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Luster as a Quality Control Tool in Mining Operations

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Abstract- Minerals have unique physiochemical properties which distinct them from one another. This mineralogical trait is of utmost importance and finds application in there mining and processing. One unique property of most minerals is there luster which can be broadly divided into metallic and non-metallic; a special characteristic exhibited by certain minerals when light is incident on them. Luster in combination with other traits like color, hardness, density etc., have been used in the search and extraction of mineral in deposits both in surface and in underground mining. One application of the effect of luster as a special trait of minerals is in its used for quality control as demonstrated in night operations at the mines in National Iron Ore Mining Co. LTD, Itakpe in Kogi State, Nigeria. This distinctiveness was put to use during night shift duty, at the time when the quality of illumination is usually not enough to cover all the working points; drilling, loading, dozing, grading etc. In such circumstances which were often times the norm experienced, the unique property of iron ore (Hematite and magnetite) which is its metallic luster was applied to distinguish the ore from other associated rocks exhibiting the same color at night; gneiss and basalt. The process of identification was very easy and the tool use simple and inexpensive. It entails visualizing the blasted muck with the use of a strong touch light. Through this practice the ores and waste were clearly differentiated and mucked separately, the ores to the ore storage yard and processing plant and the waste to the waste dump. This adoption of luster as a quality control mechanism was easy to apply under certain prevailing circumstances leading to a reduction in operational and overall cost.

Indexed Terms- Iron ore, Metallic Luster, Quality Control, waste.

I. INTRODUCTION

Mining is a very unique activity which entails the extraction of valuable minerals from their surrounding environment. These Minerals have unique physio-chemical properties and structures which give them their unique traits and differentiate them from other minerals or substance. The geology of Itakpe iron Ore deposits is Characterized by the presence of banded iron ore formations with an heterogeneous association of minerals of quartz, gneiss, feldspar, granites interwoven or banded with the ores of iron: hematite and magnetite. The deposit is located in latitude 07^{0} 36^{1} 20^{11} N and longitude 6^{0} 18^{1} 35^{11} E in Okeyi local government of Kogi State, Nigeria and is composed of a magnetite- hematite mineralization consisting of 14 ore layers of economic value ranging in grade predominantly from 14.8% Fe to 41% Fe with an overall average grade of 36% Fe. (NIOMCO, 1980).

From evaluation studies the deposit is at a shallow depth and the stripping ratio is 4:1, thus allowing for the ore to be worked through an open pit systems. The heterogeneous nature of the deposit calls for the adoption of selective mining approaches in the open pit exploitation to reduce the dilution of the ores which in nearly all the benches are inter-bedded with the gangues. The predominant waste rock or gangues associated with the ores (hematite and magnetite) are quartz, feldspars, micas, gneiss, and other meta-sedimentary rocks. Usually following the extraction of the ores, the ROM is sent to the processing plant for beneficiation and in every stage of the mining operation quality control is maintained. Quality control measures begins right in the field and areas to be blasted for extraction of ores are clearly designated and marked out in such a way as to avoid over dilution. However the nature of the deposit makes it at times, uneconomical and technically impossible to separate the ores and gangues prior to blasting. And in most cases the bench is blasted with the lines of separation between the waste and ore rocks prior to mucking of the blasted piles easily distinguished.

It is however in night mining operations that the challenge of quality control becomes significant and posses a very great challenge. At night the illumination is not enough to cover all the working areas and in most cases mobile flood lights are engaged to give light to various working points. However despite the desire to see that every area within the mine field, especially areas where operation is been conducted is well illuminated, the quality of the lighting is not usually enough, around the muck piles to enable a clear distinction between the ores and the gangues. Mining mucking operation has to be conducted in such a way as to avoid dilutions of the ore as much as possible with the gangue or associated rocks. It is during this night operation that the metallic luster, an important property of iron ore was put to great use. Luster is the effect of light reflection when light is incident on a mineral or rock.

The laws of light equation tells us that the angle of incidence = the angle of reflections. As such when light is focused on the surface of a material the possibility of it obeying the laws of light is not in question. Some of the light may be absorbed, some reflected or scattered, some refracted. In the case of iron ore the light is scattered or reflected and its appearance to the eye in the form of metallic luster is what is put to use as a quality control measure in the field mucking operations at night. This measure of quality control has saved time, energy and resources that would have been lost due to wrong material identification and this is premised on the fact that both the gangues and ROM exhibit no distinct trait in the dark and that the distinctiveness was only reveal when a strong light source was beam on the muck pile. Having worked in the field in this industry for more than a two decade I have come to see this property and used it to the shift advantage in mucking operations at night.

1.1 Literature Review

Minerals have unique properties which distinguished one mineral type from the others. Similarly ores which is a concentration of mineral that justify it been mined at a profit also have some uniqueness. One trait that minerals display is luster which can be broadly divided into metallic and non-metallic. Metallic ores exhibit metallic luster while non- metallic ores exhibit non metallic luster's (vitreous, glassy, adamantine, pearly etc)

When white light is incident upon a mineral surface, it may be reflected or scattered. It could as well be refracted, transmitted or absorbed depending on the type of mineral. If almost all of the light is reflected and/or scattered, the mineral will have a luster described as metallic luster. Most opaque minerals are metallic and tend to exhibit metallic luster. Amongst the minerals exhibiting this form of luster are hematite and magnetite which are the ores found in Itakpe hill. Most light-colored translucent minerals (meaning that it is capable of transmitting light but is not transparent), the luster is described as nonmetallic luster. There is no sharp division between metallic and nonmetallic, but after some experience in the laboratory with metallic and nonmetallic specimens, the eye evaluates these distinctions quickly. Nonmetallic luster is a distinguishing property of silicates and carbonates. The color of most minerals with a metallic luster varies little, but those with a nonmetallic luster may show a wide range.

Luster as a property of minerals differs both in intensity and kind, depending upon the amount and type of reflection of light that take place at their surfaces (Reed, 1970).

Among the various types of luster are the Metallic (luster of metals), vitreous, resinous, pearly, silky, adamantine, thus, when the surface of a mineral is sufficiently brilliant to reflect objects distinctly, as a mirror would do, it is said to be splendent. However for this work the luster have been separated into two; metallic and non .Minerals with no luster are described as dull (Reed, 1970)

1.12 Streak

For some minerals with metallic luster, the color of the streak may be helpful in its identification (Cornelius, 2013). The fine powder of the streak of a metallic mineral may be quite different from that of its color in a hand specimen. For example, iron-black hematite, Fe_2O_3, crystals with a bright metallic luster show a red streak, Chromite, $FeCr_2 O_4$, with a metallic luster and iron-black to brownish black color, has a dark brown streak. The small scratch that is used in a hardness test may show the color of the powdered mineral, but it is best seen when the mineral in question is rubbed against an unglazed white porcelain plate. Metallic minerals that show a colored streak are not completely opaque, and when streaked or scratched, the particles of powder are small enough that some light passes through them and creates the color. Minerals with a nonmetallic luster usually show a streak that is close to white or colorless. This property as important as it is can mainly be applied to identify hand specimens of rocks and its practicability for use for separating huge piles of boulder size rocks will be unwise and time consuming in night operations.

1.13 Color

Of all the physical properties that a mineral possesses, color is the most easily observed and can be used as a diagnostic tool. However, in most minerals color can be variable and as such proves an unreliable diagnostic property (Cornelius, 2013). Color as a property cannot be reliably applied for quality control measure since a single mineral may exhibit different colors and in the case of the ores in Itakpe hill they cannot be differentiated at night since both some of the gangue rocks and ores have same dark appearance.

II. METHODOLOGY

The method adopted for this study is very simple, requiring only a touch light with a very strong battery as the major equipments. Other equipments are personnel protective equipments: boots, helmets etc. The process makes use of the reflective properties of the various rocks that were blasted. It is in the form of a reconnaissance survey whereby one takes a walk along and around the blasted piles with the touch light flash at various points on the muck materials and the effect of the lights on the pile rock assessed. Cycle time which is an important component to ascertain the economy of any mining activities will be used to demonstrate the cost implication of loading ores to the waste dumps. It will also be used to demonstrate the amount of fuel that can be expended in any simple loading arrangement and the strain that this may add to production cost especially if the ores or waste is hauled to the wrong place vice versa.

III. RESULTS/DISCUSSION

With a strong touch light flashed on the blasted muck material a distinctive brilliant metallic luster was indicative on the portions of the mucked materials compose predominantly of iron ore. When the same touch light was pointed at the ore and gangue boundary, and extended into the gangue portion, no brilliance was noticed giving us a clear indication that other rocks associated with the blasted piles iron ores; gneiss, quartz, feldspar, basalt gives a dull luster and as such were identified and distinguished from iron ores in night operations and therefore serve as a vital tool in quality control mechanism. Even though the blasted piles look similar in the dark, a strong light flash on the muck materials will immediately bring out there distinctiveness. The significance of this expository work is better appreciated when one considers the economy of cycle time, the cost of fuel, manpower other economic and financial issues etc that will arise due to the error of hauling gangue or iron ores to the wrong dumping point or areas.

3.1 Cycle Time Analysis

The cycle time analysis is used here to draw an analogy of the likely scenario to be experienced if proper quality measure is not put in place and to demonstrate the financial, economic, time and manpower implication of mistakenly hauling ores or gangues to the wrong or designated areas. The time indicated for this analogy is a summary of the time for the recorded operations as such some of the time that comprises a time cycle are intentionally skip.

For a loader dumper arrangement at NIOMCO LTD
Cycle time for pay loader (CAT 992C) loading of ores = 3 Minutes with 3pass
Cycle time for haul dump truck (CAT 773E) to the beneficiation plant = 11 Minutes
Cycle time to return from the beneficiation plant (empty) = 9 minutes
Approximate cycle time for one dump truck = 11+9 = 20 minutes for one dump truck
Total cycle time for the operation = 20 + 3 = 23 minutes
Therefore number of trips for a dump truck in 1hr = 2.6
For 7hrs number of trips = 18
Using the same scenario for the ores mistakenly haul to the waste dump
Cycle time for Cat 992C Loader = 3minutes at 3pass
Cycle time for hauling and dumping at the waste dump (Full) = 3.5 minutes
Cycle time for dumper returning from waste dump to the loading point (Empty) = 2.5 minutes
Total cycle time for the haulage and loading of waste = 3.5 + 2.5 + 3 = 9minutes
Therefore number of trips for 1hr operation of a dump truck hauling waste = 6.7
For a 7hr operation, trip = 47trips
For CAT 773E which is 50Tonnes we have the following scenario:

Difference trips between the dump truck haulage for waste and ores = 47- 18 = 29trips

This translates 1450T of iron ore which could otherwise be mistakenly haul and dump at the waste dump

In the same vain when we look at the cost of fuel consumption using the same pay loader and dump truck arrangement. We will have the following:

Pay loader 992C fuel approximate consumption pay hour = 104 liters

Pay loader 992C fuel consumption for 7hrs = 104 * 7 = 728liters of diesel

Dump truck consumption/hr = 55liters of diesel

Dump truck consumption for 7 hrs = 55 * 7 = 385 Liters of diesel

For a pairing arrangement of 1:4 the following scenario will play out;

Total fuel consumption using this scenario = 728 + 4(385) = 2268 liters of diesel

The financial implication at 750Naira/ liter = 2268*750

= 1,701,000Naira/day

For a pairing arrangement of 1:3;

The fuel consumption using this scenario = 728 + 3(385) = 1883

The financial implication at same fuel price = 1883*750

= 1,412,250Naira/day

Usually because of the distance from the beneficiation plant the ideal pay loader dumper pairing arrangement is 1: 4 for ores and 1:3 for waste haulage. Assuming the remaining dump trucks are included in the calculation the amount of fuel and tons of material will be unprecedentedly high and that will invariably affect the cost of operations. The above scenario gives us tip of the loss that may be incurred and the concomitant effect on the cost of material handling, if such volumes of gangues or ores find their way mistakenly into wrong areas (waste dump, ore stockpile or into the processing plant). This analogy has excluded other cost such as those for ground preparation, drilling and blasting and other unit operation cost which when surmised would be tremendous and impactful on the mining operation. The fuel consumption giving is based on years of monitoring of the equipments and thus arriving at an average rate.

CONCLUSION

The effect of luster as an important property of minerals is well known and this property has been put to value as a quality control measure during loading and hauling operations in National Iron Ore Mining Co. Ltd. This important property has been demonstrated to be very reliable in making very quick decisions in the field with regards to mucking of blasted iron ores at night in poorly illuminated working areas within the firm. This observation are based on personal experience of decades in the iron mining industry where this phenomenon had been carefully observed and its effectiveness yet to be contested in the mucking and hauling operations at the firm. However these are my findings and it is expected that these findings will spur research in this area as the need may arise.

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