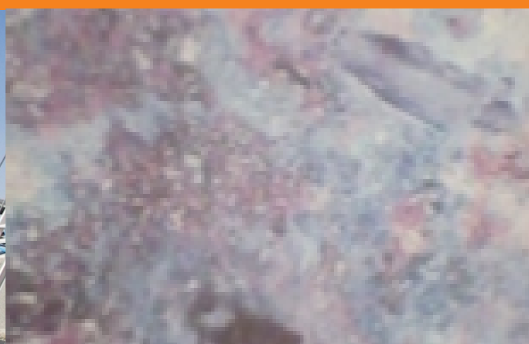
NIGERIAN MINING JOURNAL

ISSN 1117 - 4307

Volume 11 Number 1 November 2013



A Publication of

NIGERIAN SOCIETY OF MINING ENGINEERS

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MINING JOURNAL

ISSN 1117-4307

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Publisher
Nigerian Society of Mining Engineers (NSME)
NSME Secretariat, Bukuru,
P.M.B. 2036,Jos, Plateau State, Nigeria

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NIGERIAN MINING JOURNAL

INFORMATION FOR AUTHORS

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NIGERIAN SOCIETY OF MINING ENGINEERS presents technical papers covering the fields of mining, mineral processing and extractive metallurgy. The papers provide in-depth information on research findings from various aspects of actual exploitation of minerals and related engineering practice. Researches based on local technology are particularly welcome.

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An Assessment of the Environmental Effects of Mining of Tourmaline in the Pegmatites, Sarkin Pawa area North Central Nigeria

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Abstract
An assessment of the environmental effects of mining of tourmaline in the pegmatite of North Central Nigeria was conducted. The area is located in Sarkin Pawa in Niger state and lies along Lat. 10°01' to 10°02'N and Long. 7°05'30" to 7°06'30"E. The work was aimed primarily at assessing the environmental impacts of mining of tourmaline in the pegmatite that occur in Sarkin Pawa area, Central Nigeria. The geology of the area comprises basically of granite-gneiss which is the most widespread rock in the area followed by granite and schist which occur in almost equal proportion occupying the southern part of the area. The pegmatite occurs as intrusions into these rock units occurring as ridges trending mostly in the North -South direction. The main mineral mined in the area is tourmaline (Rubellite), quartz and the feldspar. The method of mining used is the open cast method. The geology of the area was studied using a topographical map on a scale of 1:10,000 employing the geological traverse, compass/clinometer method. Water samples taken from the pits were analysed using various standard analytical methods. The result indicates that bicarbonates have the highest concentration followed by calcium, chloride, phosphate and manganese. Trace element concentration shows that manganese is wide spread in the area at concentration higher than the permissible limit, followed by copper, iron and chromium. The water classifies as ~~a~~ calcium/magnesium bicarbonate water. Three groups of water were identified based on the bicarbonates, chloride and the calcium concentration. The main environment effects of mining identified in the area are personal safety, deforestation, damages to fauna, exposure of the land surface, destruction of biodiversity, and water quality degradation. Enforcement of the Nigeria Mineral Act (2007) is recommended as a key strategy in solving environmental problems that may arise from mining activities in this area and other parts of the country.
Keywords: pegmatites environment schist mining mineralisation

Introduction
Nigeria possesses very large pegmatite environment. These pegmatites are widely distributed with a marked concentration of mineralized pegmatites in a broad belt, which extends from Ago-Iwoye in the southwest to Bauchi in the northeast, an air distance of more than 400 kilometers (Akintola et al, 2008). Thousands tonnes of pegmatites occur in this belt, most of which have never been mapped or sampled in a systematic, scientific manner.

The ages, mineralogy and composition of these pegmatite units appear to be analogous to those of the pegmatites environment in Brazil, Canada and Australia (Bowden and Kinnaird, 1984). The pegmatitic belt and the orientation of the units within it appear to be related to rotational stresses created by the Benue Trough (Garba, 2002). From a more global perspective, this trend is probably the northern extension of the Brazilian pegmatite belt, which runs from Rio Grande del Sul to Rio Grande del Norte.

The pegmatite of this study area is part of late Pan African age, (Jacobson and Webb, 1949; Wright, 1970), rare (specialty) metals granitic pegmatites. The primary mineralization of tantalum, niobium, tin, beryllium and lithium is hosted in quartz-feldspar-muscovite pegmatites (Kinnaird, 1984; Abaa, 1983).

Mining is a common practice in Nigeria. Some states even have their development hinged on the mining of minerals buried underneath their lands. The problem with the activity in the country, however, is the inattention of the miners and the government to proper mining practices which poses a problem to the general public (Garba, 2003).

There is no gainsaying the fact that, prior to the discovery of oil deposits in Nigeria, the country had enjoyed a good number of benefits from solid minerals exploration. Indeed, solid minerals such as coal played a major role in the nation's economy.

If adequate attention is not paid to the activities of both licensed and artisanal miners in these communities they operate the resulting consequences may live with the communities several years after the closure of the mines. This will seriously impact negatively on productivity of the communities involved, as well as negative consequences on the health of the inhabitants of the area. In Nigeria, the recent lead poisoning is a perfect example.

Location and Accessibility

Sarkin Pawa lies along Lat. $10^{\circ}01'$ to $10^{\circ}02'$ N and Long. $7^{\circ}05'30''$ to $7^{\circ}06'30''$ in Niger State, central Nigeria (Figure 1). It is easily accessible through the Minna – Sarkin Pawa and Sarkin Pawa – Kaduna – Abuja road. Minor roads and footpaths crisscross the area leading to the mine sites, farms and other settlements. The Lagos – Kano rail line also passes through the area and very close to the mine sites. Figure 1 is a map of Nigeria that shows the location of Sarkin Pawa.

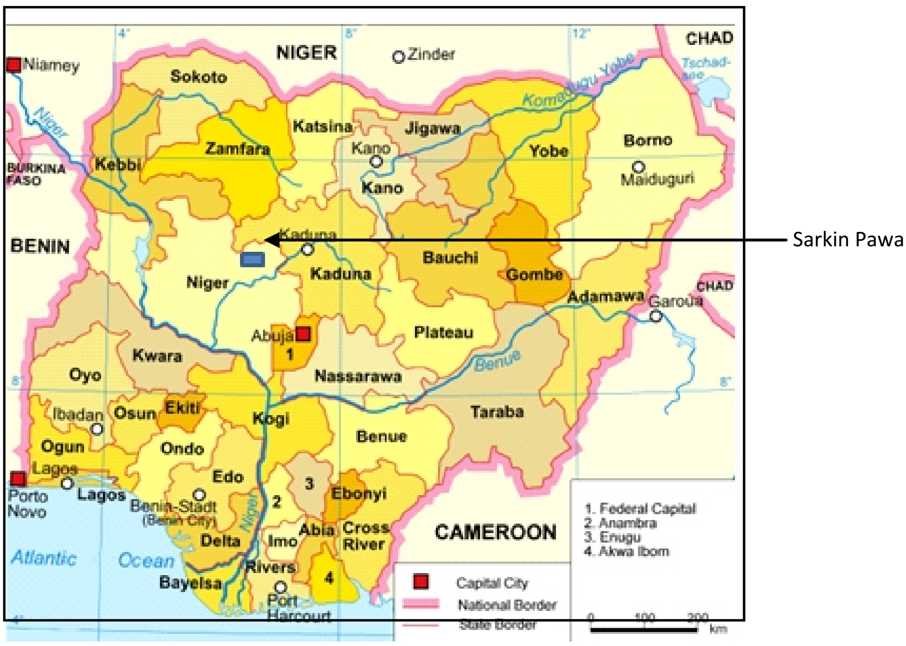

Figure 1: Map of Nigeria showing the location of Sarkin Pawa

Materials and Methods

The work was broken down into three phases;

1. Preliminary investigation / Desk study
2. Fieldwork
3. Laboratory analysis

Preliminary investigation / Desk study: Preliminary work involved preparation of maps to be used as base map for all other studies. The base map was extracted from the topographical map of Kakuri Sheet 144 on a scale of 1:100,000. This was later enlarged to a scale of 1:10,000 for the purpose of this study. This was later followed by downloading all relevant satellite imageries of the area using Google Earth and Global Land Cover Facility (GLCF). The obtained satellite imageries were interpreted using Integrated Land and Water Information System (ILWIS) to establish the extent of the mined areas and also possibly the pegmatites that host the tourmaline. All available literature relating to the area was also reviewed. As part of this phase a reconnaissance visit was undertaken to the area to confirm the information obtained from the preliminary studies. This phase allowed for a rapid assessment of access routes to the area, extent of work to be undertaken and challenges that may likely arise. The phase also allowed for adequate preparation for fieldwork and also seeking of permits where necessary to request for access to the mine site.

Fieldwork: Fieldwork was carried out using a topographical map of the area on a scale of 1: 10,000. This stage was broken into 2;

I. Geological mapping

II. Mine site investigation and sampling

Geological maps show the disposition and the aerial distribution of the different rock types in a given area. They are generally drawn on base maps which in many cases are topographical maps (Fayose, 1985). Geological maps are therefore topographical maps overprinted with different colours showing the various rock outcrops with appropriate signs and symbols indicating the dips, strikes, faults, mineral veins, etc.

Geological mapping was conducted with the aim of establishing the local geology of the area. Materials used for the exercise includes a compass/ clinometer, Global Positioning System (GPS), digital camera, field notebook and sample bags. The main rock unit of interest during the mapping exercise was the pegmatites that host the tourmaline.

Geological mapping was followed by an investigation of the mine sites. The abandoned mined areas were first visited. The visit involved the use of motorcycles from Sarkin Pawa community to the mine sites as the sites are mostly inaccessible by vehicles. The rest of the trip to the site was conducted on foot. In the abandoned mine sites, extent of the area was determined, the depth and width of the mine pits were also determined using a tape for the width and weighted rope for the depth. In some cases the mines are so deep or horizontal that the depths could not be readily established.

Areas where mining activity is still taking place were also visited, only one of such areas was found within the study area. Armed policemen were noticed keeping guard of the mine site, access was granted the researcher by the armed police as a result of the permit that was granted by the mine operator. The mine method employed was noted as well as where the mine spoil was dumped. Effect of mining on the immediate environment was observed. The miners were interviewed mostly concerning safety of operations and casualties recorded. Major injuries have to be treated at Sarkin Pawa which is over 6km away on bad road.

Samples of water and soil from the mines were also taken during this phase for further analysis in the laboratory. However samples of the mined tourmaline were only shown to the researcher as the researcher could not afford to buy any. The tourmaline samples were photographed while samples of the host rock were obtained.

It was noticed in this phase that parts of the pegmatite, especially quartz and feldspar were bagged and sold as chippings for aggregate by the miners.

Laboratory Analysis: The water sample was taken to the National Water Quality Laboratory (NWQL) at the Upper Niger River Basin Development Authority (UNRBDA) for analysis. The water was analysed for major cations, anions and trace elements. The analytical methods used were titrimetry, colourimetry and flame photometry.

A total of six (06) water samples were analysed, four from the mine pits, one from the nearby river (River Sarkin Pawa) and one from the well located in a community close to the mine site.

Results and Discussion

A geological map of the area and cross section was drawn on a scale of 1:10,000 (Figure 2) based on the geological fieldwork conducted. From the map it is noticed that the dominant rock type is granite gneiss followed by schist and the older granite which occur in almost subequal proportions. Quartzite occurs in a small portion occupying the northeastern corner of the area. The oldest rock unit is represented by the granite gneiss while the youngest is the older granite.

The pegmatites in the area occur as elongate bodies trending mostly in the N – S direction and occurring within mostly the granites and schist. It comprises of large crystals of quartz, feldspar and mica with muscovite being the most predominant mica. The pegmatite sometimes outcrop on the surface but in most cases are not exposed.

Quartz ridges also occur predominantly in the northeastern part of the area occurring as elongate ridges of whitish to pinkish quartz.

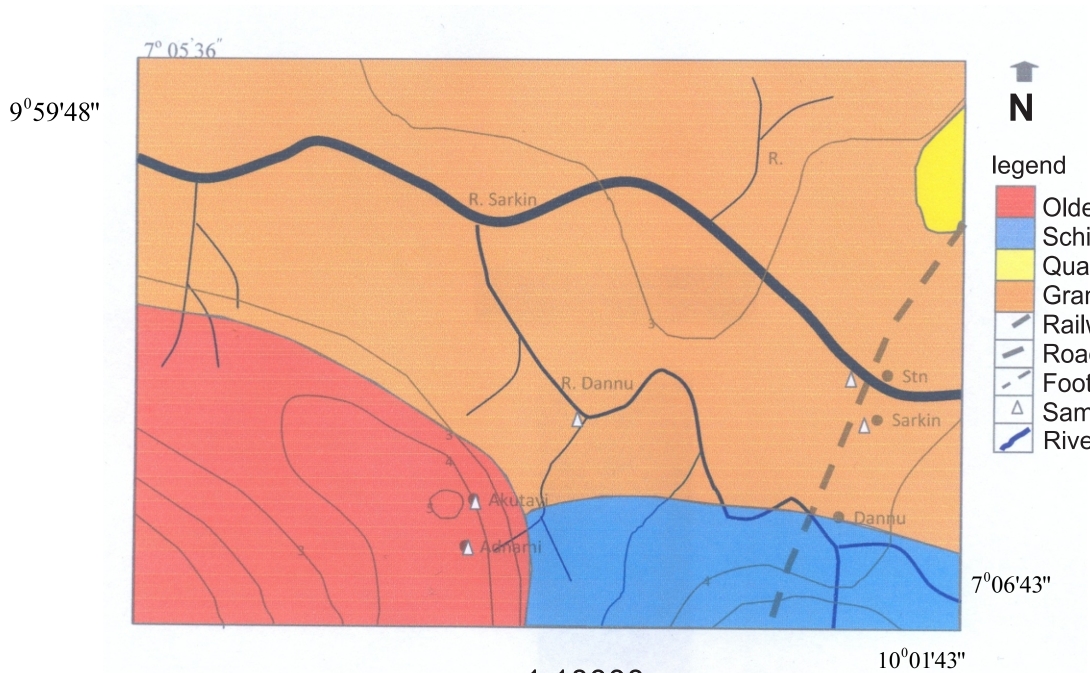

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Figure 2: Geological map of Sarkin Pawa area

Mine Site Investigations

The tourmaline mined in the area is of the rubellite variety with a blood red colour with some assuming a purplish to pinkish colour. An aerial photograph obtained from Google Earth, shows the extent of the mined area to be approximately 7km x 5km indicating a total surface area of 35km^2.

The mined area shows an open cast mining method with the mine faces stepped to accommodate movement while working on the faces. Figure 3 is a schematic diagram of the mining method adopted at the mine and also the use of a relay of water pumps to pump out water from the mine pits.

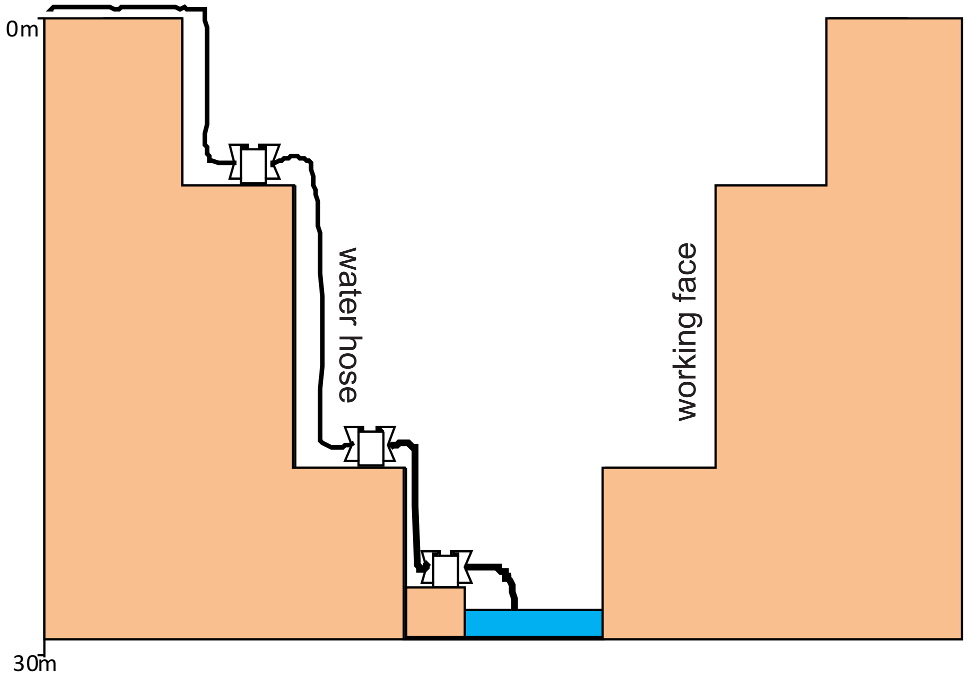

Figure 3: Schematic diagram of mining method and dewatering in the mine site

Water Analysis

Table 1 shows the locations of all the sampled water analyzed in the laboratory, the main area of concentration was the mine site and other surrounding villages and settlements, as well as River Sarkin Pawa.

Table 1: water sampling locations

S/No	Sample location	Coordinate N	Coordinate E	Elevation (m)	Description
1	Mine pit at Akutayi	9° 59’ 48?	7° 05'36?	418	20m mine pit at the fringes of the mine site
2	Mine pit about 100m away from (1) above	9° 59'41?	7° 05'31?	417	30m mine pit representing the main mined area
3	Well in Akutayi village	10° 00' 35?	7° 07'00?	422	Hand dug well in village close to the mine site
4	Sarkin Pawa community	10° 00' 35?	7° 05'12?	392	Sarkin Pawa community located about 3km from the mine site
5	Well in a village 1km from Akutayi mine site	10° 01' 25?	7° 07'40?	402	Hand dug well in village close to the mine site
6	River Sarkin Pawa	10° 01' 43?	7° 06'43?	380	River Sarkin Pawa close to Sarkin Pawa

The physical parameters of the water taken at the point of sampling are shown in Table 2. It could be seen from the table that the pH of water generally around the mine site tends towards being acidic with a mean pH of 5.52 while farther away it tends to being neutral. Temperature and conductivity values around the mine site are also higher than those farther away.

Table 2: Physical parameters of water samples in the study area

S/No	Sample location	Temp. (^oC)	Conductivity (µSm/cm)	pH
1	Mine pit at Akutayi	32	301	5.46
2	Mine pit about 100m away from (1) above	33	345	5.16
3	Well in Akutayi village	31	322	5.95
4	Sarkin Pawa community	30	248	6.65
5	Well in a village 1km from Akutayi mine site	31	322	6.01
6	River Sarkin Pawa	30	211	6.95

Table 3 is the result of the chemical analysis conducted on the sampled water, the parameters tested include the cations, anions and some trace elements, and all results are in milligrams per litre (mg/l). Figure 4 is the bar graph of all analyses parameters in the sampled water, analyzes with high concentrations stand out clearly while those with very low concentration are shown on the pie chart in Figure 5.

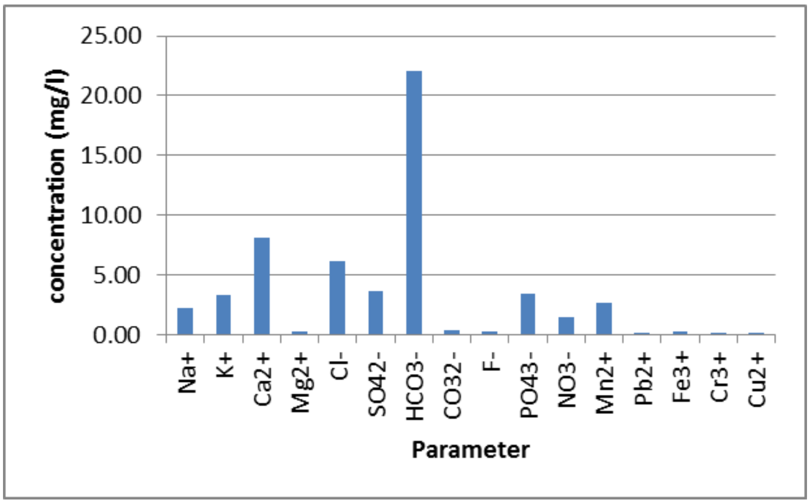

Figure 4: Bar graph of chemical composition of water in the study area

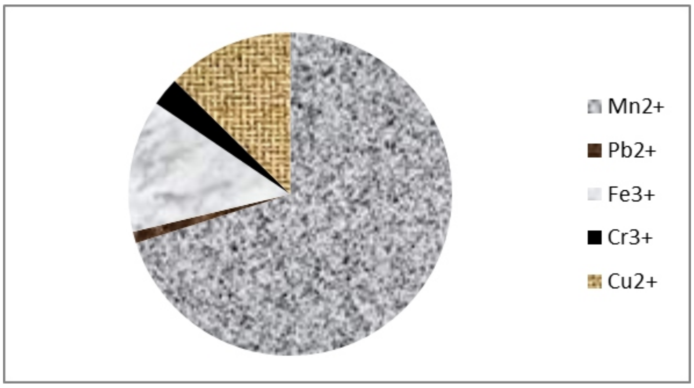

Figure 5: Pie chart of Trace Element concentration of water in the study area

Table 3: Results of chemical analysis of water in the study area

LOCATION		Na^+	K^+	Ca^{2+}	Mg^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	CO_3^{2-}	F^-	PO_4^{3-}	NO_3^-	Mn^{2+}	Pb^{2+}	Fe^{3+}	Cr^{3+}	Cu^{2+}
1.	Mine pit	2.08	0.13	3.61	0.66	18.99	6.06	62.5	0	0.3	0.71	2.03	0.07	0.01	0.52	0.05	0.32
2.	Mine pit	2.5	0.18	5.01	0.92	18.24	4.25	47.5	0	0.36	2.01	2.01	0.003	0.03	0.06	0.03	0.97
3.	Akutayi	6	0.2	6.418	1.172	21.99	7.5	40	0	0.35	0.86	2.4	0.003	0	0.15	0.04	0
4.	Sarkin Pawa	3.5	1.72	7.98	1.095	6.55	4.96	22.5	0.55	0.35	1.27	3.43	0.08	0.01	0.18	0.04	0
5.	Akutayi	2.25	4.38	10.55	0.04	0.35	3.13	8.4	0.42	0.25	3.38	0.5	3.19	0.03	0.22	0.05	0
6.	R.Sarkin Pawa	1.5	4.63	9.21	0.03	0.39	2.6	10.4	0.58	0.3	4.5	1.25	3.97	0.01	0.25	0.06	0
Mean Concentration		**2.97**	**1.87**	**7.13**	**0.65**	**11.89**	**4.75**	**31.88**	**0.26**	**0.32**	**2.29**	**1.94**	**1.22**	**0.02**	**0.23**	**0.05**	**0.22**

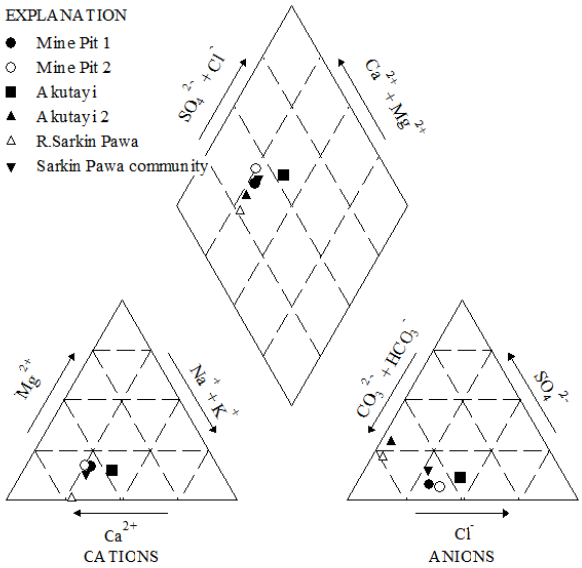

Figure 6: Piper plot of the sampled water

The Piper plot (Figure 6) shows that the main cation is that of calcium, while the main anions are those of bicarbonates and carbonates. The water plots basically as a Calcium / Magnesium Bicarbonate water.

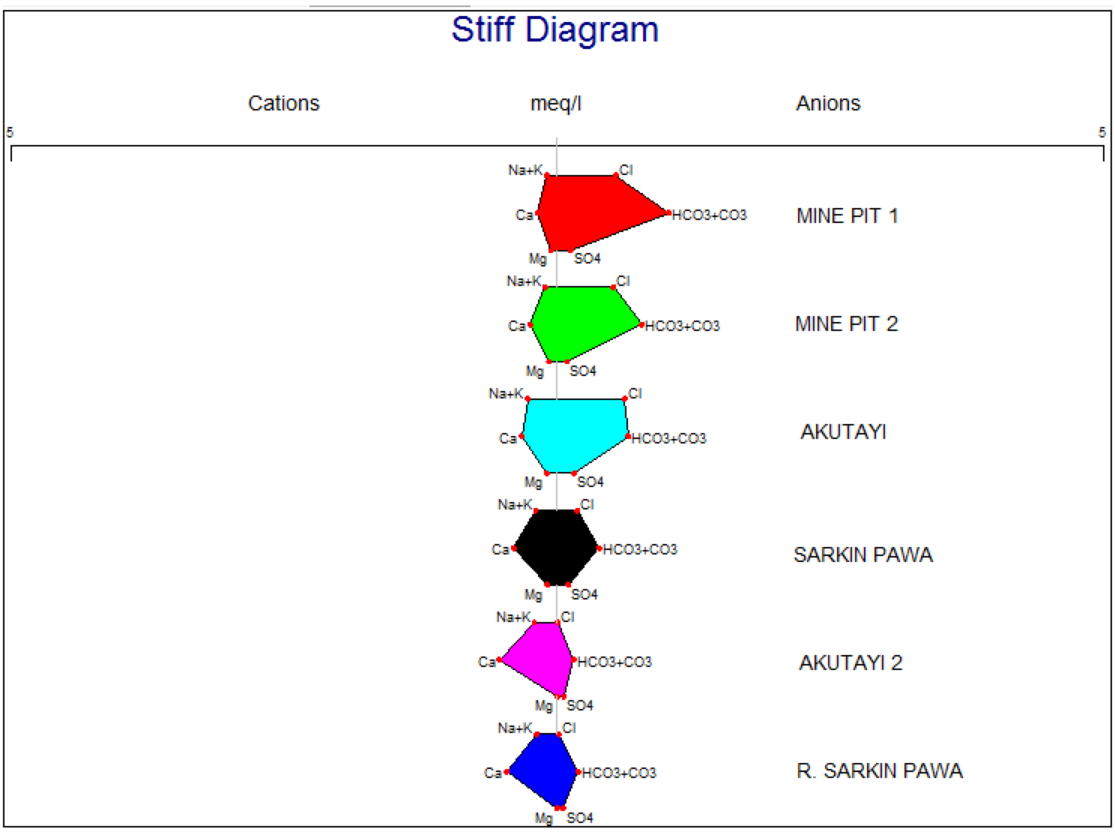

Figure 7: Stiff plot of the sampled water

The stiff plot (Figure 7) shows that the water can generally be categorized into two types; one with high concentration of bicarbonates/carbonates as main anions and the other with lower concentration of bicarbonates but higher concentration of calcium. The mine site area has mainly the first category.

Discussion

The geology of the area is basically underlain by granite – gneiss, granite and schist. The pegmatites that host the tourmaline, cut through all these rock types and occur as elongate ridges wherever they outcrop on the surface.

The main mineral mined in the area, tourmaline mostly especially the mined variety rubellite, which is a deep red to pinkish coloured mineral. The extent of land covered by mining activity is quite a large area that has been completely devastated and rendered almost unusable for any other purpose. The area has been scarred by abandoned mine pits and an area that has been completely deforested.

Groundwater is a critical factor in these pits as sometimes the pits may be half-way filled with water. To arrest this problem water pumps, sometimes used in relays, are used to pump the water out. The measured discharge is $432m^3/d$; this is quite a large volume of water that is pumped out of just one mine pit.

A plot of the mean concentration of parameters tested in the water shows that bicarbonate has the highest concentration, followed by calcium, chloride, phosphate and manganese. Those that occur in lower concentration include sodium, potassium, magnesium, sulphate and nitrates. Trace Elements tested shows that manganese has the highest concentration followed by copper and iron which occur in sub-equal proportions while lead and chromium occur in lower concentrations. The high concentration of manganese and copper can lead to health complications in children most especially. The recent incidence of lead poisoning in Zamfara as a result of gold mining that lead to the death of over 400 children can readily be recalled. A comparison of the mean concentration of these elements with Nigeria Drinking Water Quality Standard (NDWQ, 2009), shows that even though the major elements are below the Minimum Permissible Limit, the trace elements with exception of copper are all above the limit.

The Piper diagram classifies the water as predominantly a Calcium / Magnesium Bicarbonate water, while subordinately it classifies as a calcium Magnesium Sulphate Chloride water. The Stiff plot shows that the water can be grouped into three water types bearing a close similarity; these are Group 1 (samples 1 and 2), Group 2 (samples 3 and 4) and Group 3 (samples 5 and 6). The groups represent water with similar origins which however influence each other chemically.

Environmental effects in Sarkin Pawa

1. **Personal safety**

2. Movement around the abandoned mined area by the local community and others not familiar with the terrain has become very risky and hazardous because of the abandoned mine pits, some of which could be as deep as 30m. Fulani herdsman have lost cattle and sheep through their falling into the pits.

3. **Deforestation**

The area has become completely deforested with all trees and other forms of vegetation completely removed to make way for mining, this contrasts sharply with the lush vegetation and active farming in the nearby area not mined. Due to the complete devastation of the area with mounds of mine spoils everywhere it may become very difficult to reclaim the area.

4. **Damage to fauna**

All animal life in the area has been

completely lost since animals cannot survive a barren and dangerous terrain, part of the economic activities of the local inhabitants is hunting. This economic aspect of their livelihood and damage to flora has severely affected their livelihood and sustenance.

5. Exposure of land surface

The entire land surface has been stripped and exposed to climatic forces of weathering, erosion and flooding since there is no more protective vegetation cover. During the rainy season the abandoned pits become filled with water which contributes to flooding of the surrounding areas and also water logging of the area further endangering lives.

6. Destruction of biodiversity

The number of animal species in the area has been lost as a result of destruction of their habitat. For most native species destruction of their habitat is worst than human predation, in this process the organisms that used to live there were completely displaced or destroyed, thereby reducing the biodiversity.

7. Water quality degradation

Mining of tourmaline in this area has resulted in contamination of groundwater by construction of shafts and tunnels that disrupt natural groundwater regime and can allow atmospheric oxygen to enter the underground environment.

Conclusion

Mining for tourmaline and other gemstones in this area has indeed impacted negatively on the environment, many inhabitants have been maimed or even lost their lives as a result of falling into the abandoned mine pits, domestic animals like goats, sheep and cattle have also lost their lives in these areas. Owing to the large extent of land covered by the abandoned mines and even the functional ones, large parcels of land that could otherwise be used for farming and thus boosting agriculture and food security of the country has been lost to the mines. Also the area has become more prone to erosion and flooding as a result of the exposure of the land to climatic forces. Groundwater in this area also has already suffered some level of pollution as result of the mining activities.

Recommendation

The Minerals and Mining Act 2007, provides a useful framework for the exploration and exploitation of minerals in Nigeria. Enforcement of the mineral act is therefore recommended as a key strategy in solving environmental problems that may arise from mining activities. Further research can be conducted in the area to take a more critical look at the groundwater contamination.

References

Abaa, S.I. (1983) The structure and petrography of alkaline rocks of the Mada Younger Granite Complex, Nigeria. *Journal of African Earth Science* 3:107–113.

Akintola, O. F. and Adekeye, J. I. D. (2008) Mineralization Potentials of Pegmatites in the Nasarawa area of Central Nigeria. *Earth Sciences Research Journal* 12, (2): 213-234

Bowden, P. and Kinnaird, J. A. (1984) Geology and mineralization of the Nigerian anorogenic ring complexes. *Geology Bulletin*. B56, 3-65.

Fayose, E.A. (1985). Geological Map Interpretation. Mayton publishing consultants, Ibadan Nigeria. 2-10

Garba, I. (2002) Late Pan-African tectonics and origin of gold mineralization and rare-metal pegmatites in the Kushaka Schist belt, North-Western Nigeria. *Journal of Mining and Geology*, 38(1), 1-12.

Garba, I. (2003) Geochemical discrimination of newly discovered rare-metal bearing and barren pegmatites in the Pan-African (600±150Ma) basement of northern Nigeria. *Applied Earth Science* 112; 287-292.

Jacobson, R. and Webb, J. S. (1949) The pegmatites of Central Nigeria. *Geological Survey of Nigeria Buletin*. 17.

Kinnaird, J. A. (1984) Contrasting styles of Sn-Nb-Ta-Zn mineralization in Nigeria. *Journal of African Earth Sciences*, 2(2), 81-90.

Wright, J. B. (1970) Controls of mineralization in the Older and Younger Tin Fields of Nigeria. *Economic Geology*, 65, 945-951.

Wright, J. B. (1976) Fracture systems in Nigeria and initiation of fracture zones in the South Atlantic. *Tectonophys*. 34, 43-47.

Olatunji K.J. & Olapade A.A. . (2013) Nigerian Mining Journal, 11(1) 13 - 16

Financial Analysis of Artisanal Mining of Alaguntan Open – pit Marble Deposit in Ori – Ire Local Government Area, Oyo State, Nigeria

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Abstract
Artisanal mining of marble is common practice all over Nigeria. The study focused on financial analysis of manual method of mining Alaguntan open pit mine. The average thickness of the overburden was measured. The cost of manual method being used in the site was evaluated. Financial analysis of cost- product was done. The result shows that the cost of loading/mucking is about 8.45 Naira/tonne /shift (8 hours) and the possibility of profit before taxation of about N 1149050 if about 544 tonnes of marble is produced, With this it can be concluded that Alaguntan marble deposit can be mined at profit manually. It is recommended that investors in marble should source for fund and expanded market to justify the finance for mechanization, apply for loan from industrial and commercial banks to finance mechanization and reclaim the devastated land mined.

Keywords: Artisanal, marble, financial, analysis, profit, fund.

Introduction

Marble occurs within the migmatite-gneiss-schist-quartzites complex as relicts of sedimentary carbonate rock. These are upper proterozoic schist belt metasediments which are normaly marked by general absence of carbonates (Obaje, 2011). Some marble occurrences in the Nigeria's basement complex seem to have similar mode of origin despite the fact that Alagutan marble is purely dolomitic, the fractured associated strong folding has enhanced intrusion in the deposit (Geological Survey of Nigeria, 1986). In Nigeria, artisanal and illegal miners produce the following minerals: cassiterite, columbite, tantalite, gold, gemstones (garnets, tourmaline, aquamarine, amethyst), limestone, marble, talc, gypsum, galena/sphalerite, barites, sand, gravel and crushed stones. Some of these (limestone, marble, sand, gravel, crushed stones) are useful mainly in the construction industry while the others are exported usually illegally. The implements and equipment they use are simple and crude and in most cases include shovels, pickaxes, hammers, head-pans, simple crushers, sluice boxes, rolling mills and sieves. (Adekeye, 2011).

The manual working of an open pit mine utilized the use of simple equipments in the extraction of minerals mainly in mining industry (Symmons, 1970). In an open pit operation manual working is referred to as 'mining with tear or hard mining' . Combined work capability of human is also much lower than that of a machine (Rumely, 2010).

Due to manual method of mining in which there is no adequate planning of ditching during rainy season, flood gets into the mine. (Wikipedia, 2011).

The study was carried out to know the cost of estimation of manual method of mining marble in Alaguntan deposit, Oyo state, Nigeria and the expected profit.

Materials and Methods

The study area is located near Ikoyi, Ori ire Local Government Area of Oyo state, south west Nigeria. It lies between latitudes 08° 26° S to 08° 28° S and longitudes 03° 40° W to 03° 55° S.

Data of the study was collected mainly through oral interview of quarry operator in the area and observations.

Results and Discussion

The data obtained in the course of the study are presented in Tables 1-5.

Table 1 shows the cost of overburden removal.

Table 1: Cost of overburden removal

S/NO	DESCIPTION	QUANTITY	TOTAL COST
1.	Cost of overburden removal	170.078m^3	N30,000.00

Table 2 shows cost of drilling

Table 2: Cost of drilling

S/NO	DESCRIPTION	QUANTITY	COST/UNIT(N)	TOTAL COST(N)
1.	Cost of hiring compressor + jack hammer	1	10,000.00	10000.00
2.	Cost of transporting compressor + jack hammer to and fro Igbetti to Alaguntan	1	1500.00	3500.00
3.	Operator's wage for drilling 32 holes	2.1 m feet	10 per 0.3m	2240.00
4.	Cost of diesel	120 litres	40/litre	6800.00
5.	Cost of oil	8 litres	400/ litre	3200.00
6.	Total cost spent			35,740.00
7.	Cost of drilling a hole	32	35740/32	1116.88/m
8.	Cost/ Area	32	35740/32	1116.88/m^2
9.	Cost/ volume	68.26	35740/68.26	523.58/m^3

Table 3 shows cost of blasting

Table 3: Cost of blasting

S/NO	DESCRIPTION	QUANTITY	COST/UNIT(N)	TOTAL COST(N)
1.	Cost of blasting 32 holes to be charged with 2 explosives per hole	64	90	5700.00
2.	Detonating cord about 320m	320 m	70	22400.00
3.	Plain cap	1	100	100.00
4.	Safety fuse	1	150	150.00
5.	Total cost spent			28410.00

Table 4 shows cost of loading/ mucking

Table 4: Cost of loading/ mucking

S/NO	DESCRIPTION	QUANTITY	COST/UNIT(N)	TOTAL COST (N)
1.	Cost of breaking and jacking (moving) 16 loads out of the pit.	16 loads	800/load	12800.00
2.	Cost of loading 1 tipper	16 loads	300/load	4800.00
3.	Cost of tipper rentage per trip or load	16 loads	10000/ load	16000.00
4.	Operator's wage for transporting each load	16 loads	200/load	3200.00
5.	Total cost spent			36800.00
6.	Cost per ton (total ton is 544 tonnes)	544 tonnes	36800/544	67.64/tonne
7.	Cost/tonne/8 hours	8 hours	67.64/8hrs	8.45 N/t/hr

Table 5 shows the estimation of net profit

Table 5: Estimation of net profit

S/NO	DESCRIPTION	QUANTITY	COST/UNIT(N)	TOTAL COST (N)
1.	Total operating cost spent on overburden+Drilling+Blasting+loading/mucking			130950.00
2.	Cost at which one tone of marble is sold (a truck carries about 65 tonnes)		2352.94117	
3.	Tonnes 4 people can load in 8hrs	544 tonnes		
4.	Selling price per tonne x tones loaded in 8hrs shift		2352.94117	1280000.00
5.	Profit over 544 tonnes			1149050.00
6	Profit	1 tonne		2112.22

Conclusion and Recommendations

The relative profit of manual mining (excluding reclamation cost) of Alaguntan marble deposit shows it can be mined at a profit. The mechanization if employed will definitely produce to meet the target of the customers at the right time, reduce the production cost and exposure of workers to hazards.

It is hereby recommended that:

a) the investors should source for more market to justify the finance for mechanization;

b) the investors should apply for loan from industrial and commercial banks to finance mechanization;

and

c) the investors should reclaim the devastated area already mined by manual method.

References

Adekeye J.I.D. (2011). The Impact of Artisanal and Illegal Mining on the Environment in Nigeria. Centre For peace and Strategic Studies, University of Ilorin, Ilorin-Nigeria. http: //www.unilorin.edu.ng/.../pg28.

Geological Survey of Nigeria (1986). Sedimental sediments. Retrieved from http://www.nnpc.gov.ng/html

Obaje G.N. (2011). Geology and Mineral Resources of Nigeria. Springer, pg 132

Rumely A. (2010). 'Machines' Popular Mechanics(published by Hearst publication) Vol. 12 p.136

Symnons (1970). Open Pit Mine in Peele R (Ed.,) Surface Mining published by American institute of Mining Engineers Inc. New York. pg 104

Wikipedia (2011). Feasibility of mine. Retrieved from http: //en.wikipedia.org/wikiequipment/se/.

Akande J.M. & Lawal A.I. (2013) Nigerian Mining Journal, 11(1) 17 - 23

Effects of Controllable Blasting Parameters on Geometric Volume of Blast in NSCE and Ratcon Quarries, Ibadan, Oyo State, Nigeria

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Abstract
The research examines effect of controllable blasting parameters on geometric volume of blast in NSCE and Ratcon quarries at Ibadan in Oyo State, Nigeria. Blasting data were collected from the study areas. The collected data were analysed statistically using Microsoft Excel© software. The results of the research reveal that out of the six input controllable parameters, five of them which are blast-hole depth, blast-hole diameter, spacing, burden, and average charge per hole have positive effects on geometric volume of blast while specific charge has negative effect on geometric volume of blast. The goodness of fits (R^2) between the geometric volume of blast and blast-hole diameter, blast-hole diameter, spacing, burden, average charge per hole and specific charge are 0.3800, 0.9235, 0.7691, 0.8501, 0.6831 and 0.8397respectively.Out of all the goodness of fits only the blast-hole diameter has weak value while others have values range from strong to vary strong goodness of fits. The statistical package for social sciences (SPSS) software was used to generate an equation relating all the input parameters to geometric volume of blast.

Keyword: Controllable blasting parameters, Blast-hole diameter, Blast-hole depth, Spacing, Burden, Geometric volume of blast, Specific charge.

Introduction
Blasting is the principal method of rock breakage in mining and construction projects throughout the world. This may probably be due to its distinct advantages like economy, efficiency, convenience and ability to break the hardest of rocks (Adhikari *et al.,* 2005). Blasting is a technique of rock excavation which consists of using the energy of explosives to break the rock, which is later extracted by mechanical means (Leonardo, 2012). Efficiency of blasting is largely dependent upon the proper choice of explosive, the weight of the charge, the number, depth and location of shot holes, and on other parameters of drilling and blasting operations in conformity with the properties of the ground traversed and the cross-section of the opening. Hagan (1986) pointed out that blasting can affect subsequent drilling. When the blasting causes considerable over break for example, the mean inclination of the newly created face is often so small that the toe burden for front row vertical blasting in the results are sub-optimal.

The major concern areas of blasting operation are productivity, environmental effects and safety. Productivity is related with obtaining desired fragmentation with uniform or appropriate size and proper displacement of rocks. Planning engineer should try to optimize blast design which results in productive and environmentally safe blasting. This is very difficult task because of varying nature of rock, geologic structure of rock mass, and explosive (Birol and Ercan, 2010). The productivity of the blasting depends on some controllable blasting variables such as spacing, burden, drill hole depth

Table 1: Blasting Variables Obtained from NSRC and Ratcon

Drill Hole Diameter (mm)	Drill Hole Depth (m)	Spacing(m)	Burden (m)	Average Charge per Hole (kg/hole)	Specific Charge (kg/m^3)	Geometric Volume of Blast (m^3)
76.2	9	2.3	2.2	20.50	0.32	2914.56
76.2	10	2.3	2.3	22.50	0.43	3385.60
88.9	12	2.6	2.5	24.17	0.31	4680.00
76.2	12	2.6	2.4	23.20	0.31	4792.32
88.9	15	2.6	2.4	27.20	0.29	4792.32
88.9	15	2.6	2.6	27.20	0.27	6084.00
76.2	9	2.3	2.1	20.50	0.47	2608.20
76.2	10	2.3	2.3	22.50	0.43	3174.00
76.2	10	2.3	2.3	22.50	0.43	3385.60
76.2	9	2.3	2.3	20.50	0.43	3047.04
76.2	9	2.3	2.2	20.50	0.45	2732.40
76.2	9	2.3	2.1	20.50	0.47	2782.08
88.9	15	2.6	2.1	27.20	0.33	4914.00
88.9	12	2.6	2.2	24.17	0.35	4118.40
76.2	9	2.3	2.3	20.50	0.43	3047.04
76.2	9	2.3	2.3	20.50	0.43	2856.60
76.2	10	2.3	2.3	22.50	0.43	3385.60
88.9	12	2.6	2.4	24.17	0.32	4492.80
88.9	12	2.6	2.5	24.17	0.31	4992.00
88.9	15	2.6	2.6	27.20	0.27	6084.00
76.2	3	1.5	1.1	5.94	1.20	549.45
76.2	3	2.0	1.8	6.00	0.56	1198.80
76.2	3	1.5	1.5	5.94	0.88	540.00
76.2	3	1.5	1.5	5.94	0.88	749.25
76.2	3	2.0	2.0	6.00	0.50	960.00
76.2	3	2.0	1.8	6.00	0.56	1198.80
76.2	3	1.5	1.4	5.94	0.94	699.30
76.2	3	1.5	1.5	5.94	0.88	749.25
76.2	3	2.0	2.0	5.94	0.50	960.00

Figure 2 shows the plot of geometric volume of blast and blast-hole diameter, the regression equation is as written in Equation 1

$$G_V = 2.4189^{0.0859\phi} \quad ...1$$

where G_v is the geometric volume of blast in m^3, and ϕ is the diameter of hole in mm.

The regression equation of the reveals that blast-hole diameter has a positive effect on geometric volume of blast and the coefficient of correlation between them is 0.38 indicating weak correlation between them.

among others. This research work was carried out to determine the effect of controllable blasting parameters on volume of rock produced after blasting.

Description of the Study Area

The study areas are located at Ibadan, Oyo State. Oyo State is located in South-Western Nigeria on Longitude ranges between 3˚43'30" and 4°20'30"E and Latitude ranges between 7˚41'30" and 8°23'00" N (Rahman, 1976). Oyo State exhibits the typical tropical climate of averagely high temperatures, high relative humidity and generally two rainfall maxima regimes during the rainfall period of March to October. The mean temperatures are highest at the end of the Harmattan (averaging 28°C), that is from the middle of January to the onset of the rains in the middle of March. Even during the rainfall months, average temperatures are between 24°C and 25°C, while annual range of temperature is about 6°C. The basement complex rock gives rise to wide variety of soil. Two quarries namely Ratcon and NSCE located at Ibadan, Oyo State were used for this research. The geological setting of Oyo State is as shown in Figure 1.

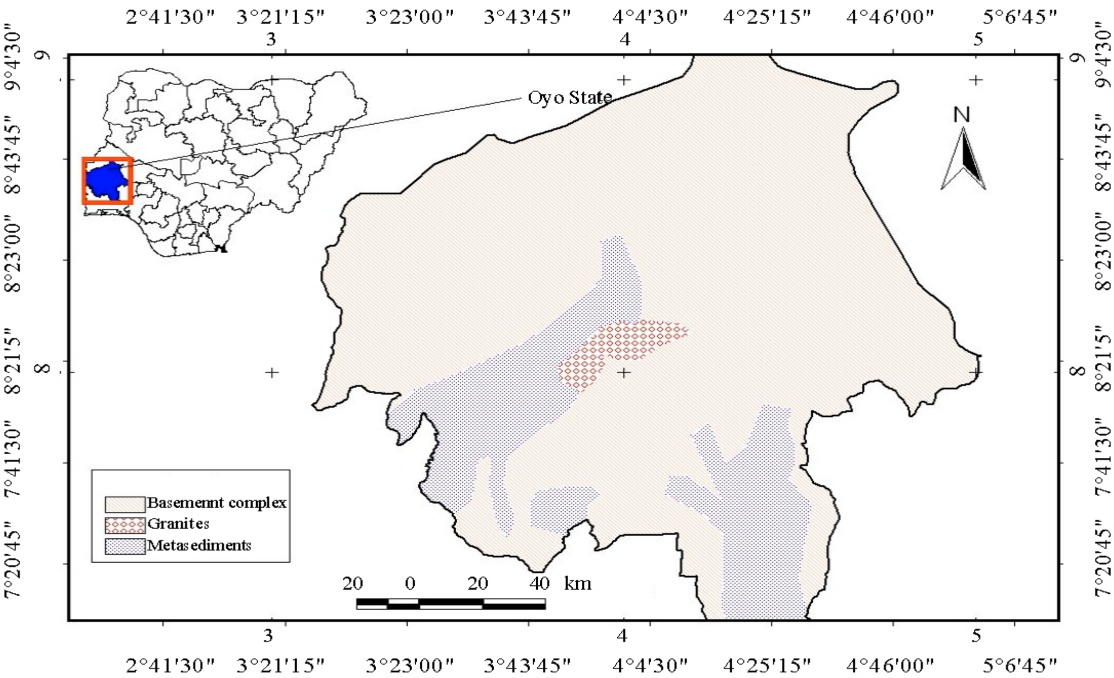

Figure 1: Geological Setting of Oyo State (Source: After Balogun, 2000).

Materials and Methods

Data Collection and Analysis

Blasting parameters (blast-hole diameter, blast-hole depth, spacing which defined as the distance between holes in any given row (Hustrulid, 1999), and burden which is defined as the distance between the individual rows of holes (Hustrulid, 1999) were obtained from the study areas by both collection of past blasting records and direct recording during the witnessed blasting operations and the data were analysed using statistical tools. Twenty nine blasting records from the study areas were obtained.

Results and Discussion

Table 1 shows the result of blasting parameters obtained from the field

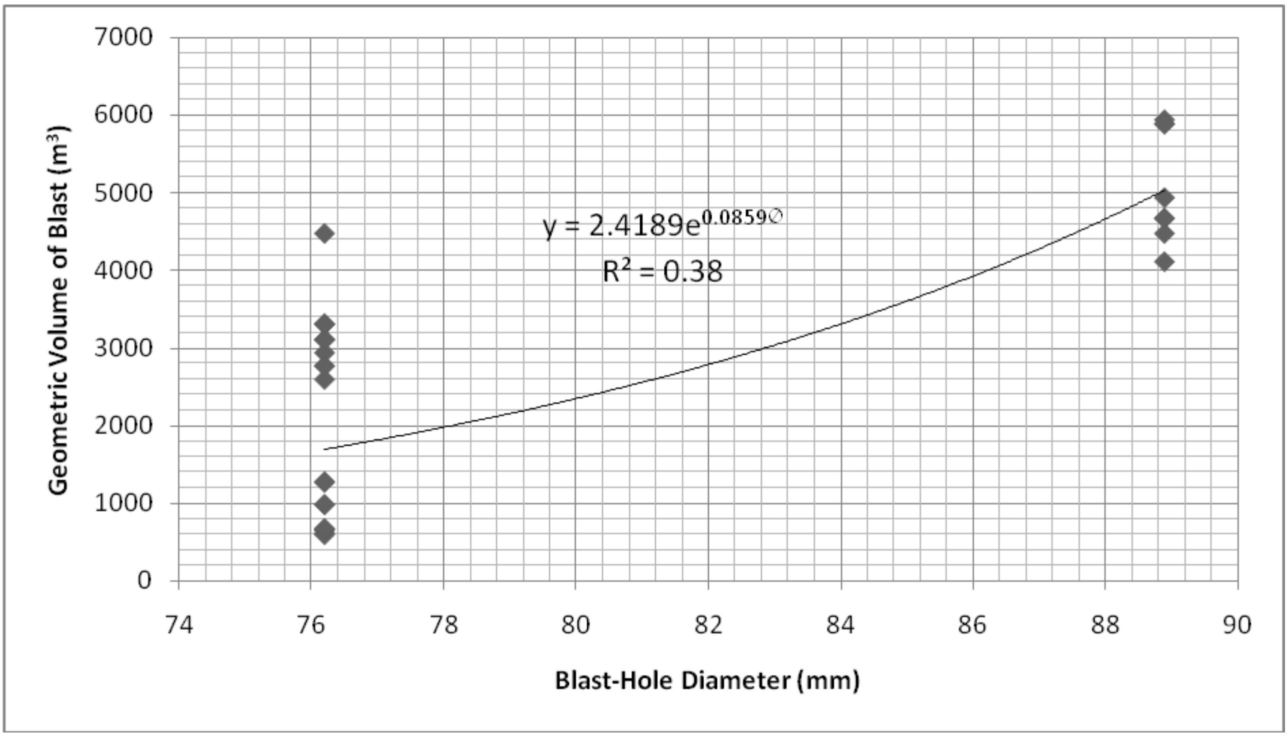

Figure 2: Geometric Volume of Rock Blasted against Blast-Hole Diameter

Figure 3 shows the result of correlation between the geometric volume of blast and blast-hole depth, the regression equation is as written in Equation 2

$$G_v = 508.71e^{0.1768H} \quad ...2$$

where H is the drill-hole depth in m.

The regression equation reveals that blast-hole depth has a positive effect on geometric volume of blast and the coefficient of correlation is 0.9235 indicating very strong correlation between them.

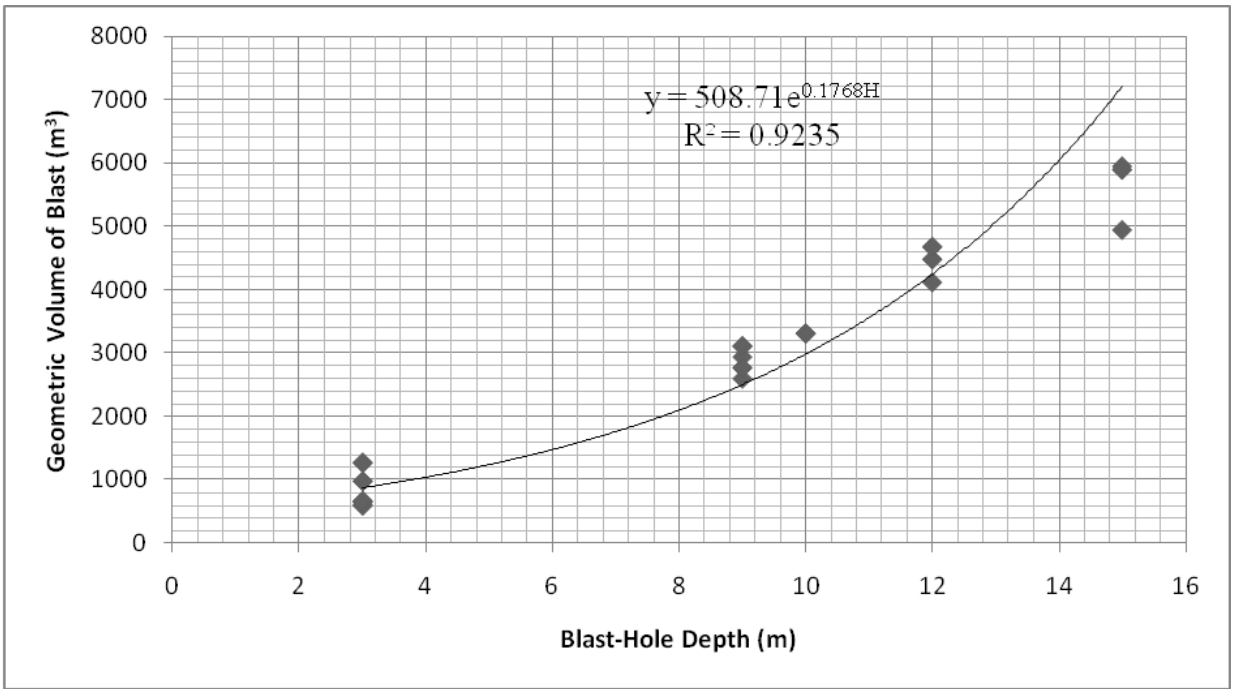

Figure 3: Geometric Volume of Rock Blasted against Blast-Hole Depth

Figure 4 shows the relationship between geometric volume of blast and spacing, the regression equation is as written in Equation 3.

$$G_v = 49.51e^{1.7446S} \qquad ...3$$

where S is the hole spacing in meter.
The regression equation reveals that blast-hole spacing has a positive effect on geometric volume of blast. The coefficient of correlation between them is 0.769 indicating strong correlation between them.

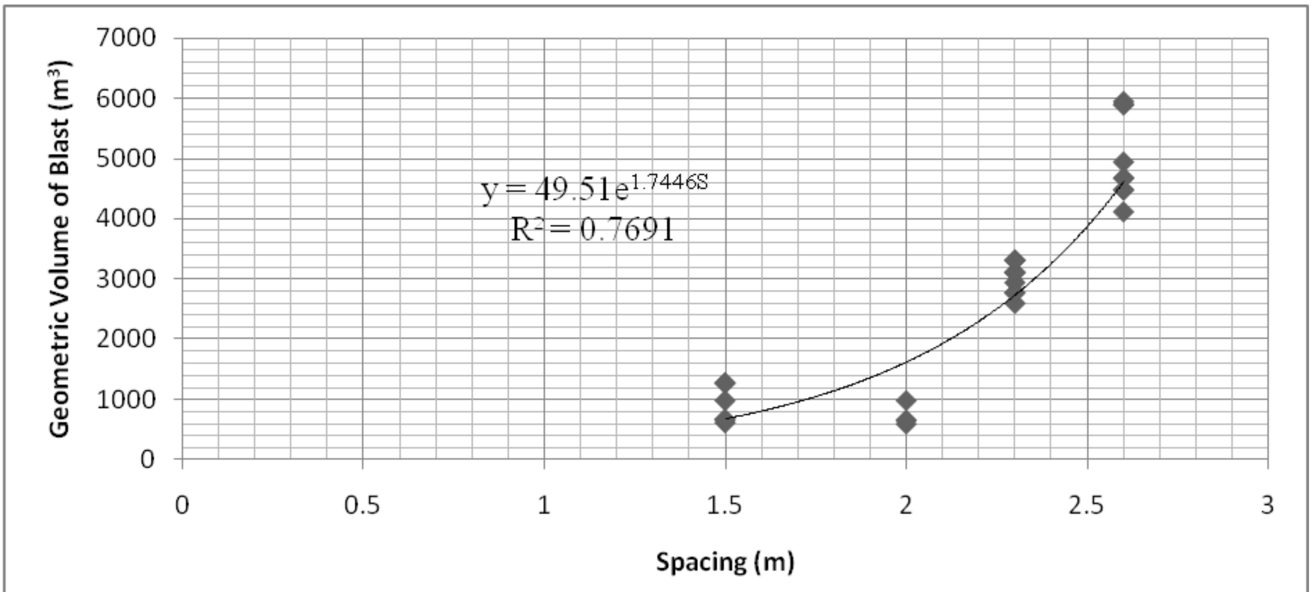

Figure 4: Geometric Volume of Rock Blasted against Spacing

Figure 5 shows the relationship between geometric volume of blast and burden and the regression equation is as written in Equation 4.

$$G_v = 43.287e^{1.9022B} \qquad ...4$$

where B is hole burden in m.
The regression equation reveals that spacing has a positive effect on geometric volume of blast and the coefficient of correlation between them is 0.8501 indicating very strong correlation between them.

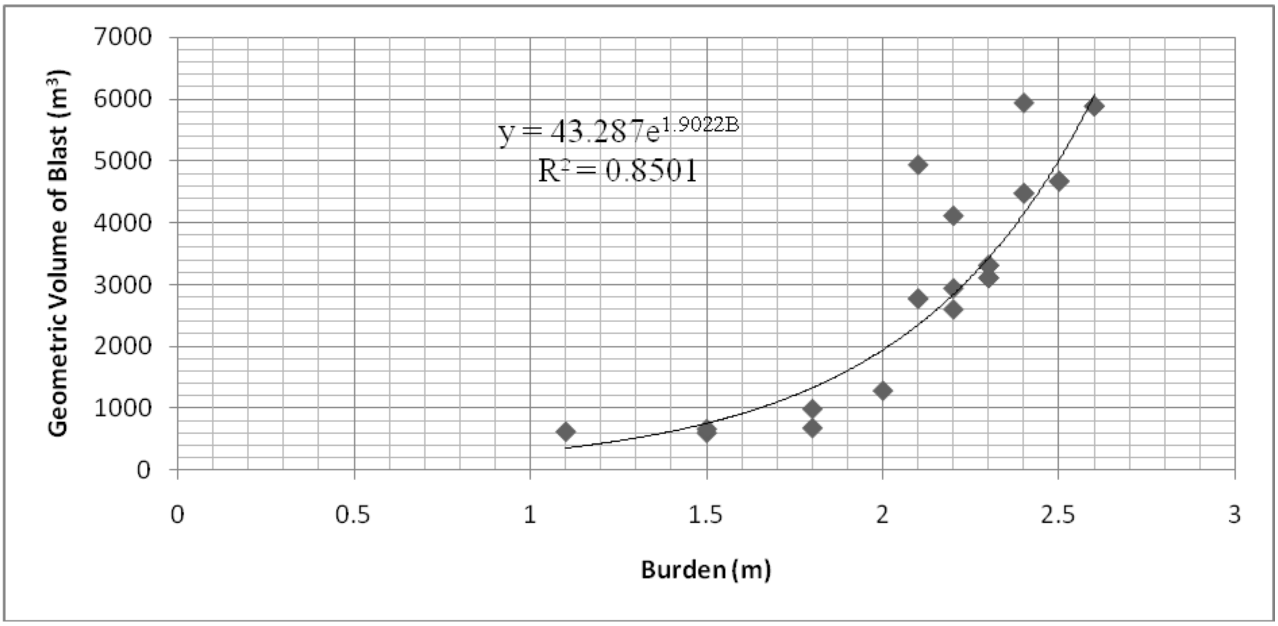

Figure 5: Geometric Volume of Rock Blasted against Burden

Figure 6 shows the graph of geometric volume of blast and average charge per hole, the regression equation is as written in Equation 5

$$G_v = 586.48e^{A_{CH}} \quad ...5$$

where A_{CH} is the average charge per hole in kg/hole.

Equation 5 reveals that there average charge per hole has a positive effect on average charge per hole and the coefficient of correlation between them is 0.6831 indicating strong correlation between them.

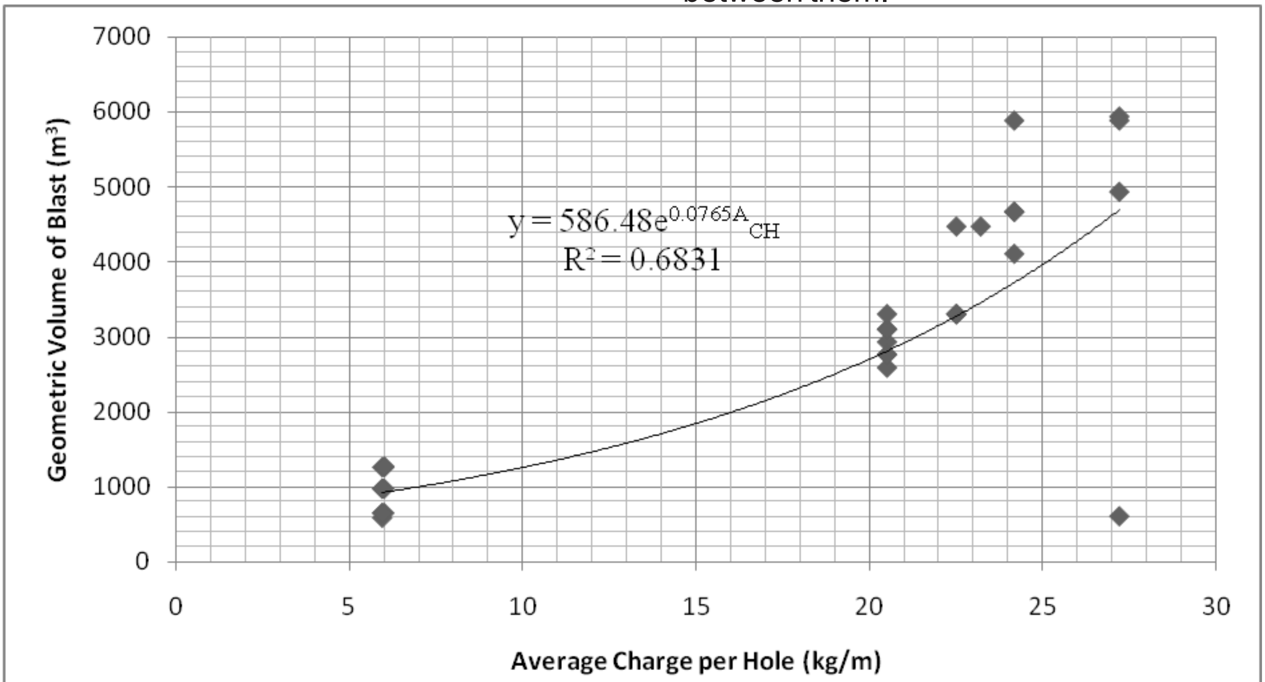

Figure 6: Geometric Volume of Blast against Average Charge per Hole

Figure 7 shows the plot of geometric volume of blast and specific charge, the regression equation is as written in Equation 6.

$$G_v = 10540e^{-3.026S_C} \quad ...6$$

where S_C is the specific charge in kg/m^3.

Equation 6 reveals that specific charge has a negative effect on geometric volume of blast and the coefficient of correlation between them is 0.8397 indicating strong correlation between them.

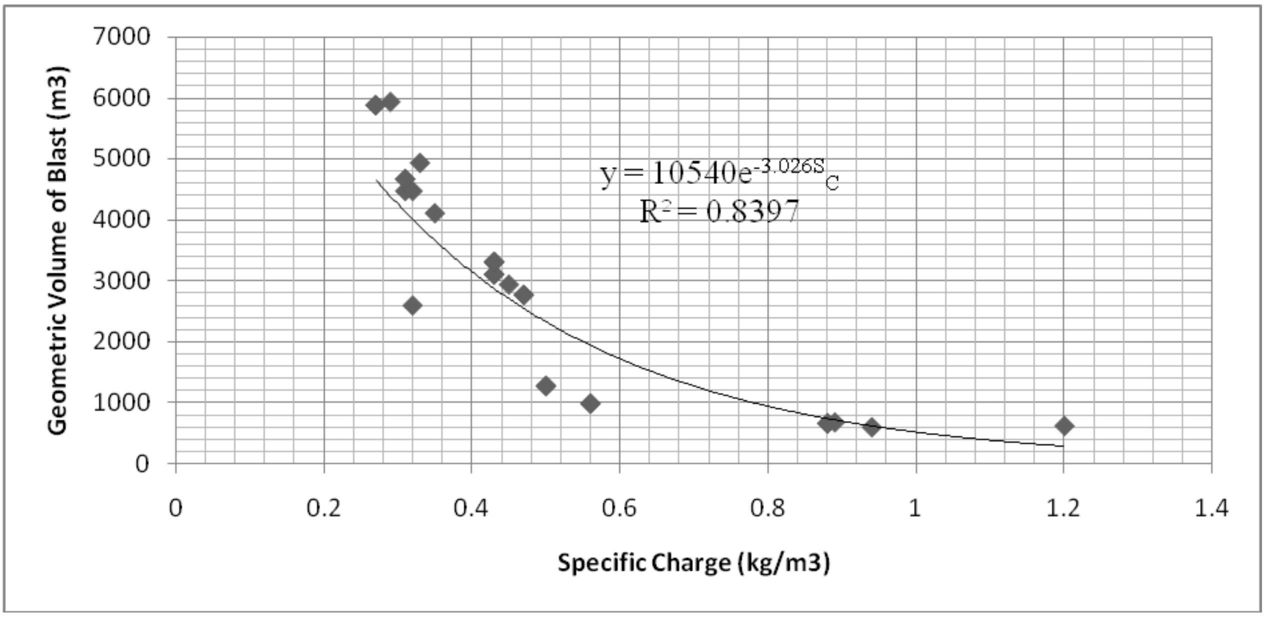

Figure 7: Geometric Volume of Blast against Specific Charge

Equation 7 is the general equation generated through SPSS software combining all the input parameters together

$$Gv = -8057.504 + 8.737\phi + 508.132H + 1114.823S + 2202.553B - 139.834ACH + 2678.680Sc \quad ...7$$

Conclusion

From the research work, the following conclusions can be drawn:

(a) out of all the controllable parameters obtained from the field only the specific charge per drill-hole has a negative effect on geometric volume of blast while others that are blast-hole diameter, blast-hole depth, spacing, burden and average charge per hole have positive effects; and

(b) the empirical equations generated (Equations 1 to 6) can be used to determine either of the two parameters directly, that is, if geometric volume of blast is known other controllable parameters can be determined and also if the controllable parameters are known geometric volume of blast can be determined and the equation generated using SPSS is useful for the determination of geometric volume of rock.

References

Adhikari, G. R, Venkateih, H. S., Theresraj, A. J, Surrendra, R, Balachander, Nitin, K. J and Gupta, R. N. (2005): Role of Blast Design Parameters on Ground Vibration and Correlation of Vibration Level to Blasting Damage to Surface Structures. Pp. 18-20.

Balogun, O. Y. (2000): Senior Secondary Atlas. 2nd Edn,. Longman, Nigeria.

Birol, E. and Erca, A. (2010): Evaluation of Parameters Affected on the Blast Induced Ground Vibration (BIGV) by using Relation Diagram Method (RDM). Acta Montarisca Slovaca, Cislo 4, pp. 261-268

Hagan, T. N. (1986): The Influence of Some Uncontrollable Blast Parameters Upon. Muckpile Characteristics and Open Pit Mining Cost. Proc. Conf. Large Open Pit Mining. Aus. Inst. Metallurgy/inst., pp. 123-132

Hustrulid, W. (1999): “Blasting Principles for Open Pit Mining”. Vol. I. A.A. Balkema, Rotterdam.pp 27- 31, 38-39,42-44, 73 & 77, 854-855.

Leonardo. F. T. P. (2012): Study of Blast-Induced Damage in Rock with Potential Application to Open Pit and Underground Mines. Ph. D Thesis Submitted to the Department of Civil Engineering University of Toronto, p. 3.

Rahman, M. A. (1976): Review of the Basement Geology of South Western Nigeria. In Geology of Nigerian, Edited by C. A Kogbe, Elizabethan Publishing Company, Lagos, Nigeria. Pp. 41-58

Alaba O.C. & Agbalajobi S.A. (2013) Nigerian Mining Journal, 11(1) 25 - 31

Probable Reserve Estimation of Akure – Ijare Lateritic Deposit for Construction Purposes using Vertical Electrical Resistivity Method in Ondo State, Nigeria

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Abstract
This paper discussed the reserve estimation of laterite deposit for construction purposes in Akure Ondo State, Nigeria. The Schlumberger array method of electrical resistivity technique was used in the investigated laterite deposit with the electrode spacing (AB/2) varying from 1 to 40m along the established traverses. The resistivity values of laterite sand (1st and 2nd layers) varied from 219 -m to 1511 -m with average thickness of 13.18m. The estimated reserve of laterite sand from the investigated deposit is 1,085,044m^3. Overburden thicknesses are generally less than 0.2m, making open pit mining option suitable for the extraction of the investigated deposit.

Keywords: Laterite, vertical electrical sounding, reserve, estimation, open pit mining

Introduction
The utilization of laterite sand was formerly discussed in connection with mining of minerals such as bauxite, manganese, iron and aluminum until recent time when the civil engineering aspect mostly in connection with construction purposes such roads, dams and buildings became lime light of the society (Maigien, 1996). Chuarman (1988) gave the reason for the high demand of laterite sand in construction works as a result of its lower cost when compared with stone and other construction materials, while Lyon (1971) observed that laterite sand can only be viable for construction purposes when there is large reserve deposit that can be sufficient for construction work. The electrical resistivity method which is less expensive with good can be used to infer the reserve estimate of laterite deposit. The method is based on the principle that different materials offer different resistance to the passage of an electric current (Keller and Frischnecht, 1966). The resistance to the passage of the current is determined by measurement of the specific resistance (resistivity) of the material, which is defined as the resistance in ohms between opposite faces of a unit cube of the material (Akintorinwa et al., 2010). Several methods involving different electrode arrangements have been developed for field resistivity measurements such as wenner, schlumberger, and Dipole-Dipole array. A major difference between all three configurations is the spacing between the current and potential electrodes.

Vertical Electrical Sounding (VES) provides information on the variation of subsurface materials with depth. This is accompanied by maintaining the center of the electrode spread at a given location and taking a series of resistivity readings as the electrode space is increased; the depth of material that affects the apparent resistivity, and changes in material are reflected in the resistivity values obtained. The vertical electrical sounding apparent resistivity values are usually plotted on a bi-log graph against electrode spacing to generate sounding curves. The objective of this research work is to assist government at all tiers, the construction companies and individual owners of laterite deposit to quantify the volume of laterite sand in a laterite deposit by using electrical resistivity method which is less expensive. This method will also help to infer the mining techniques that are suitable for the mining of laterite deposit.

Research Methodology

The investigated laterite deposit belongs to Akure Oyemekun Ife-Oluwa CMU Ltd. The deposit is located along Akure-Ijare road with coordinates A(N07°19^{1}11.5^{11}; E005°09^{1}40.7^{11}), B(N07°19^{1}14.2^{11}; E005°09^{1}41.4^{11}), C(N07°19^{1}11.2^{11}; E005°09^{1}43.8^{11}) and D(N07o19111.911; E005o09144.411), as shown in Figure 1. The topography of the deposit is relatively flat and drainage pattern in the areas is mainly dendritic. The area is located within the tropical region (Rahaman, 1989).

The instruments used for the electrical resistivity data acquisition are resistivity meter (R50 DC resistivity meter), reel of cables, four metal electrode, Hammers and Power source. The deposit was divided into two traverses of E-F and G-H and Schlumberger array was used to determine the VES with electrode spacing (AB/2) varying from 1 to 40m along the established traverses of E-F and G-H. A total of five (5) Vertical Electrical Soundings (VES) were carried out along the traverses E-F while a total of four (4) Vertical Electrical Soundings (VES) were carried out along the traverses G-H as shown in Figure 1.

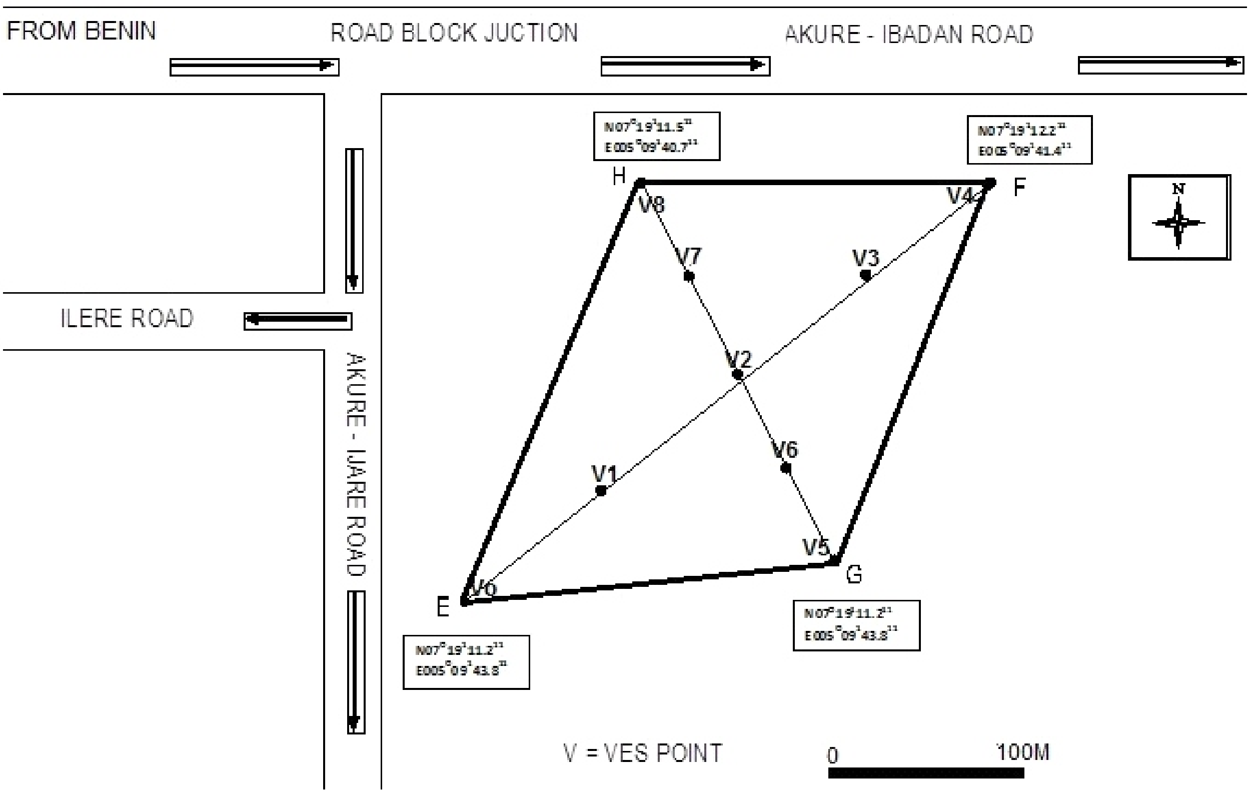

Figure 1: Location of Akure Oyemekun Ife-Oluwa CMU Ltd laterite deposit

Results and Discussion

Table 1 shows the resistivity values for the occupied VES points across the established traverses of the deposit. The field sounding curves for the VES points of the deposit were obtained with the use of RESIT software packages and were shown in Figures 2 while, Table 2 gives a summary of the results of the VES curves of the deposit. The root mean square (RMS) error of the generated curves for the deposit ranges between 3.1 and 7.3 which show models of well smoothened, iterated curves (Afolabi, *et al.,* 1996). The interpretation of the VES data were done by visual inspection of curve types, partial curve matching and computer iteration. The number of layers delineated at the deposit is four and KH curve type was identified in all the VES points

Table 1: Resistivity Values of the Investigated VES points

AB/2 (m)	RESISTIVITY (Ohm-m)								
	V0	V1	V2	V3	V4	V5	V6	V7	V8
1	411	490	493	610	491	408	479	310	291
2	518	514	520	665	415	456	512	365	215
3	590	570	623	678	416	495	541	378	216
4	670	670	678	705	432	630	641	405	232
6	792	855	735	776	539	650	635	476	339
6	952	930	792	850	550	750	695	530	528
8	1053	850	850	890	650	830	710	590	650
12	978	736	806	952	744	890	817	652	740
15	921	626	750	1050	860	980	905	750	650
15	957	578	650	955	940	729	1020	655	550
25	888	695	792	825	730	595	891	530	460
32	1230	965	1000	850	730	725	725	550	670
40				1180	1000	850	1020	855	

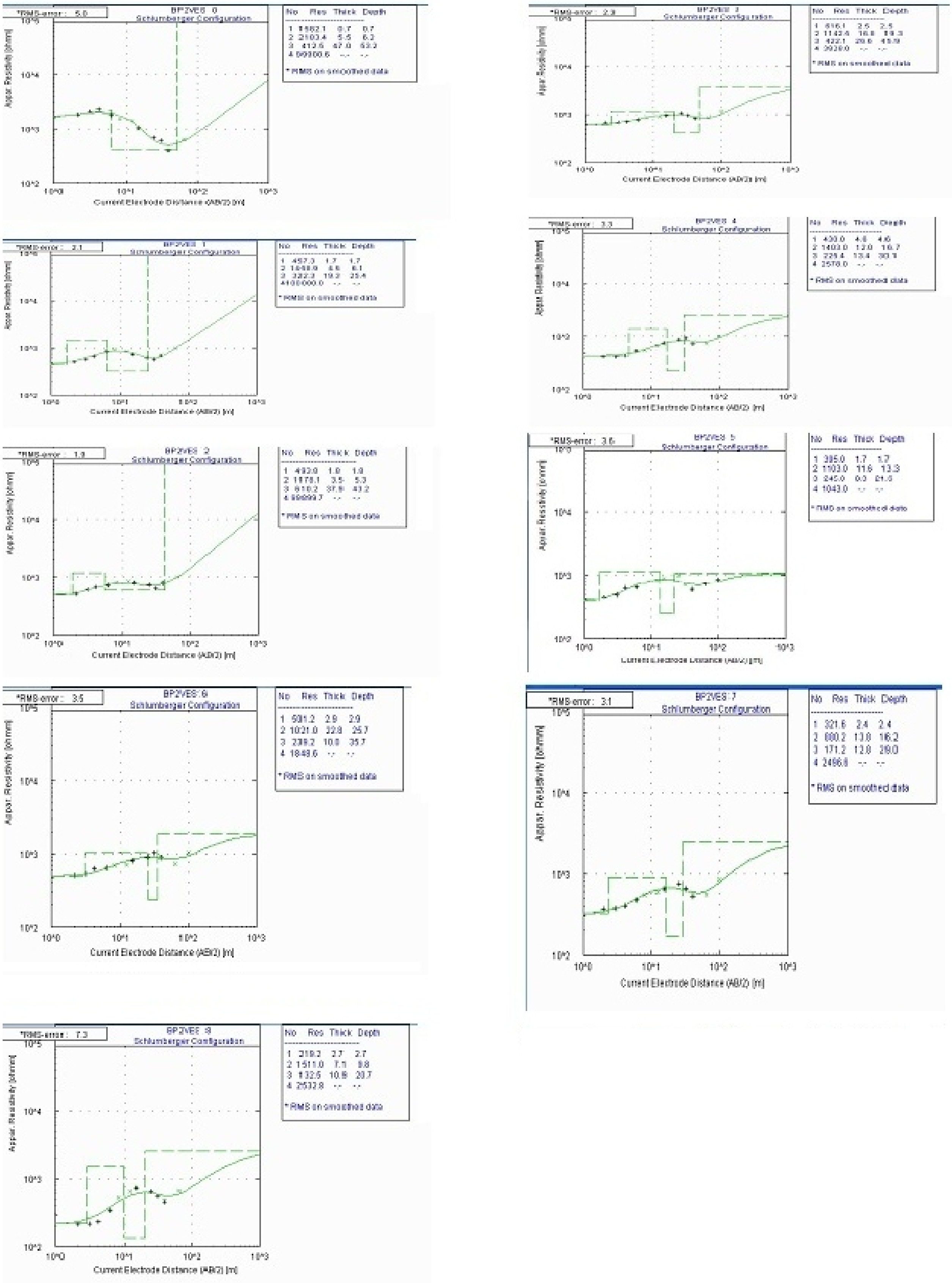

Figure 2: The field sounding curves for the Occupied VES points

Table 2: Summary of the results of the VES curves of the deposit

VES No	Layer No	Resistivity (ω? m)	Thickness (m)	Interpreted Lithology	Curve types
0	1	1582	0.7	Topsoil (Laterite)	
	2	2173	5.5	Lateritic Layer	KH
	3	413	47.0	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	8	ND	Bedrock	
1	1	457	1.7	Topsoil (Laterite)	
	2	1459	4.5	Lateritic Layer	KH
	3	322	19.3	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	8	ND	Bedrock	
2	1	494	1.8	Topsoil (Laterite)	
	2	1178	3.5	Lateritic Layer	KH
	3	610	37.9	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	8	ND	Bedrock	
3	1	616	2.5	Topsoil (Laterite)	
	2	1143	16.8	Lateritic Layer	KH
	3	422	26.6	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	3828	ND	Bedrock	
4	1	430	4.6	Topsoil (Laterite)	
	2	1403	12.0	Lateritic Layer	KH
	3	225	13.4	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	2578	ND	Bedrock	
5	1	395	1.7	Topsoil (Laterite)	
	2	1103	11.6	Lateritic Layer	KH
	3	245	8.3	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	1043	ND	Bedrock	
6	1	501	2.9	Topsoil (Laterite)	
	2	1021	22.8	Lateritic Layer	KH
	3	238	10.0	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	1849	ND	Bedrock	
7	1	322	2.4	Topsoil (Laterite)	
	2	880	13.8	Lateritic Layer	KH
	3	171	12.8	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	2497	ND	Bedrock	
8	1	219	2.7	Topsoil (Laterite)	
	2	1511	7.1	Lateritic Layer	KH
	3	133	10.9	Weathered Layer	$(\rho_1 < \rho_2 > \rho_3 < \rho_4)$
	4	2533	ND	Bedrock	

ND – Not detected

Geoelectric Sequence

Table 2 was used to prepare 2-D geoelectric sections for the deposit along traverse E-F and G-H. The sections identify four geoelectric layers comprising the lateritic layer (topsoil included), weathered layer, and the fresh basement bedrock as shown in Figures 3 and 4 respectively.

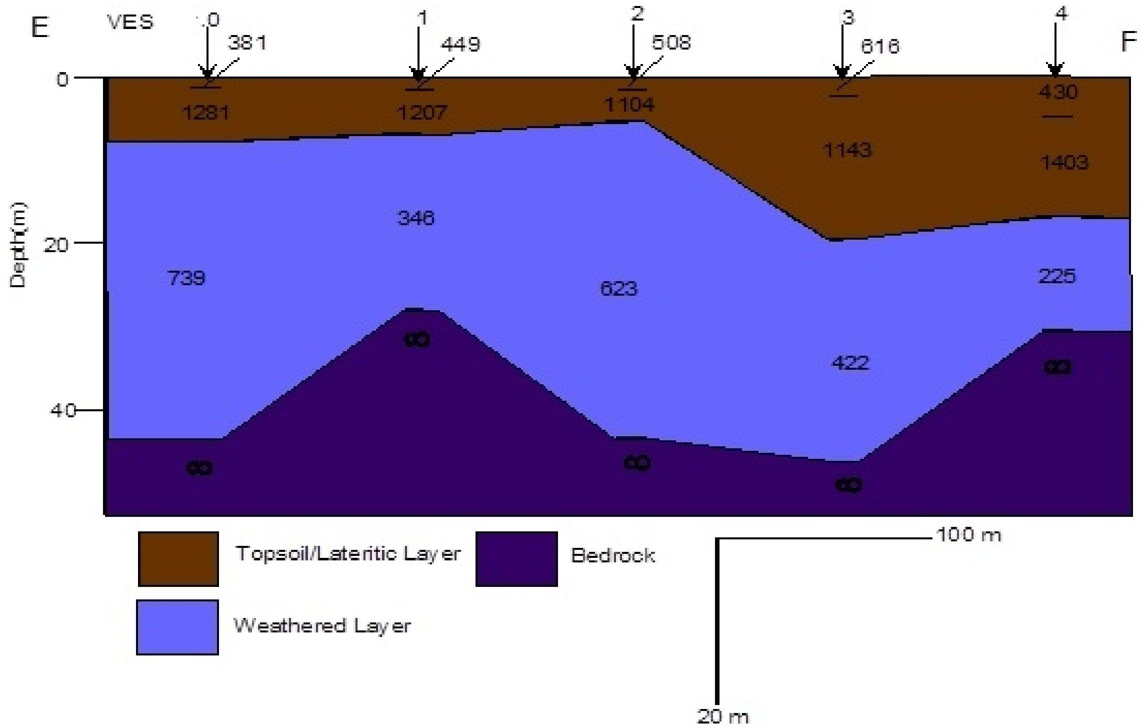

Fig. 3: Geoelectric Section of the Investigated Laterite Deposit along Traverse E-F

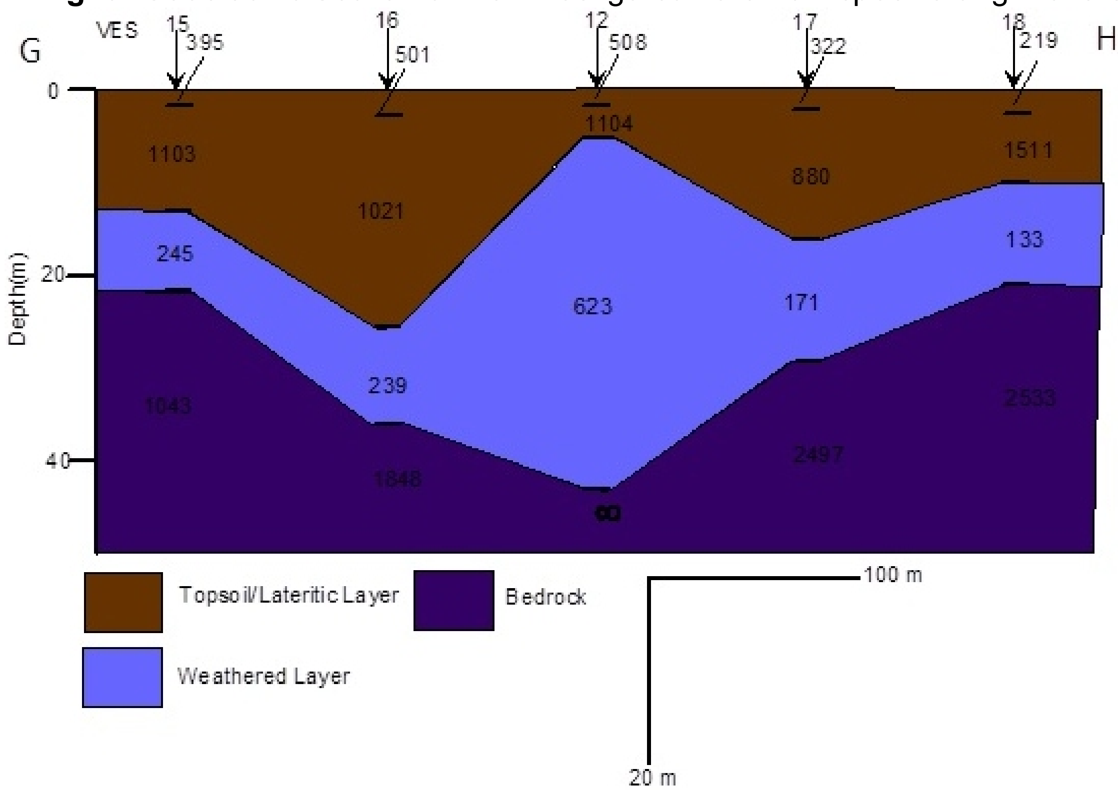

Fig. 4: Geoelectric Section of the Investigated Laterite Deposit along Traverse G-H

Reserve Estimation of the Investigated Laterite Deposit

The probable reserve estimation of the investigated deposit was calculated by using Hero's formula to determine the piloted area of the deposit. The result obtained from the piloted area was multiplied by the average thickness of the deposit to obtain the probable reserve. Table 2 and Figures 3 and 4 show that the 1st and the 2nd layer of the investigated deposit constitutes the lateritic sand that can be used for construction work. The piloted area and average thickness of the investigated laterite deposit are 82,325m^2 and 13.18m. Therefore, the probable reserve estimation of the laterite sand are calculated as shown in equation (1)

Reserve Estimation = Piloted Area X Average Thickness ...1

$$= 82325m^2 \times 13.18m = 1085044m^3$$

The estimated volume only covers the immediate premises of the piloted area (investigated VES points). Also, the deposit has negligible overburden thickness, making open pit mining method suitable for the mining of the laterite deposit.

Conclusions

The study was carried out to assist government at all tiers, the construction companies and individual owners of laterite deposit to quantify the volume and cost of laterite sand in a laterite deposit by using electrical resistivity method which is less expensive with good. This method will also help to infer the mining techniques that are suitable for the mining of laterite deposit. The 1st and the 2nd layer of the investigated deposit constitute the lateritic sand that can be used for construction purposes with probable reserve. It can therefore be concluded that the investigated laterite deposit is economical viable for mining from the point of view of quality (High layer resistivity and the signature of the field curves) and volume (reserve). Also, open pit mining method is suitable for the extraction of the investigated laterite deposit.

References

Afolabi, O., M. O. Olorunfemi, A. O. Olagunju and J. F. Afolayan (2004): Resource Quantification of a Kaolin Deposit using the Electrical Resistivity Method – Case Study From Ikere Ekiti, Southwest, Nigeria, Ife Journal of Science, Vol. 6 no. 1, pp. 35-40.

Akintorinwa O. J., J. S. Ojo and M. O. Olorunfemi (2010): Geophysical Investigation of Pavement Failure in a Basement Complex Terrain of Southwestern Nigeria, Pacific Journal of Science and Technology, Volume 11. Number 2.

Charman, J.H. (1998). Laterite in Road Pavements. Construction Industry Research and Information Association (CIRCA), Special Publication 47, Westminster, London, England, UK. pp. 11-14.

Keller, G. V. and Frischnecht, F. C. (1966): Electrical Method in Geophysical Prospecting. Pergarmon Press: Oxford, UK. 523.

Lyon/BRRI Associates (1971). Laterites and Lateritic Soil and other Problem Soils of Africa. An Engineering Study for USAID. AID/csd-2164, Baltimore, MD, USA, p.7

Maigien, R. (1996). Review of Research on Laterite. Natural Resources Research IV, United Nations Educational Scientific and Cultural Organization, Paris France. p. 23

Rahaman, M.A., (1989): Review of the Basement Geology of Southwestern Nigeria. In: Kogbe, C.A., (ed) Geology of Nigeria, Rock View (Nig.) Limited, Jos, Nigeria, pp. 39-56.

Ogah, V. E. & Abu, L. (2013) Nigerian Mining Journal, 11(1) 33 - 39
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Aeromagnetic appraisal and X-Ray Fluorescence Analysis of Pyrite Deposit in Anmoda, Ohimini Local Government Area of Benue State, Nigeria

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Abstract
Aeromagnetic appraisal and X – ray fluorescence analysis of pyrite deposit in Anmoda, Ohimini Local Government of Benue State, Nigeria was carried out to ascertain the original and geochemical properties of the pyrite. Aeromagnetic study of the area revealed a volcanic intrusion. Rising mineralizing waters and volatile materials warmed and supplied with dissolved metals from magma activities led to the deposition of the iron sulphide. Pyrite is identified as raw material used in chemical, metallurgical, textile and pharmaceutical industries. The geochemical analysis gave a grade of 45.07% Fe_20_3 and 37.7% SO_3, good enough to justify its extraction. Though the deposit enclosed in a massive intrusive body would make its mining difficult and expensive. Traces of other minerals like Nacrite, Pyrophyllite, Mullite, Pyrolusite, Spinel and Micas abound in the deposit may enhanced its value. Further geotechnical, hydrological and technological properties of the ore deposit are recommended for evaluation to ascertain its economic viability.

Keywords: Aeromagnetic, pyrite, geochemical.

Introduction

Nigeria has pyrite deposit resources estimated at several hundred million tons (Ogah and Jatau, 2011). Lack of adequate information on the potential resources has prevented the realization of the economic importance of these deposits. To realize optimum utilization of this important mineral resource, there is need to determine and document the location, quality and chemical properties of available pyrite deposits and ascertain the natural and economic conditions in which they occur. These are the prime objectives of this study.

The deposit is found in a village called Anmoda in Ohimini Local Government Area of Benue State, Nigeria. Anmoda is about 6-7km SW of Otukpo the ancestral headquarters of the Idoma people in North Central Nigeria. The pyrite is found on a co-ordinate, Latitude 07^0 11' 41N and Longitude 008^0 04'13E. The location altitude is 128m above sea level.

The area is endowed with tropical climate. The mean annual rainfall is between 1500mm to 1800mm. Temperature fluctuates between 26°C to 34°C most of the year (Ogah, 2010). Geographically the area is a generally low-lying, gently undulating plain. Savannah woodland type vegetation, cover much of the area.

Geology

Regional Geologic Tectonic Setting of the Area

The area is underlain by Cretaceous Sediments of the Benue Trough mainly comprising shale, sandstones and limestone (Fig. 1). The Trough is envisage as being due to combination of down warping and rift-type faulting of an attenuated sialic crust with subsidence enhanced as a result of isostatic loading by the sediments filling the trough.(Carter et al, 1963).Lithostratigraphic and biostratigraphic divisions range from Albian ,Turonian through Santonian to ConiacianAwgu formations (Reyment, 1964: Offodile, 1976). Major Santonian deformations gave rise to numerous folds, faults and fractures in this area (Benkhelil, 1989). Tectonic activity remained localized along the major fault zones but also resulting insub meridian mineralized fractures. Various types of volcanic occurrences especially dolerite intrusions transect the area. These igneous intrusions are associated with both Pre and Post Turonian tectonic episodes (Nwachukwu, 1972).

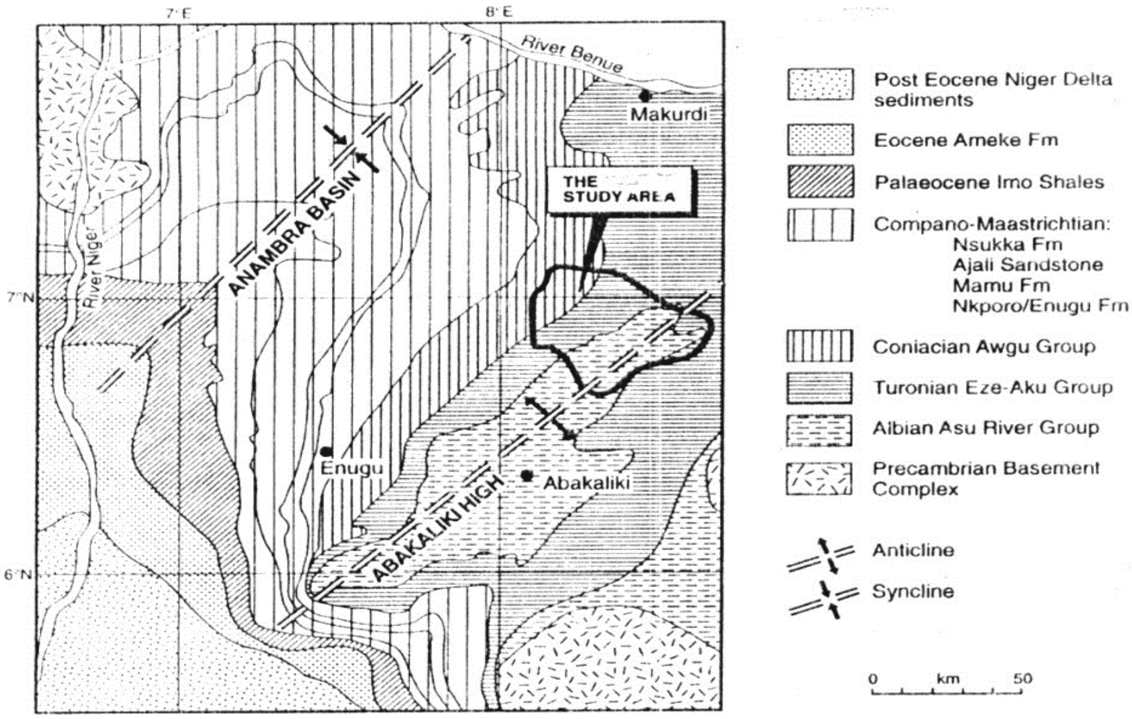

Figure 1.Regional Geological Map of theArea.

Local Geology of the Area

The oldest sediments present in the area belong to the Albian marine transgression. Middle Albian transgression caused the deposition of very thick marine, dark, grey shales, siltstone and subordinate limestone of the Asu River group, which uncomformably overlie the crystalline basement of Pre- Cambrian age (Nwachukwu, 1972).

The second cycle resulted in the deposition of Eze-Aku Formation at the end of the Cenomanian transgression that ended with a regression in the early or beginning of Turonian. The Eze-Aku formation consists of thick flaggy calcareous and non-calcareous shales, sandy or shaleylimestones, and calcareous sandstones. It overlies the Asu River Group (Nwajide, 1986).

The Eze-Aku formation is overlain by Awgu shale formation. This group comprises bluish-grey, very soft, shallow marine bedded carbonaceous mudstones with occasional muddy limestone and siltstones as well as a narrow band of sandstone known as the Agbani Sandstone formation, which is generally fine to medium-grained and moderately cemented Agagu and Adighije, 1983; Agagu et al, 1985).

Methodology

Aeromagnetic Study

The aeromagnetic map of the area was obtained from Geological Survey Agency of Nigeria (GSAN), Abuja. The aeromagnetic map was digitized at an equal spacing of 1km on a 52 by 52 grid lines. The data was fed into a computer file (MS DOS), which serves as the input file for the computer program. This program calculates the longitude, latitude and the magnetic values of the co-ordinates as X, Y and Z which is then accepted by the contouring package 'SURFER' and is used to effect residual separation. Regional residual separation is analogous to filtering in other geophysical techniques like seismic.

In this study the analytical method was applied. The analytical method of determining the residual anomalies involves the use of numerical operation on the observed data to isolate the residual anomalies without relying on the visual graphical method. The analytical method requires the magnetic values to be spaced in a regular array or grid. The polynomial fitting analytical method is based on computer programme that is founded on statistical theory; since the observed data are computed by least square method to obtain a surface that has the closest fit to the magnetic field (Johnson, 1969; Deton, 1976). The aeromagnetic map interpretation showed a volcanic intrusion.

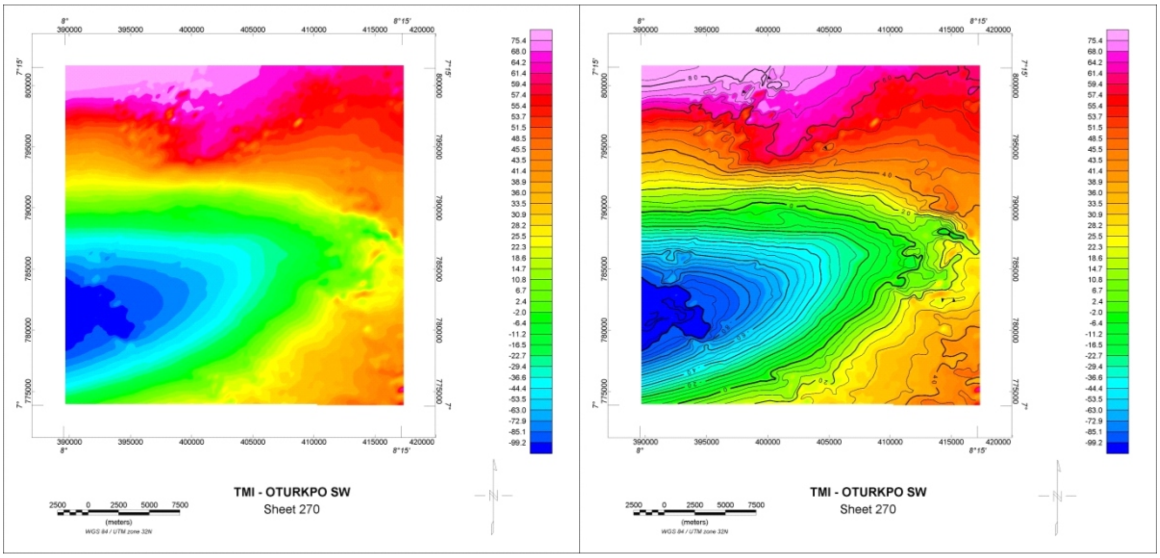

Figure 2. Aeromagnetic map interpretation of the area showing igneous intrusion.

Geochemical Analysis

For geochemical investigation, the X-Ray Fluorescence (XRF) analysis was carried out at the Research Laboratory of Geological Survey Agency of Nigeria, Kaduna; Random samples were picked and analyzed to determine the chemical, mineralogical composition of the ore and of the trace metals.

The sample was powdered to pass through 60µm sieve. 10g of the powdered sample was thoroughly mixed with 1g of stearic acid (binder) and transferred into a circular disk 40mm in diameter and pressed into a pellet at a pressure of 25 tons using special hydraulic pressure to yield a specimen pellet of the sample.

The pellet was measured for major and minor elements using Energy Dispersive X-Ray Fluorescence Spectrometer (Mimi Pal 4). The system condition set for the analysis was 14kv, Kapton Filter used, the measurement was done in air medium for a measurement time of 60 seconds. The system consists of Rh X-ray tube; the detector type is silicon drift detector. The detector can measure photon energies from 1 Kev (Naka) to 17.4 Kev (Moka) efficiently. The maximum count rate is 70,000 – 90,000 count per seconds (Peter, 2006). The spectrometer (Mimi pal 4) can determine elements from sodium to uranium at various condition sets. The result of this analysis is shown in Table 1 below.

Table1: XRF Geochemical Pyrite Analysis result

Major Oxide	Al_2O_3	SiO_2	P_2O_5	SO_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	H_2O+
% Composition	1.00	1.5	ND	37.7	45.07	0.5	0.04	ND	ND	ND	0.054	2.5

Trace Element	Cr	Ni	Zn	Cu	Sn	La	Pb	Ag	Mo
% Composition	0.003	0.001	0.009	0.018	0.001	0.009	ND	1.3	9.6

ND = Not Determined

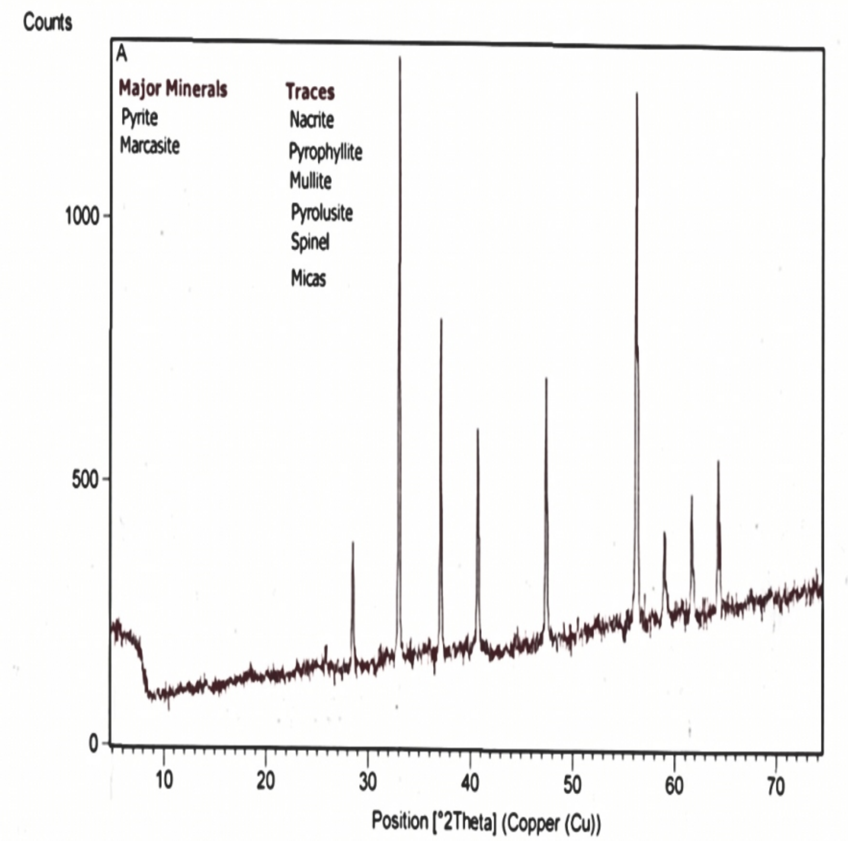

Fig.3: XRF Analysis chart

Origin of the Pyrite Mineralization

Ofoegbu and Odigi (1990) recognized that structural lineaments in the Benue Trough form a strong network of shearing fissures, folding and fractures. There is a perception associated with escape of magma and mineralization in Benue Trough (Wright, 1976). It is also known that magmatic activities were contemporaneous with the opening and infilling of the Benue Trough, resulting in a sub meridian mineralized fractures.

The pyrite mineralization is associated with magmatic activity as the pyrites was discovered within a large igneous rock (dolerite). The large intrusive body lies between 12-15m buried below the surface at the coordinate given earlier. Presently the igneous body at Anmoda is being quarried as construction material. The approximate size of the igneous body can be inferred from the analytical signal map in Fig. 2 Outliving this igneous activity was the rising of (juvenile) mineralizing waters and volatile materials that led to the deposition of the iron sulphide. This activity is usually more pronounced where anticlinal structures resulting from magma eruption have indicated upwelling of sub-crustal materials.

The pyrite mineralization is attributed to the circulation of heated brines, leaching base metals from sediments and underlying basement. Olade (1976) appeals to a deeper and more widespread heat source than localized magmatism to drive the hydrothermal solutions that leached base metals from sediments and underlying basement. The hydrothermal solutions were partly connate pore waters in the sediments. They may have been mainly seawater percolating down onto the sediments and underlying basement to be warmed and supplied with dissolved metals, before migrating upwards to precipitate the sulphides in suitable structural locations.

Here again, the emplacement of the ores by space-filling rather than by replacement argues a tensional regime at the time of mineralization. Igneous bodies presumably acted both as subsidiary heat sources for the circulating fluids and eventually as sites for emplacement of the mineral veins.

Uses of Pyrite

Pyrite is mined for its sulphur. Deposit of pyrite is used in making sulphuric acid. Sulphur and sulphuric acid find multitudinous uses in chemical, metallurgical engineering, textile, pharmaceutical industries etc.

Ogah (2012) identified that Pyrite is used as raw materials in the production of heavy chemicals, fertilizers and insecticides, pulp and paper, paint and vanishes, explosives, dyes and coal tar products, Rayon and film, iron and steel, etc.

The Physical Properties of the Ore and Nature of its Host Rocks

The ore deposit is found overlain by 12-15m thick sedimentary overburden enclosed within a large mass of dolerite intrusive. The pyrite occurs in a banded form (more like a vein) 1m wide and 5-10cm in thickness. The pyrite, specimens examined have a mixture of grey and yellow colour. The mineral grains are interlocking and of medium sizes. The grain particles are irregular in shape. The pyrite has various forms of complex interpenetrant crystals. The lump size, shape and nature of ore bodies affect the workable grade.

Result and Discussion

The XRF result indicate that two major mineral resources are present in the deposit Pyrite and Marcasite. Traces of other minerals like Nacrite, Pyrophyllite, Mullite, Pyrolusite, Spinel and Micas are abounding in the deposit.

Pyrite, a hypogene mineral deposit, derives its source directly from magmatic materials, as evident from the aeromagnetic study of the area. The ore body was deposited by hot watery fluid called hydrothermal solution. In various hydrothermal deposits iron is concentrated in varying quantities as oxides and sulphides. Sulphur occurs as a constituent of pyrite and marcasite which accompany the base metal sulphides as well as in those later minerals in eruptive rocks, with a very uniform brass yellow colour (Telford et al, 1990).

The geochemical analysis gave a grade of 45.07% Fe_2O_3 and 37.7% SO_3. With this result the quality of the Pyrite is good as the recommended average minimum exploitable grade of iron is 25% while that of sulphur is between 20-25 percent (Ogah, 2012).

To be of economic importance the ore must be of high enough concentration, in sufficient quantity and not too deeply buried but yet in a mineable condition. The deposit here is enclosed in a massive intrusive body that would make its mining difficult and expensive. It would involve blasting the igneous body to liberate the pyrite ore. The tonnage of the ore is yet to be ascertained.

Conclusion

The pyrite contains appreciable quantities of iron and sulphur, sufficient to justify its extraction for the various uses mentioned. However the natural and uneconomic condition in which the deposit occurs makes it less favourable for mining at its present economic value.

Recommendations

The pyrite deposit has constituent impurities. The nature of the impurities (trace minerals) too can be evaluated for other industrial uses. As geologists must provide the basis for investment decision in mining using the analytical data derived from its investigations, further basic geotechnical, hydrological and technological properties of the ore deposit are recommended for evaluation. This is important because assessment of the pyrite mineral density, average magnetic susceptibility contrast of the ore, average moisture content, reserve estimation, water absorption and adsorption etc of the mineral are necessary as this will provide basis for decision in mining handling, storage and processing of the ore.

References

Agagu, O.K and Adighije, C.I., (1983). Tectonic and Sedimentation Frame Work of the lower Benue Trough, South-eastern Nigeria. Journal of African earth sciences, 1, 267-274.

Agagu, O.K., Fayose, E.A. and Peters, S.W., (1985). Stratigraphy and Sedimentation in the SenonianAnambra Basin of Eastern Nigeria, Nigeria Journal of Mining and Geology, 22, 25-36.

Benkhelil, J., (1989). The origin and evolution of the Cretaceous Benue Trough. Journal of African Earth Science, 8, 251-282.

Carter, J.D., Barber, W., Tait, E.A. and Jones, J., (1963). The Geology of parts of Adamawa, Bauchi and Borno province in North-Eastern Nigeria. Geological Survey, Nigeria, Bulletin No. 30, 1-109.

Johnson, W.W., (1969). A lest – squares method of interpreting magnetic anomalies caused by two-dimensional structures. Geophysics, 34.P.65-74.

Nwachukwu, S.O., (1972). The Tectonic Evolution of the Southern Portion of the Benue Trough. Geological Magazine 109, 411-419.

Nwajide, C.S., (1986). A systematic Lithostraligrahy of the Makurdi Sandstones Benue Trough, Nigeria. Journal of Mining and Geology 22, 9-23.

Offodile, .E., (1976). A Review of the Geology of the Cretaceous of the Benue Valley.Mecon Services (Nig.) Ltd., Jos Nigeria. P. 365-368.

Ofoegbu, C.O. and Odigi, M.I., (1990). Basement Structures and Ore Mineralization in the Benue Trough. In: Ofoegbu, C.O., (ed.). The Benue Trough Structure andEvolution.Earth Evolution series, Vieweg, 239-248.

Ogah, V.E., (2012). An assessment of the suitability of Pyrite deposit for metallurgical and chemical uses: A Case Study of OgyomaAkpa Pyrite deposit, Otukpo, Benue State, Nigeria. International Journal of Human Resource Development. Vol.2, No.1, 120-128.

Ogah, V.E and Jatau, B.S., (2011). Topographical and Geological Investigations in Otukpo Local Government Area of Benue State, Nigeria. A paper presented at the Nigeria Society of Mining Engineers (NSME) Conference, Kaduna.

Olade, M.A., (1976). On the genesis of lead zinc deposits in Nigeria Benue Rift (Aulacogen). A re-interpretation. J. Mining and geol. (Nigeria) 13, 20-27.

Peter, B., (2006). Theory of XRF: Getting acquainted with the principles Panalytical B.V. Lelyweg 1, 7602 EA Almelo. The Netherlands p.8-21.

Reyment, R. A., (1964). Review of

Nigeria Cretaceous Cenozoic Stratigraphy. Journal of Mining and Geology, 1, 61-80.

Telford, W.M., Geldart, L.P. and Sheriff, R.E., (1990). Applied Geophysics.2nd ed. Cambridge University Press, Cambridge, New York Port Chester Melbourne Sydney, p.3.

Wright, J.B., (1976). Origin of the Benue Trough. Critical review in: Geology of Nigeria (edited by Kogbe, C.A). Elizabeth Publishing Co. Lagos, Nigeria. P.309-317.

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Determination of the Liberation size of Koton Karfe Iron Ore Deposit

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Abstract

The determination of the liberation size of Koton Karfe iron ore was carried out to establish the degree of freedom of the iron bearing minerals. The iron ore is predominantly magnetite, goethite, siderite, and has hematite, silica and other associated minerals as minors. Because of the physicochemical composition of the various types of iron minerals in the matrix of the Koton Karfe iron ore, the liberation size of the Koton Karfe iron ore was determined for both the as-received(run-of-mine (uncalcined)) and calcined iron ore at 1200^{0}C using the sieve size analysis technique . From the assay test conducted, 60.50%Fe_T was obtained for the as-received Koton Karfe iron ore while 64.00%Fe_T was obtained for the calcined Koton Karfe iron ore as the highest assays values of total iron contents at a sieve size fraction of -180+125µm, making the sieve size fraction of -180+125µm the liberation size of the Koton Karfe iron ore.

Significance: To determine the liberation size of Koton Karfe iron ore for the purpose of crushing and grinding the ore to the size required to liberate the valuable mineral from the gangue for the development of the process route of the Koton Karfe Iron ore deposit.

Key words: liberation size, Koton Karfe iron ore,

Introduction

The process design flow sheet of any mineral processing route for a newly discovered ore is usually built on the existing mineral processing conceptual factors that are utilized to present a vivid control mechanism and cost effectiveness of beneficiating the ore. These conceptual factors are numerous; among them is the liberation size of the valuable mineral in the ore. This factor expresses the need to unlock the associated minerals and establish their degree of freedom (or degree of liberation) for the individual mineral in the ore with emphasis placed mostly on the grain size of the valuable mineral and probably the gangue which may likely affect the subsequent separation process. The degree of freedom or liberation refers to the percentage of the mineral occurring as free particles in the ore in relation to the total content. This can be high if there are weak boundaries between mineral and gangue particles, which are often the case with ores composed mainly of rock-forming minerals, particularly sedimentary materials. Usually and however, the adhesion between mineral and gangue is strong and during comminution the various constituents are cleft across producing much middling and low degree of liberation (Wills, 2006).

Among the modern approaches applied

to increase the degree of liberation is directing the breaking stresses at the mineral grain boundaries, so that the rock can be broken without breaking the mineral grains or subjecting the mineral ore to heat-treatment process (calcination) as demonstrated by Yaro and Dungka (2011). Many researchers have tried to quantify the degree of liberation with a view to predicting the behaviour of particles in separation process. The first attempt at the development of a model for the calculation of liberation was made by Gaudin in 1939 while King in 1979 to 1982 developed an exact expression for the fraction of particles of a certain size that contain less than a prescribed fraction of any particular mineral. These models however, suffer from unrealistic assumptions that must be made with respect to the grain structure of the mineral ore, and as a result have not found much practical application. Attempts at quantifying liberation by means of automated optical image analysis have also been relatively unsuccessful due to the inherent inadequacies of the instrument in working with ore assemblies (Wills, 1985).

In comminuting mineral ores, sometimes high degree of liberation is unnecessary in certain processes and may be undesirable. For instance it is possible to achieve a high recovery of values by gravity and magnetic separation even though the valuable minerals are completely enclosed by gangue and hence the degree of liberation of the values is zero. As long as a pronounced density or magnetic susceptibility difference is apparent between the locked particles and the free gangue particles, the separation is possible. A high degree of liberation may only be possible by intensive fine grinding which may reduce the particles to such a fine size that separation becomes very inefficient. Froth flotation and chemical leaching which requires surface exposure of such minerals can be utilized to effectively concentrate/separate them (Weiss, 1985; Wills, 1985; Yaro and Dungka, 2009).

In practice ores are ground to an "optimum mesh-of-grind" to produce an economic degree of liberation which will suite the concentration process. This economic degree of liberation can be determined on the basis of the percentage distribution of the assay values of the valuable and the gangue minerals contained in the mineral ore sieved and retained on various sieves size fractions. It is on this basis that the liberation size of the Koton Karfe Iron Ore deposit is investigated, as it poises as another potential source of iron ore deposit in the country in case the Itakpe iron ore deposit currently being exploited becomes exhausted. (It is expected that the Itakpe iron ore deposit will last for 25 years and that period in the life of a Nation is by no means anything to write home about) (Dungka, Yaro, et-al, 2008).

The Koton Karfe iron ore deposit is located in the vicinity of Igbide village within the Koton Karfe Local Government Area of Kogi State; the deposit was discovered by the Nigerian Geological Survey Department (now Nigerian Geological Survey Agency) and has an estimated ore reserve of about 428 million tonnes. The iron ore is predominantly magnetite, goethite, siderite and has hematite, silica and other associated minerals as minor minerals.
(Dungka, 2008)

Liberation size of some Nigerian Iron Ores Deposits

The Table 1.0 below gives the liberation sizes of some Nigerian iron ore deposits which were determined after grinding to the respective size fractions stated in the table.

Table 1.0: Mineralogy and liberation size of some Nigerian Iron Ores

Ore	Mineralogy of the mineral ore	Liberation size of the valuable mineral in the ore
Agbaja	Principal constituent mineral is goethite With 1.5 % P_2O_5, 46-50% Fe	Effective liberation size = 5µm
Agbado – Okudu	Banded,	Effective liberation is achieved after grinding to -75µm.
Toto-Muro	Consists principally of magnetite, quartz and hematite with 25 – 38% Fe and low phosphorus content.	Effective liberation is achieved after grinding to: 63µm
Itakpe	Coarse grained with magnetite, hematite and quartz.	Liberation is achieved at about 800 – 600µm.
Birnin – Gwari	Banded, consists of magnetite, hematite and quartz.	Liberation size is achieved after grinding to -180+125µm.

(Source: Dungka, 2001, 2002)

Materials and Method

Material

The iron ore samples used for this research work were obtained from Igbide village of Koton Karfe Local Government Area in Kogi State. The samples were collected from three different pits 1,2 and 3 with pits 1and 2 samples obtained at 6 metres depth beneath the outcrop while sample from pit 3 was obtained at 1metre depth, the pits are 400m apart. 50kilograms of samples (totaling 150 kilograms) were collected from each of the three pits in lump sizes.

Equipment

The equipment used in this research work are listed below:

1) Denver pulverizing machine
2) Denver sieve shaking machine
3) Metallurgical microscope with in-built camera and point counting machine
4) Electric weighing machine
5) Muffle electric furnace with temperature range from 0 to 1500°C
6) XRF, XRD machines and gravity wet method of chemical analysis.

Procedure

Preparation of Samples

The 50kg sample from each of the different pits were broken down into small sizes that would be convenient for pulverization. Each pit sample was crushed, pulverized and ground using the laboratory Denver crushing and grinding machine. The pulverized samples were shared into equal parts using the Jones riffles cone and a representative sample from each of the pits prepared for further analysis.

Determination of Chemical Composition of the ore using X-ray Fluorescence (XRF)

The test was carried out to determine the full elemental chemical compositions of the samples from pits 1, 2 and 3 of the deposit using X-ray fluorescence (energy dispersive) technique (XRF). Standards in form of pellets were produced and tested in order to calibrate the XRF machine after which representative sample from pit 1 of the ore was taken, mixed with binder, pressed into pellet and then introduced into the machine and its elemental chemical composition was determined. Same was repeated for each of the representative samples from pits 2 and 3. The silica, phosphorus and sulphur contents of the representative samples from pits 1, 2 and 3 were determined using gravimetric techniques separately and the results are presented in Tables of the already published works in Journals like Journal of Engineering and Technology, Bayero University, Kano, Vol. 4, No.1, Pp 65-71(2009), Journal of Nigerian Society of Mining Engineers (2007) and African Journal of Engineering Research and Development Vol.1, No.1, (2008).

Determination of Mineralogical and Petrological Composition of the ore using XRD and Petrological Microscope

The mineralogical analysis to determine the mineral compositions of the samples from pits 1, 2 and 3 was conducted using XRD machine and the frequency of distribution of the various minerals present in the ore samples was determined using the XRD power diffraction chart. The distribution of the major and minor minerals, their degree of association and their microstructures were analyzed using polarized and unpolarized light of the Petrological microscope with built-in camera and point counting machine. The results have been published in the above said journals for references.

Determination of the Liberation Size of the Calcined and Uncalcined Koton Karfe Iron Ore using Particle Size Analysis

Calcination of the Sample

In this process, only the samples from pits 1 and 2 were used on the basis of their chemical and mineralogical compositions. The samples were blended together after comminution (crushing and grinding) to a fine size. The sample was weighed and divided into two portions using the Jones riffles cone , one portion was taken for calcination and the second portion left as uncalcined. The 10kg of the sample meant for calcination was loaded into the Muffle electric furnace, preheated for 30minutes at the temperature of 450°C and then finally heated to 1200°C. It was heated continuously for 2 hours so as to enhance the drying, burning off of the volatile matters and decomposition of the sample. After 2 hours of heating the sample, the colour changed from light brown to red, an indication that transformation has occurred.

Particle size analysis

The samples of the calcined and uncalcined samples were sieved separately using laboratory Denver sieve shaking machine for 15 minutes on the basis of $\sqrt{2}$ formula into the following sieves size fractions: + 355μm, -355+250μm,-25+180μm, -180+125μm,-125+90μm,-90+63μm,-63+50μm, -50+45μm and -45μm. The sieved size particles were weighed and their weights were recorded. The samples were labeled according to the sieve size fractions in a Nylon pack. The calcined and the uncalcined samples were assayed using (XRF) technique for iron content determination while gravimetric method of analysis was used for silica content determination of the samples. The results of the test are presented in Tables 2-3

Discussion of Result

The determination of the chemical, mineralogical, Petrological compositions and the effects of calcination on the Koton Karfe iron ore sample has been carried out and published already in Journals like Journal of Engineering and Technology, Bayero University, Kano, Vol. 4, No.1, Pp 65-71(2009), Journal of Nigerian Society of Mining Engineers (2007) and African Journal of Engineering Research and Development Vol.1, No.1, (2008).

Determination of Koton Karfe iron ore Liberation Size

Tables 2,3 and figure 1.0 gives the results and variations of the assay values of the iron and silica contents for the calcined and un-calcined various sieved particle size fractions of the Koton Karfe iron ore samples of pit 1 and 2 blend together as a sample. From Table 2 the following assay values were obtained for the uncalcined sieved particle size fractions with 56.8% Fe_T ,3.65% SiO_2 in +355µm, 56.10% Fe_T ,2.71%SiO_2 in –355 +250µm, 54.90% Fe_T ,2.56% SiO_2 in –250 +180µm, 60.50% Fe_T ,1.83% SiO_2 in –180 + 125µm, 56.60% Fe_T 1.38% SiO_2 in – 125 + 90µm, 49.20% Fe_T ,0.71% SiO_2 in – 90 + 63µm, -63 + 50µm has 50.50%Fe_T ,0.47% SiO_2, 51.20% Fe_T ,0.43% SiO_2 in –50 + 45µm and 53.80% Fe_T ,0.36% SiO_2 in -45µm respectively. Table 3 gives the following assay values for the calcined sample as+355µm has 63.10% Fe_T, 3.10% SiO_2, 63.00% Fe_T,2.02% SiO_2 in - 355 + 250µm, 60.20% Fe_T ,1.80% SiO_2 in –250 +180 µm, 64.20% Fe_T, 1.06% SiO_2 in –180 +125 µm, 56.80% Fe_T, 1.05% SiO_2 in –125 + 90 µm, 49.80% Fe_T , 0.37% SiO_2 in –90 + 63 µm, 52.50% Fe_T , 0.36% SiO_2 in –63 + 50 µm, 51.20% Fe_T, 0.34% SiO_2 in –50 + 45 µm and -45 µm has 50.90% Fe_T, 0.32% SiO_2 respectively.

From the results of Tables 2 and 3, it is obvious that sieve size fraction of -180 +125µm has the highest assay values of the total iron content of 64%Fe_T for the calcined and 60.50%Fe_T for the un-calcined sieved samples. Hence, the sieve size of -180+125µm is the liberation size of the Koton Karfe iron ore sample as defined by liberation studies(2006), which states that, it is the size fraction at which the valuable minerals are liberated and has the highest assay value of the valuable mineral retained in that sieve size fractions. The variation in the proportion of the iron content in the calcined and un-calcined Koton Karfe iron ore samples, the decreased in weight of the calcined ore sample and the change in colour of the Koton Karfe iron sample are explained in the already published works as stated above.

Conclusion

In conclusion the determination of the liberation size of Koton Karfe iron deposit has been found to be possible at sieve size fraction of -180+125µm for both the calcined and un-calcined samples of the iron ore. With the calcined sample having iron content of 64%Fe and 60.50%Fe for the un-calcined sample compared to others sieve size fractions of the same iron ore.

Reference

Dungka, G.T. (2002): Beneficiation of Toto Muro Iron Ore Deposit, Dept. of Met. Eng. Ahmadu Bello University Zaria, M.Sc. Thesis, Unpublished.

Dungka, G.T., Jatau, B.S. and Yaro, S.A (2008): The Effects of Calcination on the Beneficiation of Koton Karfe Iron Ore, African Journal of Engineering Research and Development, Vol. 1, No.1.

Weiss, N.L., (1985): Mineral Processing Handbook by American Institute of Mining Metallurgical and Petroleum Engineering Incorporated in the United States of America by Kings Port Press.

Wills, B.A. (1985 and 2006): Mineral Processing Technology, fifth, sixth and seventh Editions, Pergamon Press.

Yaro S.A. And Dungka, G.T. (2009): Chemical And Mineralogical Characteristics Of Koton Karfe Iron Ore Journal Of Engineering And Technology (Jet) Bayero University, Kano Vol. 4, No.1, Pp 65-71

Yaro, S.A and Dungka, G.T. (2001): Determination of Optimum Mesh of Grind Toto Muro Iron Ore, Journal of Engineering Technology and Industrial Application, Kaduna Polytechnic, Vol. 1, pp 71-75

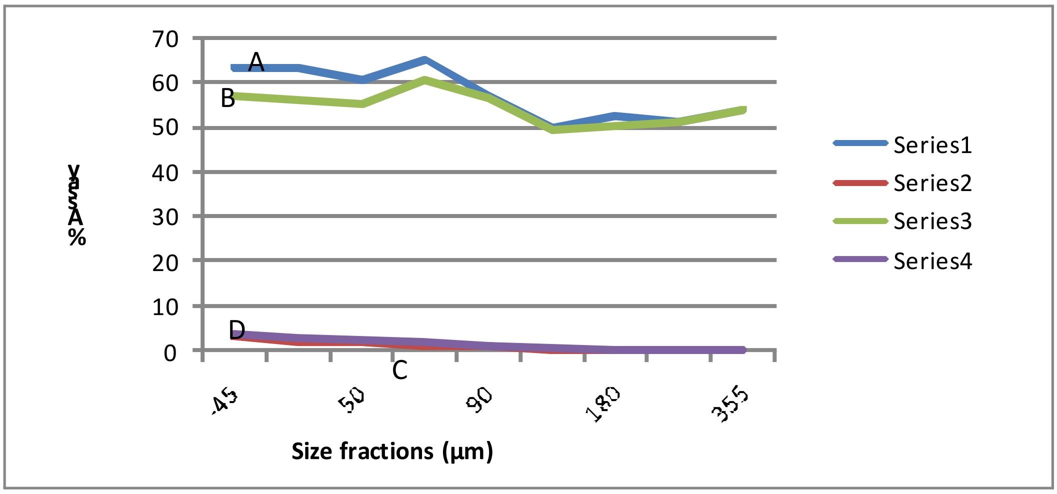
Results of the Analysis of the Calcination Test conducted on Koton Karfe Iron Ore Sample

Table 2.0: Analysis of iron and silica contents of uncalcined sample

Seize size fraction (μm)	Weight retained (g)	Weight Percentage retained (%)	Assay of Fe_T in each Fraction (%)	Assay of SiO_2 in each Fraction (%)
+355	1436	33.68	56.80	3.65
-355+250	343	8.05	56.10	2.71
-250+180	568.00	13.32	54.90	2.56
-180+125	453.5	10.63	60.50	1.83
-125+90	415.50	9.75	56.50	1.38
-90+63	731.00	17.15	49.20	0.71
-63 +50	125	2.93	50.30	0.47
-50+45	99	2.32	51.20	0.43
-45	92.50	2.17	53.80	0.36
	4263.5			

Table 3.0: Assay of iron and silica contents of the calcined sample

Size Fraction (μm)	Weight of sample retained (g)	Assay of Fe_T (%)	Assay of SiO_2 (%)
+355	1021.00	63.10	3.10
-355+250	255.30	63.00	2.02
-250+180	508.00	60.20	1.80
-180+125	308.00	64.80	1.06
-125+90	239.00	56.80	1.05
-90+63	535.00	49.80	0.37
-63+50	61.00	52.50	0.36
-50+45	47.00	51.20	0.34
-45	45.00	53.90	0.32



Key

Series1(A)=%Fe in the calcined sample, Series2(C)=%silica in the calcined sample Series3(B)=%Fe in the uncalcined sample, Series4(D)= %silica in the uncalcined sample

Fig.1: Variation of percentage assay of Fe and silica against size fractions for the calcined and un-calcined Koton Karfe iron ore sample.

Investigation and Evaluation of Environmental Impact of Bitumen Deposit on Building Materials in Agbabu Area Ondo state

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Abstract
Building materials are those materials that are used for building constructions and other engineering structures. These materials are usually subjected to aggressive environment as a result of the presence of contaminants associated with minerals deposit or exploitation in our environment. Bitumen in Agbabu community contains some contaminants that have found their ways into the water and soil which causes the building materials to undergo some physical and chemical changes. These changes may result to loss of strength and other properties that may put building materials into a risk or not performing to design requirement if not properly monitored. As a result of this, the investigation and evaluation of impact of bitumen on building materials in Agbabu community was carried out in order to affirm the level of truth of the recent claim by the community that the deterioration of their buildings is as a result of bitumen deposit in their community. Water and soil samples associated with bitumen deposit were collected from ten (10) different locations within the community in accordance with ASTM D3370 – 10 and ASTM (2005) E-1727 respectively. The samples were analyzed for pH, chloride, sulphate, ammonium and magnesium by using analytical methods of American Society of Testing and Material (ASTM) standard. The mean results obtained from both the soil and water samples show the following concentration: sulphate (48.14mg/l, 5.14mg/l), chloride (7.41mg/l, 3.37mg/l), magnesium (7.52mg/l, 2.14mg/l) and ammonium (8.55mg/l, 2.55mg/l). These results suggest these elements were not responsible for the deterioration of building materials in Agbabu community especially when compared with BRE Digest 363Standard, British Standard, European Pre-Standard ENV 260 and Water Research Centre (WR_c) Standard except soils pH (5.35) that have corrosion effect on concrete, cast iron and steel. The pH value result therefore partly supports the insinuation of the people of Agbabu community that bitumen deposit in their domain is responsible for the deterioration of their buildings.

Keywords: Bitumen, building materials, pH, sulphate, chloride, ammonium, magnesium

Introduction
Agbabu community is located in Odigbo Local Government Area of Ondo State, at an altitude of 62m above the sea level. The bitumen deposit occur between latitude 6º 37'-60' 30'' and longitude 4º 30'-50' 00'' with an area of 247.5 square kilometre wide as shown in Figure 1. The major occupation of the people living in Agbabu community is farming and fishing (Adegoke *et al*, 1991).

Majority of the buildings in Agbabu community were either built with clay bricks or cement blocks with concrete base which have been cracked and deteriorated. Most of the iron and steel used to support the buildings have been rusted including the roofing sheets.

Bitumen was first discovered in Agbabu, Ondo state in 1910 and stretches through at risk their structural integrity or ability to perform to design requirements (Garvin *et al*, 1996). The major substances associated with bitumen deposit that have various effects on building materials are sulphates, chlorides, acids, magnesium salts, ammonium salts and chromium ions.

This research work was carried out in order to assess the recent claims of Agbabu communities that the deterioration of their building is as a result of bitumen deposit in their communities. The identified buildings materials in this community are concrete/concrete reinforce, masonry (e.g. clay bricks, concrete/cement blocks, mortar) and metals (e.g. cast iron, steel/stainless steel).

Materials and Method

Sample collection: A total of ten (10) representative water samples (500 ml each) were collected into a different polyethylene bottle in accordance with ASTM D 3370 – 10, which were properly rinsed with the same sampled water. Floating debris and other contaminants were avoided while collecting the samples. The samples were properly labeled as WS_1, WS_2 to WS_{10} and then taken to the laboratory without undue delay for analysis. Soil samples were also collected from ten (10) different places by using auger at a depth ranges from 10 to 60cm in accordance with ASTM (2005) E-1727. The samples were transferred to plastic bags and labeled as SS_1, SS_2 to SS_{10} and taken to laboratory for analysis.

Laboratory Analysis: The analyses of water and soil samples were carried out at the Chemistry Departmental Laboratory of the University of Ibadan.

Water analysis: In the laboratory, the representative water samples were concentrated by measuring about 100ml of each of the samples into 250ml beaker with 10ml of concentrated nitric acid and heated until the volume of the water reduced to 50ml in accordance with ASTM D1971-11. The sample was filtered and analyzed for pH, sulphate, chlorides, ammonium and magnesium. The pH was determined by using pH precise laboratory measurement in accordance with ASTM D1293-12 while chloride was determined by using Silver nitrate titration in accordance with ASTM D512-12. While magnesium was determined by complexometric titration in accordance with ASTM D511-09 (Cheng and Bray, 1951) and sulphate was determined by turbidimetric method in accordance with ASTM D516-11.

Soil analysis: In the laboratory, soil samples were air-dried, crushed and finely grounded, sieved through 2.0mm in accordance with AASHTO T 248 and the representative samples were preserved in labeled plastic bags. 1.0g of the representative sample was digested in 3ml of concentrated hydrofluoric acid (HF) and 5ml of aquaregia. The mixture was heated in steam bath in addition with 15ml of saturated solution of boric acid for about 30mins in accordance with ASTM D 1586 - 98. The pH was determined by using pH meter in accordance with AASHTO T 289 while chloride was determined by using Mohr's titration method in accordance with ASTM T291; Magnesium was determined by ASS in accordance with ASTM D511-09 and sulphate was determined by gravimetrically method in accordance with ASTM T 291.

Results and discussion

Results: The results of the laboratory analyses of the water and soil samples collected from Agbabu community within the bitumen deposit area are shown in Table 1 and 2 respectively.

Okitipupa, Irele, Odigbo and Ese-odo local government areas. The first commercial exploitation of bitumen was by the defunct Nigeria Bitumen Corporation (NBC) between 1908 and 1914 (Adegoke *et al*, 1991). Since then, both foreign and indigenous institutions as well as experts have been invited to conduct various types of researches and studies on the bitumen deposit between 1907 and 1990. Their findings provides the total reserve of Nigeria bitumen deposits and also ranks Nigeria alongside Egypt, and Madagascar as the three leading countries with potentials in oil sand and heavy oil resources (Adegoke and Ibe, 1982).

Figure1: Location Map of the Study Area

Bituminous sands contain naturally occurring mixtures of sand, clay, water, and dense viscous form of petroleum technically referred to as bitumen. The crude bitumen is petroleum that exists in the semi-solid or solid phase in natural deposits (Akande and Akinbinu, 2005). Bitumen contains several elements, a number of which are toxic. According to Adebiyi and Omode (2007) the chemical composition of Nigeria bitumen are Asphaltenes (9-18%), Resinous or Polar Aromatics (39–44%), Non-Polar aromatics or Naphtene aromatics (12 – 19%), Saturates (22 – 24%), Sulphur (1.3%), and Trace metal (Nickel 33-36ppm, Vanadium 25-28ppm). They concluded that some of these chemicals and metallic components that are associated with bitumen deposit contaminate soil and water, thereby putting the various objects on the land and water at risk, such objects includes building materials, living organism etc.

Building materials are materials that are used for building construction and some other civil engineering structures which include: building block, stone, granite and mortar, cement, timber, iron sheet, and other roofing materials (BRE, 1994). Building materials are often subjected to aggressive environments, as a result of the presence of contaminants associated with mineral deposit, industries, and other activities of man which cause them to undergo physical or chemical changes. These changes may result in loss of strength or other properties that may put

Table 1: Result of Water Analysis

WATER SAMPLES	pH	Chloride (mg/L)	Magnesium (mg/L)	Sulphate (mg/L)	Ammonium (mg/L)
W_{S1}	8.30	2.57	2.65	3.18	3.22
W_{S2}	8.50	3.24	2.44	3.04	4.12
W_{S3}	8.20	3.22	2.06	3.83	0.36
W_{S4}	8.10	4.23	1.64	6.14	0.38
W_{S5}	8.40	3.32	2.20	4.55	2.02
W_{S6}	8.00	2.37	2.42	6.54	2.53
W_{S7}	8.10	4.12	1.66	6.31	3.44
W_{S8}	7.80	3.34	1.78	5.67	3.25
W_{S9}	8.10	4.23	2.34	6.02	3.04
W_{S10}	8.20	3.13	2.21	6.07	3.16
MEAN	8.17	3.37	2.14	5.14	2.55

Table 2: Result of Soil Analysis

Water Sample	pH	Chloride (mg/l)	Magnesium (mg/l)	Sulphate (mg/l)	Ammonium (mg/l)
Ss1	5.23	8.22	8.43	51.80	8.55
Ss2	5.14	8.30	6.32	36.30	7.38
Ss3	5.33	6.93	6.05	42.10	8.38
Ss4	5.42	5.33	8.92	57.40	9.37
Ss5	5.34	5.83	8.48	58.60	10.40
Ss6	5.55	7.14	7.24	45.70	8.58
Ss7	5.35	8.52	8.13	48.90	8.40
Ss8	5.23	8.07	7.61	53.50	8.67
Ss9	5.42	7.32	6.41	32.50	7.36
Ss10	5.47	8.43	7.58	54.60	8.34
Mean	5.35	7.41	7.52	48.14	8.55

Discussion

Effects of pH: The acceptable pH standard for concrete according to British Standard (BSI, 1988) is ≥ 5.5. Comparing this standard with the mean pH value of the soil and water samples as shown in Table 1 and 2 respectively, it can be deduced that soil pH is one of the factors responsible for the cracking, spalling and deterioration of concrete used in foundation base of Agbabu's buildings. More so, the pH limit for asbestos cement use in soil and water according to British Standard BS 8010: 1985 (BSI 1988) is ≥ 5.5. When this standard was compared with the mean pH value of the soil and water samples, it shows that soil pH contributes to the corrosion of asbestos cement used as building material in Agbabu community. The guidelines of Water Research Centre (WR_C) on the use of metals stated that highly acid water and soil of pH < 5 are corrosive towards cast iron (Crathorne, 1987and BRE, 1994). Comparing this pH value with that of water and soil as indicated in Table 1 and 2 respectively, it suggests that pH is not responsible for the corrosion of cast iron used as a building material in Agbabu's community. According to BRE (2000), the acceptable pH range for steel is 6.5 to 8.5. When this value was compared with soil pH (5.35) as indicated in table 2, it can be deduced that soil pH is one of the factors responsible for the corrosion and deterioration of steel used in reinforcement, septic tank and others in Agbabu's buildings.

Effects of Sulphate: According to European Pre-Standard ENV 206, the sulphate concentration in water and soil that can attack any forms of concrete is ≥ 600 mg/l. Comparing this value with mean concentration of sulphate in water and soil samples as indicated in Table 1 and 2 respectively, it was clearly shown that sulphate is not responsible for the cracking, spalling and disintegration or loss of strength of any forms of concrete used as foundation base in Agbabu's buildings. However, British Standard BS 8010: 1985 (BSI 1988) advises that where the pH is less than 5.5 and the SO4 level above 5mg/l the use of concrete must be closely monitored. Therefore, the use of concrete in Agbabu community must be closely monitored and protected since the soil pH is <5.5 and sulphate is >5mg/l. BRE Digest 363(1999) stated that the durability of clay bricks under salt crystallization attack is attributed to a combination of their low soluble salt content, low porosity and coarse pore structure. Since the mean concentration of sulphate in soil and water is very low as indicated in Table 1 and 2 respectively, it therefore not responsible to the cracking and the deterioration of the clay bricks used for building in Agbabu community. Meanwhile, it concluded that cement blocks will be affected where sulphate levels exceed 3mg/l which means that both sulphate in the soil and water would contribute to the cracking and disintegration of cement blocks used for building in Agbabu community.

Effects of Chloride: The stipulated limit for chloride by BRE Digest 363 (Watford, 1996) in soil and water that can attack concrete is ≥ 2000mg/l. When this value was compared with the mean concentration of chloride as shown in Table 1 and 2 respectively, it was observed that chloride has no effect in deterioration of concrete and reinforced concrete used in buildings of the study area. Moreso, Water Research Centre guidance stated that soil and water contain ≥ 300ppm chloride may corrode even protected cast iron and steel. When this value was compared with that of water and soil as shown in Table 1 and 2, it was clearly shown that chloride was not responsible for corrosion of iron and steel used as building material in Agbabu community.

Effects of Magnesium and Ammonium salts: The acceptable standards of magnesium and ammonium salts for concrete according to European Pre-Standard ENV 206 are ≥ 1000 and ≥ 30mg/l respectively. When these values were compared with that of magnesium and ammonium salts as shown in Table 1 and 2, it was concluded that magnesium and ammonium salts were not responsible for the loss of strength and deterioration of the concrete used in Agbabu's building.

Conclusion and Recommendation

The results of the analysis of the soil and water samples showed that bitumen in Agbabu community contains some contaminants that have found their ways into the soil and water of the study area which can have deleterious effects on building materials. These contaminants include pH, sulphates, chloride, ammonium, and magnesium. Though, the concentration of some of these contaminants in the soil and water bodies associated with the bitumen deposit is very low to the level of affecting the building materials used in Agbabu community as insinuated by the people. Only soil pH contributed to the corrosion effect of concrete, cast iron and steel used as building materials in Agbabu community.

Meanwhile, the concentrations of other contaminants have to be closely monitored as there is rises in water level of the area. The claims of the community cannot be completely rejected since pH played significant roles in corrosion of some of their building materials. Therefore, the following recommendations are made in order to reduce the effect of corrosion in building materials used in Agbabu community:

(a) The community should make use of well compacted concrete with a low water:cement ratio in addition to coatings or sacrificial layers to resist corrosion; iron and steel should be coated with epoxy coatings or make use of corrosion inhibitors e.g. nitrite based inhibitors to resist corrosion

(b) Local expert should be employed to assess the building site prior to commencement of building in order to give technical advice.

(c) Government should expedite action on exploitation of bitumen deposits in order to boost the economy of the community so that they can afford to purchase standard building materials.

(d) This research work should be reviewed by the time the exploitation of bitumen commences in order to take immediate action on any effect of bitumen exploitation on building material in Agbabu community.

References

AASHTO (2010). Technical Manual for Design and Construction of Road Tunnels – Civil Elements, Washington DC,

AASHO T298 (1991). EN-standard Method of Testing for determining pH of Soil for Use in Corrosion Testing-Twentieth Edition, available at www./page45.aspx.

Adebiyi, F.M. and Omode, A.A. (2007). Chemical and elemental characterization of components of Nigerian bitumen sands. Energy sources 29(8): 669-676.

Adegoke, O. S. and Ibe, E. C. (1982). The tar sand and heavy crude resources of Nigeria. Proc. 2nd Intern. Conf. on heavy crude and tarsands, Caracas, Venezuela, ch 32: 280 – 285

Adegoke, O. S., Omatsola, M. E. and Coker, J. L. (1991). The geology of the Nigerian tarsands. In: Heavy crude and tarsands hydrocarbons for the 21st century. Proc. 5th UNITAR Intern.Conf. on Heavy Crude and Tarsands 1991: 369 – 385

Akande, J. M. and Akinbinu, V. A. (2005). Impact Assessment of bitumen mining on the water and soil characterization of mining area of Ondo State. J. Sci. Eng. Technol 12:2

ASTM Annual Reports, (2010). "Referenced in the NRC Regulatory Guides": In Water Testing Standards-ASTM International available at www.astm.or/standards/water-testin, accessed on 12th October, 2012

Barker, A.P and Mathew, J.D. (1994). Concrete Durability Specification by Water/cement or Compressive Strength for European Cement Type: In the European Pre-standard for Concrete, ENV 206, available at www.concrete.org/PUBS/JOURNALS/OLJD, accessed on 12th October, 2012

Baker, D.E. and Suhr, N.H. (1982). Atomic absorption and flame emission spectrometry. Methods of soil analysis, Part 2. 2nd edition. Agronomy Monogram. Madison, USA, ASA and SSSA.

BRE Digest, 363 (2000). The Building Research Establishment Document Deals with the Specification of Sulphate Resisting Concrete, available at www.encyclo.co.uk/define/Bre%2520 Di../, accessed on 12th October, 2012

British Standards Institution (1993). 'Structural Use of Concrete. Code of Practice for Design and Construction'. British Standard BS 8110:Part 1:1985. London. BSI, 1985. (Reprint incorporates Amendments AMD 5917, May 1989; AMD 6276, December 1989; and AMD 7583, February 1993)

British Standards Institution (BSI,1988). 'Code of Practice for Pipelines'. Part 2. Pipelines on land: Design, Construction and Installation. Section 2.3:1988. Asbestos Cement. British Standard BS 8010: Section 2.3:1988. London,

Building Research Establishment, Watford (1996). 'Sulfate and Acid Resistance of Concrete in the Ground'. BRE Digest 363, Construction Research Communications Ltd.

European Pre-standard ENV 206 (1988). Concrete Performance, Production, Placing and Compliance Criteria, pp. 230-255

Garvin, S. L, Lewry, A.J and Ridal, J.P. (1996). 'Building Materials Performance in Contaminated Land: Experimental and Field Work', Proceedings of the Third International Symposium on Environmental Contamination in Central and Eastern Europe, pp835-837, Warsaw, September, 1996.

Grimm C T. (1987). 'Durability of Brick Masonry: A Review of the Literature'. American Society for Testing and Materials Special Technical Publication STP871. Philadelphia, ASTM, pp 202-234, 1987.

Moersh J, *et al* (1995). 'Investigations into the Durability of Corrosion Protection by Epoxy Coatings on Reinforcement', Advances in Concrete Technology, Proceedings 2nd CANMET/ACI Int Sym, Las Vegas, USA, SP170-11.

Water Research Centre. The Research Centre for Construction and Real Estate Economic and the Research Centre for Construction, available at www.bre.polyu.edu.hk/publications/d ../ , accessed on 12th October, 2012

Water Research Centre (1987). 'The Effect of Soil Contaminants on Materials Used for Distribution of Water'. Final report to the Department of the Environment,1452-M. Medmenham.

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