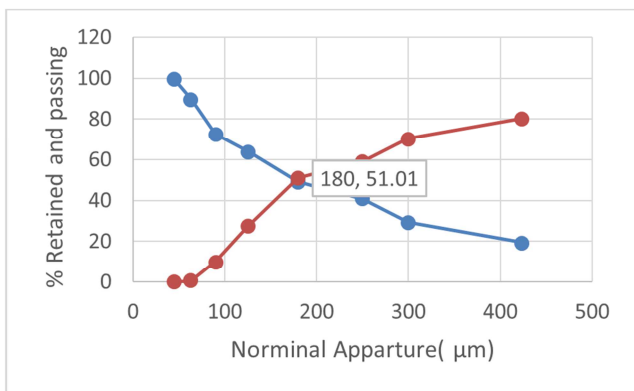
Tables 3 and 4: shows the result for the Sieve test result Iperindo gold-bearing rock



**Figure 1.** Shows the graph of cumulative % retained against particles size of Iperindo gold-bearing rock.



**Figure 2.** Shows the graph of cumulative % passing against particles size of Iperindo gold-bearing rock.



**Figure 3.** Shows sieve size (mm) against cumulative % retained and cumulative % passing of the Iperindo lode gold.

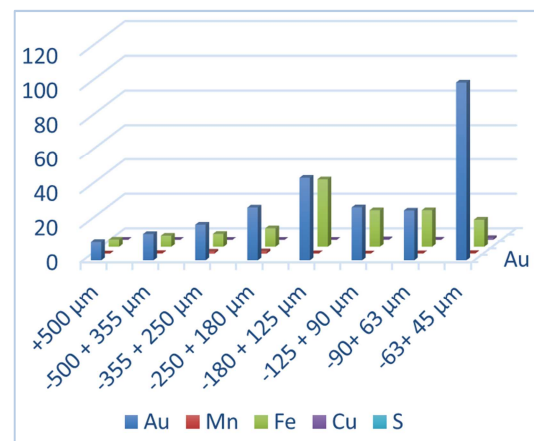
**Table 3.** Result of sieve analysis of Iperindo Gold-bearing rock.

Sieve Size	(w <sub>1</sub> )g	(w <sub>2</sub> )g	(w <sub>3</sub> )g	Average (g)
+500	19.20	19.50	19.10	19.30
355	9.50	10.10	9.70	9.77
250	11.70	11.60	10.10	11.13
180	7.80	8.10	8.20	8.03
90	15.70	15.20	13.70	14.87
63	7.50	9.70	7.80	8.33
45	17.50	17.90	15.40	16.97
-45	-	0.50	1.40	0.63
Total	98.50	99.3	97.40	98.33

**Table 4.** Result of Sieve Analysis of Iperindo gold-bearing rock.

Nominal Aperture (μm)	Weight	%Cumulative Retained	%Cumulative Passing
500	19.56	19.56	80.44
355	9.94	29.50	70.50
250	11.32	40.82	59.18
180	8.17	48.99	51.01
125	15.11	64.10	35.90
90	8.47	72.57	27.43
63	17.26	89.83	10.17
45	9.53	99.36	0.64

From figures 1 and 2; cumulative % retained and cumulative % passing lead to figure 3, it shows that the economic liberation size is at the range of -250+180 μm. Processing the economic liberation size will lead to quantity instead of quality and the end product will have more gangue than mineral of interest.



**Figure 4.** Show the result for the chemical analysis of the particle size fractions in part per million.

From figure 4, it shows that a significant liberation of gold was achieved at sieve size fraction of -63μm+45μm with percentage assay of 103ppm Au being the highest percentage of gold when compared to other sieve sizes. This indicates that at the optimum liberation size of -63μm+45μm, processing of gold, which is economical viable from the ore deposit using froth flotation is desirable. Hence, efficient flotation of the mineral particle at the optimum liberation size of 45μm which lies favorably within the range of 10–150μm sighted from literature, will lead to good recovery of the gold particle.

## 4. Conclusion

In conclusion, the liberation size of Iperindo gold-bearing rock ore from Ilesha goldfield in Osun state, Nigeria has been determined and found to be 45 μm. This optimum liberation size serves as panacea for the development of a process route for the beneficiation of Iperindo lode gold ore deposit to metallurgical grade. Nigeria can benefit immensely via the exploration, exploitation, processing, extraction and utilization of the depletable resources as a result of this, overcome its present economic struggle if adequate attention

is directed towards the solid mineral sector because it is pivotal to the economic and technological development of a nation.

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