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Particle Size Analysis of Itagunmodi Southwestern Nigeria Alluvial Gold Ore Samples by Gaudin Schumann Method

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Abstract**—**Mining of alluvial gold ore by artisanal miners has been going on for decades at Itagunmodi, Southwestern Nigeria. In order to optimize the traditional panning gravity separation method commonly used in the area, a mineral particle size analysis study is critical. This study analyzed alluvial gold ore samples collected at identified five different locations in the area with a view to determine the ore particle size distributions. A 500 g measure of as-received alluvial gold ore sample was introduced into the uppermost sieve of an electrical sieve shaker consisting of sieves arranged in the order of decreasing nominal apertures of 5600 µm, 3350 µm, 2800µ m, 355 µm, 250 µm, 125 µm and 90 µm, and operated for 20 minutes. The amount of material retained on each sieve was measured and tabulated for analysis. A screen analysis graph using the Gaudin Schuman method was drawn for each of the screen tests on the alluvial samples. The study tests showed that the cumulative percentages of fine particles size -125+90 µm fractions and below were 45.00%, 36.00%, 39.60%, 43.00% and 36.80% for the selected samples. These primary ore characteristic results provide reference data for the alluvial gold ore processing method selection, process performance measurement and optimization.

Keywords**—**Alluvial gold ore, Gaudin Schumann, particle size, sieve shaker.

I. Introduction

THE principle of gravity separation of material constituents revealed that individual particle size, weight and shape are some of the critical elements that affect the efficiency of the process. Panning, a typical gravity separation method is currently used extensively for the extraction of gold particles at Itagunmodi, Southwestern Nigeria. Gold panning is a method of extracting gold particles from its alluvial ores using pan. Although, panning process of solid gold particles extraction was a dominant ancient practice as there are other modern methods of gold prospecting and extraction, however, gold ore panning is still in used today essentially by artisanal miners because of its simplicity, cost effectiveness and environmental friendliness. This study examined the particle size distribution of gold ore samples from the selected goldfield using Gaudin Schumann method, with a view to providing primary reference information aimed at improving the performance of the dominant traditional panning. This is essential for ensuring that loss of valuable gold fine particles to tailings is significantly minimized. Improvement in the overall efficiency of the gold recovery in the study area through appropriate method would surely boost the revenue accruable to all stakeholders.

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II. Methodology

A. Samples Procurement

Alluvial gold ore soil samples were collected from five different identified locations, cleaned off of vegetative materials, weighed and labeled appropriately. Sample identification and measurement results are presented in Table I.

B. Sieve Tests

Measured quantities of as-received alluvial gold ore samples were taken for particle size analysis tests. Set of sieves in the order of decreasing nominal apertures of 5600 µm, 3350 µm, 2800 µm, 355 µm, 250 µm, 125 µm and 90 µm were arranged in the sieve stack ranging from the coarsest sieve on the top and the finest sieve at the bottom. A tight-fitting pan was placed below the bottom sieve to receive the final undersize particles of –90 µm size. A lid was placed on the top of the coarsest sieve to prevent major escape of the sample particle during the operation of the equipment as the sieve shaker vibrate the loaded soil sample in a vertical plane. For each test cycle, the sieve shaker was operated for 20 minutes during which the undersize material passes through successive sieves until it was retained on a sieve having apertures slightly smaller than its diameter. In this way, each bulk test sample was separated into size fractions, and the amount of material retained on each sieve was measured and tabulated for analysis. Results of the sieve tests were tabulated and presented in Tables II-VI. Sieve test results for the five samples were subsequently analyzed to obtain screen analysis graphs using Gaudin Schuman method. Graphs in Fig. 1 compare particles size screening test results for the five alluvial gold ore samples obtained from Itagunmodi gold field.

III. Results and Discussion

Particle size tests for the alluvial samples assist in determining the gradation of the study feed samples and eventually, the gold particles distribution through these ore body representatives. Fig. 1 showed that the Gaudin Schumann graphs for the alluvial gold ore sample I to sample V and their comparison. It was observed that particles size distributions across the five gold ore soil samples were similar, as the samples' sieve graph patterns were very identical. This was an indication that the recommendation made from this research can be applied over a vast portion of the Itagunmodi goldfield and other similar alluvial deposits.

The results further showed that fine particles size -125+90 µm fractions and below were found experimentally to be 45.00%, 36.00%, 39.60%, 43.00% and 36.80% for the five alluvial gold ore samples, respectively. These values are indicative that the bulk of the ores samples in the area are very fine and any selected ore concentration process should be very effective in fine particles range so as not to leave behind significant part of the feed untreated.

TABLE I
ITAGUNMODI ALLUVIAL GOLD ORE SAMPLES' DESCRIPTION

Sample Description	GSP Location Identification	Weight of Sample (g)
Alluvial Sample I	(7^{0}31ʹ44ʹʹN; 4^{0}42 ʹ11ʹʹE)	5400
Alluvial Sample II	(7^{0}31ʹ25ʹʹN; 4^{0}44ʹ36ʹʹE)	5800
Alluvial Sample III	(7^{0}28ʹ51ʹʹN; 4^{0}44ʹ04ʹʹE)	6050
Alluvial Sample IV	(7^{0}30ʹ45ʹʹN; 4^{0}39ʹ32ʹʹE)	5750
Alluvial Sample V	(7^{0}32ʹ53ʹʹN; 4^{0}41ʹ04ʹʹ E)	7850

TABLE II
ALLUVIAL GOLD ORE PARTICLES SIEVE TEST RESULT FOR SAMPLE I

Particle Size Fraction (µm)	Nominal Aperture (µm)	Weight Retained (g)	Percentage Weight Retained (%)	Cumulative Percent Undersize	Cumulative Percent Oversize	Log of Cumulative Percent Undersize	Log of Sieve Size
+5600	5600	300	6.00	94.00	36.00	1.97	3.75
-5600+3350	3350	320	6.40	87.60	12.40	1.94	3.53
-3350+2800	2800	220	4.40	83.20	16.80	1.92	3.45
-2800+355	355	750	15.00	68.20	31.80	1.83	2.55
-355+250	250	650	13.00	55.20	44.80	1.74	2.40
-250+125	125	510	10.20	45.00	55.00	1.65	2.10
-125+90	90	1250	25.00	20.00	80.00	1.30	1.95
-90		1000	20.00	0	100		

TABLE III
ALLUVIAL GOLD ORE PARTICLES SIEVE TEST RESULT FOR SAMPLE II

Particle Size Fraction (µm)	Nominal Aperture (µm)	Weight Retained (g)	Percentage Weight Retained (%)	Cumulative Percent Undersize	Cumulative Percent Oversize	Log of Cumulative Percent Undersize	Log of Sieve Size
+5600	5600	450	9.00	91.00	9.00	1.96	3.75
-5600+3350	3350	300	6.00	85.00	15.00	1.93	3.53
-3350+2800	2800	350	7.00	78.00	22.00	1.89	3.45
-2800+355	355	200	4.00	74.00	26.00	1.87	2.55
-355+250	250	500	10.00	64.00	36.00	1.81	2.40
-250+125	125	1400	28.00	36.00	64.00	1.56	2.10
-125+90	90	1200	24.00	12.00	88.00	1.08	1.95
-90		600	12.00	0	100		

TABLE IV
ALLUVIAL GOLD ORE PARTICLES SIEVE TEST RESULT FOR SAMPLE III

Particle Size Fraction (µm)	Nominal Aperture (µm)	Weight Retained (g)	Percentage Weight Retained (%)	Cumulative Percent Undersize	Cumulative Percent Oversize	Log of Cumulative Percent Undersize	Log of Sieve Size
+5600	5600	300	6.00	94.00	6.00	1.97	3.75
-5600+3350	3350	240	4.80	89.20	10.80	1.95	3.53
-3350+2800	2800	720	14.40	74.80	25.20	1.87	3.45
-2800+355	355	520	10.40	64.40	35.60	1.81	2.55
-355+250	250	500	10.00	54.40	45,60	1.74	2.40
-250+125	125	740	14.80	39.60	60.40	1.60	2.10
-125+90	90	900	18.00	21.60	78.40	1.33	1.95
-90		1080	21.60	0	100		

TABLE V
ALLUVIAL GOLD ORE PARTICLES SIEVE TEST RESULT FOR SAMPLE IV

Particle Size Fraction (µm)	Nominal Aperture (µm)	Weight Retained (g)	Percentage Weight Retained (%)	Cumulative Percent Undersize	Cumulative Percent Oversize	Log of Cumulative Percent Undersize	Log of Sieve Size
+5600	5600	200	4.00	96.00	4.00	1.98	3.75
-5600+3350	3350	350	7.00	89.00	11.00	1.94	3.53
-3350+2800	2800	500	10.00	79.00	21.00	1.90	3.45
-2800+355	355	600	12.00	67.00	33.00	1.82	2.55
-355+250	250	800	16.00	51.00	49.00	1.71	2.40
-250+125	125	400	8.00	43.00	57.00	1.63	2.10
-125+90	90	1150	23.00	22.00	78.00	1.34	1.95
-90		1000	20.00	0	100		

TABLE VI
ALLUVIAL GOLD ORE PARTICLES SIEVE TEST RESULT FOR SAMPLE V

Particle Size Fraction (µm)	Nominal Aperture (µm)	Weight Retained (g)	Percentage Weight Retained (%)	Cumulative Percent Undersize	Cumulative Percent Oversize	Log of Cumulative Percent Undersize	Log of Sieve Size
+5600	5600	140	2.80	97.20	2.80	1.99	3.75
-5600+3350	3350	240	4.80	92.40	7.60	1.97	3.53
-3350+2800	2800	200	4.00	88.40	11.60	1.95	3.45
-2800+355	355	600	12.00	76.40	23.60	1.88	2.55
-355+250	250	980	19.60	56.80	43.20	1.75	2.40
-250+125	125	1000	20.00	36.80	63.20	1.57	2.10
-125+90	90	890	17.80	19.00	81.00	1.28	1.95
-90		950	19.00	0	100		

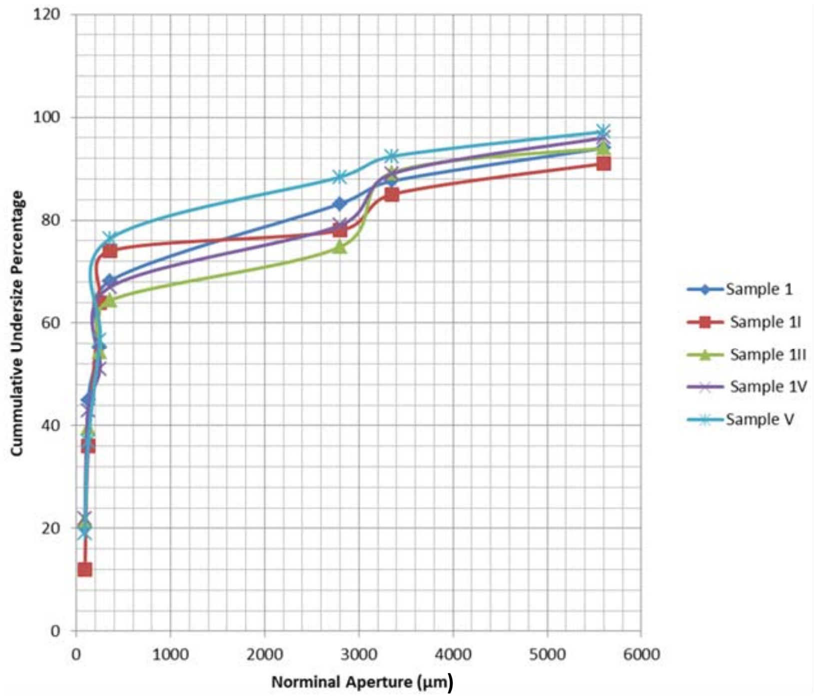

Fig. 1 Gaudin Schumann particles analysis graphs for alluvial gold ore samples

This study results were corroborated by other earlier studies on the Southwestern Nigeria goldfield. A study on the amenability of alluvial gold ore to froth flotation revealed that particles size fraction of +106 µm has the utmost concentration of gold mineral. This fine particles' range was subsequently nominated for the upgrade treatment by froth flotation using convectional standard reagents [3]. In a study on the response of Ilesa gold ore to amalgamation and leaching, experimental results showed that the gold ore is more amenable to percolation leaching than amalgamation at the optimum leaching condition of 6 hours retention time, sodium cyanide concentration of 0.3% and pH of 1. The highest recovery was obtained with the smallest size fraction of -75 µm of the ore samples [1].

Therefore, the use of gravity separation method(s) on the Nigeria Southwestern alluvial gold deposits should be well designed to ensure efficient gold recovery. The most effective gravitational separation process occurs when applied to ore particles of approximately the same size. Gold mineralization usually contains a combination of fine particles in the range less than 100 µm and coarse gold particles of the size fractions that is greater than 100 µm. In situ size and shape, behavior, distribution, and abundance of particles govern sediment sampling characteristics, grade distributions, and metallurgical properties. Gold particles range from single scattering particles and particle clusters to cm-scale masses [4].

Poor and inadequate sampling and ore gradation can result in inaccurate reserve estimates; poor project development decisions; poor process control; design flaws in process equipment. Any of these outcomes can, in turn, lead to poor coordination between mines and factories, project shutdown or shortened mine life, and essentially, incorrect financial models [6], [7]. No two ores are absolutely identical, making general assumptions about mineralization type and potential gold grain size impossible. These core ore characteristics should be well studied, as basic decisions around the ore processing hinge on this information. It should be noted that some pure gold-dominated mineralizations may exhibit gold clustering that produces pseudo-coarse gold effects [5]. It is therefore important that adequate effort is made to obtain mineralogy and other mineral assemblage characteristics of a gold deposit to enhance recovery.

IV. Conclusion

Gravity concentration like traditional panning is the process of enriching a desired mineral, in this case gold, based on the difference in specific gravity between gold and gangue minerals. The specific gravity of gold is 19.5 and quartz (the gangue mineral commonly associated with gold) has a specific gravity of 2.65. This means that gold is heavier than quartz, which is why gravity concentration works in alluvial gold ore concentration. The use of the traditional panning method in concentrating coarse solid gold particles has evidently been largely successful in the study area, miners come home daily with recovered gold particles in economic quantities. The process is also notably friendly to environmental health and safety, unlike other gold extraction processes such as amalgamation and cyanidation. However, the loss of fine and ultra-fine gold particles to panning tailings is inevitable due to the limitations set by the particle size range where panning can work effectively. Mineral elemental analysis results have also confirmed that fine gold particles are being lost in the panning tailings that are abundant in the area. This underscores the need for gold extraction process optimization [2].

Various gravity separation methods have been identified for concentrating gold ores, each effective within specific particle size ranges [8]. It is evident that shaking tables and jigging can recover finer gold particles more effectively than the commonly used panning method in the area. Therefore, it is recommended that other gravity concentrators, capable of treating fine ore samples, should be used to complement panning method. These additional methods can be applied to the recovery of gold from as-received ore or for the secondary treatment of panning tailings.

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