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# Mineralogy of Basalt in Ikom, Cross River State of Nigeria.

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***Abstract:***
***Background****: Basalt is a dark coloured, hard, dense, fine grained basic volcanic extrusive rock. It is a very important rock widely spread across Ikon in Cross River State of Nigeria and the globe. It is extensively used as engineering materials such as basalt reinforcing fibre, as coarse aggregates for cement and asphaltic concrete mix, rock fill for dams and break waters in sea port construction, material for rail road ballast and highway base course.*
***Materials and Methods****: Basalt coarse aggregate samples were collected from the site and examined in the laboratory using X-ray diffraction method.*
***Results****: The samples were found to contain a major percentage of Silicon oxide followed by Aluminium oxide and other trace minerals such as Antimony oxide, Strontium oxide and Lead oxide. The results show that the mineralogical composition of Basalt in Ikom are suitable for use as coarse aggregates in the production of concrete for structural elements.*
***Key Word****: Basalt, coarse aggregate, mineralogy, diffraction, composition, rocks.*

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## I. Introduction

Basalt is a dark coloured, hard, dense, fine grained basic volcanic extrusive rock. It is a very important rock widely spread across Nigeria and the globe. It is extensively used as engineering materials such as basalt reinforcing fibre, as coarse aggregates for cement and asphaltic concrete mix, rock fill for dams and break waters in sea port construction, material for rail road ballast and highway base course [1]. Other uses of basalt includes; polymer reinforcement, auto, aircraft and ship building as well as fire proof products.

Basalt is basically composed of plagioclase, pyroxene and olivine and often having a glassy appearance. It has several interesting properties including high thermal conductivity, inert with no environmental risks. It has high modulus of elasticity (E = 60 – 80GPa) resulting in excellent specific tenacity three times that of steel fibre, high tensile strength, resistant to acids and aggressive chemicals, electromagnetic resistant and good fatique resistance [2].

Detection of aggregate properties and behavior before use in construction activity can indicate the unexpected happening and can prevent the post construction problems likely to be associated. This explains why it becomes necessary to sample and properly test aggregates to guarantee durability and optimum performance of construction [3].

Basalt is found in large quantities in Cross River State and the north central region of Nigeria. These are found in the Bachit formation, Kahwang rock formation and the Ikom columnar basalt in Cross River State [4].

[4] States that basalt rocks are chemically characterized by low absorption of humidity, they exhibit eight loss in boiling water and are more stable in strong alkalis. Basalts are compatible with phenolic resins and possess resistance to ultra violet (uv) radiation and also resistant to biologic and fungal contamination. Basalt has a melting point of $1450^0$c and a low thermal conductivity of 0.031 – 0.038 w/mk (watts per meter-kelvin) making it ideal for fire protection and insulation applications.

Basalt is well distributed across the geopolitical zones of Nigeria, it is densely concentrated in the Jos and Biu plateau [5]. In the south eastern part of Nigeria, the Afikpo basin and Anambra basin hosts some igneous rocks which are basaltic in nature [6]. Basalt is largely found in the Jos plateau, the Biu plateau which is located north of the Jos plateau, the Benue valley which is located south of the Jos Plateau, the Cameroun volcanic line and the ocean islands in the Atlantic Ocean, to the south east [5].

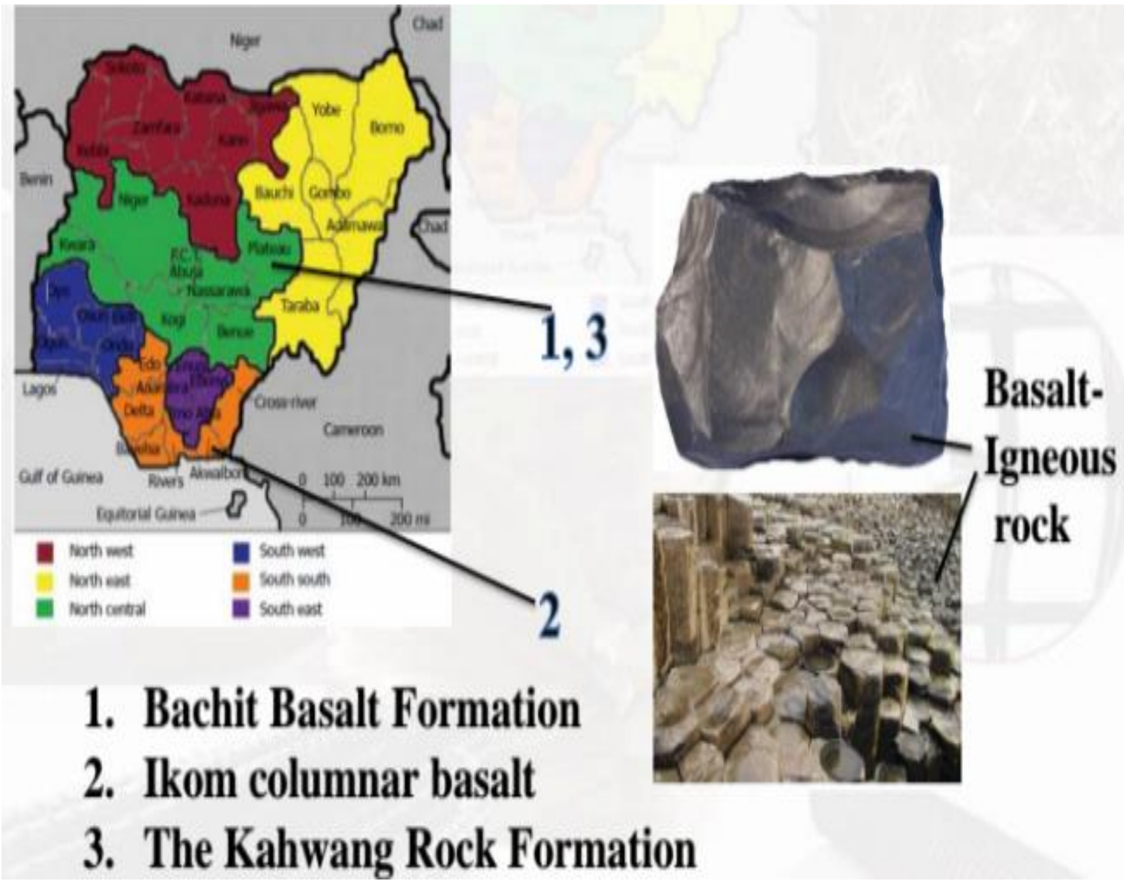

Figure 1.0: Formation of Basalt in Nigeria [4].

The mineralogy of basalt is characterized by the major presence of calcic-plagioclase feldspar and augite and partly olivine [3]. Coarse aggregates of different mineralogical composition produces concretes of different characteristics as the type of aggregate affects the stiffness and strength of long-term deformations of hardened concrete [7]. This is because some coarse aggregates could be reactive with cement in the negative form while some coarse aggregates are inert materials, just filling spaces. This reactivity of aggregates explain why the elastic modulus, creep and shrinkage could vary depending on the type of aggregate. The mineralogical composition of aggregate also affect the resistance of concrete to abrasion.

Chemical analysis on basaltic rocks shows that basalt is mainly composed of silicon di oxide $s_{i}o_{2}$ (48.70%), followed by aluminium (16.15%) and iron oxides (11.55%), a composition that reflects the basic rock quality. Others include: calcium oxide (8.29%), magnesium oxide (6.22%), potassium oxide (1.07%), sodium oxide (4.39%), sulphate oxide (0.3%), Phosphate oxide (0.46%), Titanium oxide (1.81%) and loss on ignition (0.89%) [3].

**Table 1.1:** Chemical composition of Hamdan basaltic rock [3].

| Oxides | SiO2 | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SO_3$ | $P_2O_3$ | $TiO_2$ | LOI | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % | 48.70 | 16.15 | 11.55 | 8.29 | 6.22 | 1.07 | 4.39 | 0.30 | 0.46 | 1.81 | 0.89 | 99.84 |

Basalt is composed of 48.0% silicon dioxide, 15.1% iron oxide, 14.4% aluminium oxide, 6.18% calcium oxide, 5.95% magnesium oxide, 4.05% sodium oxide, 2.29% potassium oxide, 2.29% titanium oxide and 1.74% loss on ignition [6].

**Table 1.2:** Chemical composition of basalt rock [6].

| **Compound** | **Percent** |
|---|---|
| Silicon dioxide | 48.0 |
| Aluminium oxide | 14.4 |
| Iron oxide | 15.1 |
| Calcium oxide | 6.18 |
| Magnesium oxide | 5.95 |
| Sodium oxide | 4.05 |
| Potassium oxide | 2.29 |

| | |
|---|---|
| Titanium oxide | 2.29 |
| Loss on ignition | 1.74 |

"Basalt is a magnesium-rich primitive rock containing silicon, iron and calcium with trace minerals with no elutriation or leaching into ground water. It is non-toxic and safe to aquatic animals and plant life" [2]. Basalt powder chemical analysis in Jordan yielded the chemical composition by mass as follows; 48.84% silicon dioxide, 15.52% aluminium oxide, 10.38% iron oxide, 9.52% calcium oxide, 6.60% magnesium oxide, 3.95% sodium oxide, 1.66% titanium oxide, 1.01% potassium oxide, 0.37% phosphate oxide and 1.15% loss on ignition [2].

**Material and Methods**

The X-ray diffraction method was used to determine the mineral content of the basalt samples.

**X-ray Diffraction (XRD) Procedure**

The XRD was powered and from the panel, the voltage and current were set at 45kV and 40 mA. The temperature was set at 21-23 $^0$C. The computer system was switched on and the software of XRD was double clicked to run. The settings dialogue was clicked and all the required setting of power and temperature were checked to correspond to that of the XRD. Sample was poured into the sample holder and then placed in the sample chamber column. Then the door was shut and confirmed from the computer. The measurement setting were then set for scan axis as Gonio, start and end position were also set so is the angle and time of scan. The scan began and then stopped at the required time and the result was saved to a file.

The Scanning Electron Microscope energy dispersive X-ray spectroscopy (SEM-EDS) Phenom Prox model, manufactured by phenomWorld Eindhoven, Netherlands was used to carry out the morphology analysis. Sample is placed on the Aluminium holder stub using sticky carbon tape. The sample was insulated using gold and then grounded electrically. The samples each are then labeled on their stub, then dried in the oven at 60 $^0$C. Nitrogen line was opened at 50 psi and the vent button is pressed to fill the area with nitrogen for proper purging of the chamber. The sample holder stub was then placed in the sample chamber holes and the door was shut and the rotary pump picked and a vacuum of 5 x 10 $^{-5}$ Pa was created. The filament light was switched on and the monitor automatically switched on. At this stage, the accelerator voltage was 15kV and the filament burned out. The atoms on the surface are excited by the electron beam, emitting specific wavelengths of X-rays that are characteristic of the atomic structure of the elements. An energy dispersive detector (a solid-state device that discriminates among X-ray energies) can analyze these X-ray emissions. Appropriate elements are assigned, yielding the composition of the atoms on the specimen surface. The lowest scan mode of 10x is picked and the TV scan clicked. The magnification is then taken to 1000x at a slow scan, 2000, 3000 to 5,000. The Energy dispersion spectrum scan on the intensity of each of the element present and gives the molar concentration in %, then Image was saved. This procedure is called The Scanning Electron Microscope Energy dispersive X-ray spectroscopy (SEM-EDS) and is useful for analyzing the composition of the surface of a specimen

## II. Result

The results of X-ray diffraction on the samples are presented in table 4.1

**Table 2.1: Mineral composition of Ikom Basalt**

| **Element** | **Content (%)** |
|---|---|
| $Al_2O_3$ | 13.4890 |
| $SiO_2$ | 46.0494 |
| $P_2O_5$ | 15.1785 |
| $K_2O$ | 1.4800 |
| CaO | 7.2923 |
| $TiO_2$ | 1.7210 |
| MnO | 5.0928 |
| $Fe_2O_3$ | 5.4558 |
| SrO | 0.0872 |
| $Na_2O$ | 3.0045 |
| $Sb_2O_3$ | 0.0051 |
| PbO | 0.0030 |
| Loss on Ignition | 1.1414 |

## III. Discussion

The percentage composition of the various elements in Basalt sample determines the reactivity of the basalt coarse aggregates when it is used in the production of concrete. Since aggregates are supposed to be inert and not expected to participate in any chemical reaction with cement in the process of concrete hardening, it is critical to know the mineralogy of aggregates to determine their reactivity and suitability for use.

The results show a greater percentage of Silicon oxide (46.0494 %), followed by phosphorus oxide (15.1785 %) which is closely followed by Aluminium oxide (13.4890 %). Others include: Calcium oxide (7.2923 %), Iron oxide (5.4558 %), Manganese oxide (5.0928 %), Sodium oxide (3.0045 %), Titanium oxide (1.7210 %), Potassium oxide (1.4800 %), Strontium oxide (0.0872 %), Antimony oxide (0.0051 %) and Lead oxide (0.0030 %). The results show that basalt aggregates in Ikom are suitable for use as coarse aggregates in the production of concrete since the composition of silicon oxide is less than 50%.

## IV. Conclusion

The mineralogy of basalt in Ikom, Cross River State of Nigeria has been determined using X-ray diffraction method in the laboratory. The mineralogical composition of coarse aggregates is very important in determining the suitability of coarse aggregates for production of concrete. Since coarse aggregates are expected to be non-reactive, their mineralogical composition is critical to ascertain their suitability for use in concrete production. The investigation show the following:

- The mineralogical composition shows a higher percentage of silicon oxide (46.0494 %) and the least percentage of Lead oxide (0.0030 %).
- Basalt in Ikom will be suitable for production of concrete for structural element since the percentage of silicon oxide is less than 50 %.
- The mineralogical composition will be useful in further analysis in determining the alkali-silica reactivity of basalt coarse aggregates in concrete production.

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