PRELIMINARY REPORT ON BORBORBU BATHOLITH GEOLOGY

Report Title: PRELIMINARY REPORT ON A BATHOLITH FOR QUARRYING

Report Subtitle: GEOLOGICAL AND GEOTECHNICAL OVERVIEW OF THE OUTCROP'S COMPOSITION AND STRENGTH

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1.0 INTRODUCTION

Bo town is the second capital city of Sierra Leone, and as demands for both roads and other infrastructures keep soaring, so is the demands for the construction materials. The aggregates demands for all local engineering construction except roads is been provided by the local miners who use fire to create thermal expansion and sudden contractions resulting in exfoliation of the rock. And of course this has it downsides on the general strength of the aggregate. While the road construction companies operate on aggregates they produces and do not sell their aggregates. Until most recently there is one private company in Bo which is producing dimension stones for both local and international market.

The geological and geo technical view as will be seen further chapter will discuss in detail the batholith composition and strength and aggregate strength and the general geomorphology and access

A place where rocks are mined is called quarry and the act of mining the rock above ground level is quarrying. This can be done by local individual miners on small scale and also by companies on a large scale the can last for centuries. Therefore, for company to last longer, the batholith must be in economic quantity like the Borborbu batholith. A batholith in economic quantity has been identified and studied around in the Borborbu community, Gbo chiefdom, Bo district. A boot on ground Trip was made to the site for day field trip was at the site for geological field observation of the outcrop and collecting of fresh samples for further analysis which is the subject of this paper. Field observation, laboratory analysis and desk study all arrived at the same conclusion with a GARNETIFEROUS GNEISS nomenclature for Borborbu batholith. Gneiss as we know is characterized with high quality and economical value because of their engineering properties. They can be used for ornamental work, building stone, and cladding and as tiles. These properties of gneiss which makes it valuable in the construction companies will be elaborated upon in further chapter.

The composition of batholith mined depends on the location of the outcrop within the country. A quarry in Freetown will be mafic; gabbroic, pyroxenite, anorthosite or norite. Elsewhere in the same country you find quarry of different composition. In Bo to be specific, you find felsic minerals, light coloured batholith of granitic gneiss. The map in figure 1 illustrates the geology of Sierra Leone, with more focus on the studied area.

2.0 GEOLOGY OF SIERRA LEONE

The West African craton composed mainly of Archaean granite-greenstone terrain (Williams 1978), is bounded on the west by a westward dipping zone of intense, ductile shear deformation which has been interpreted as a possible Archaean suture or terrane boundary (Williams 1979, 1988). To the west of this shear zone lie granulite facies metamorphic supracrustal of the Archaean Kasila Group (Williams & Williams 1976). Immediately to the east of the shear zone, klippen of mainly greenschist facies, recumbently folded metasediments and volcanic rocks the Marampa Group, lie on Archaean granite-greenstone terrain. The Marampa Group, probably of late Archaean or early Proterozoic age (Hurley et al. 1971), also lies in tectonic contact with the late Precambrian to Cambrian sedimentary and volcanic rocks of the Rokel River Group (Allen 1969). The western side of the country is occupied by the Freetown basic igneous complex. Next lying to it is the Bullom group which is the youngest group.

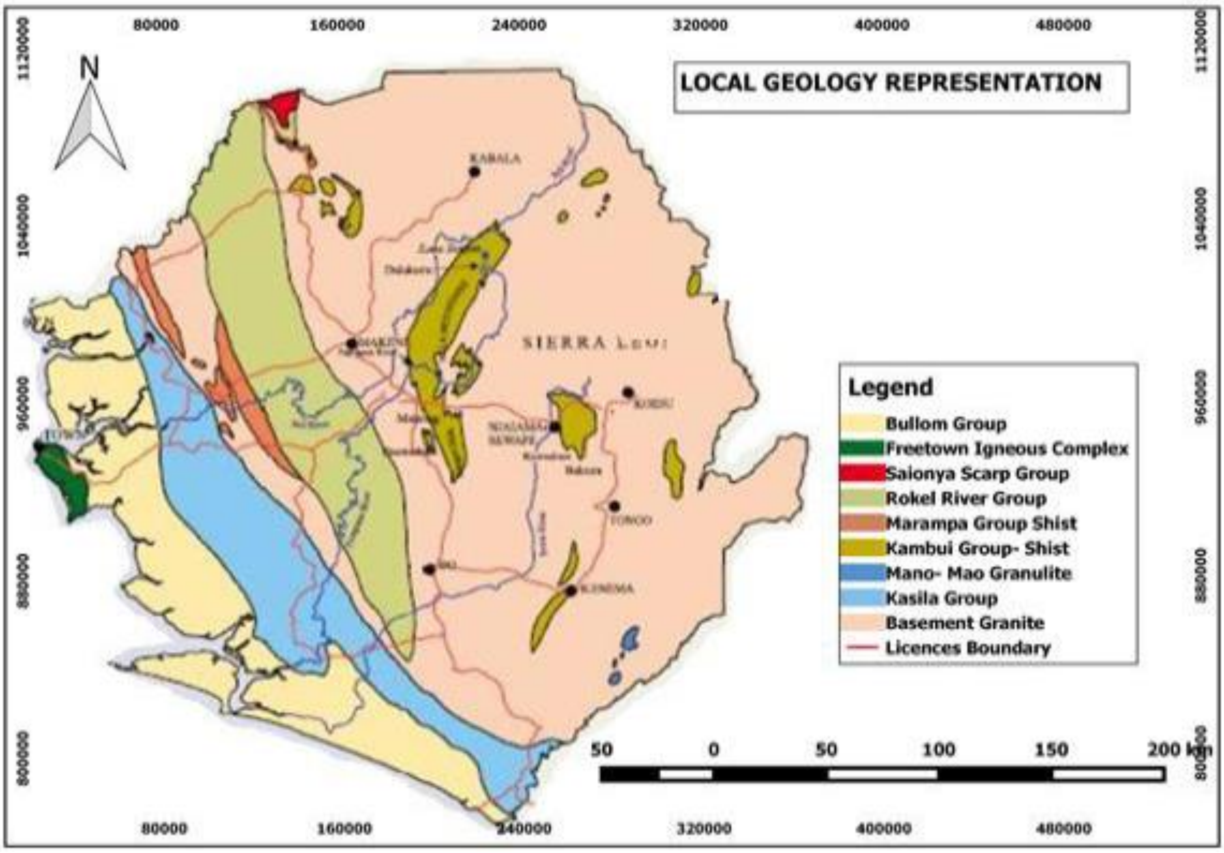

Figure 1 showing the Geology map of Sierra Leone

3.0 THE GEOLOGY OF THE STUDIED AREA

The studied area is in the granite greenstone terrain, where in granitic component forms the most dominant section of the division. It formed the basement granite, the supracrustal and the younger granitic intrusion. The greater part of the basement is occupied by the basement granitic shield containing gneissic relics of still older formations. They date from the early

Archean and include coarsely crystalline granites, quartz granulites, and hematitic granulites. Upon them, apparently unconformably, lie serpentines, amphibolites, conglomerates, and iron-stones of the ophiolitic Kambui Group which forms the Sula Mountains and the Kangari, Kambui, Nimini, and Gori ranges of hills. As these have also been deformed and metamorphosed together with the underlying gneisses and intruded by late and post- orogenic granites it seems clear that there have been several epochs of granite formation.

In northern Sierra Leone a complex history of granite formation, migmatization, deformation along east-west axes, and pegmatite formation can be found. This thermotectonic episode is defined as the Leonean and it is assumed that it preceded the deposition of the Kambui Group. Another thermotectonic episode recorded in this terrain is the Liberian event which is younger (less than 2700ma) than the Leonean event and as a result leaves its NS striking features in the terrain. The younger granitic intrusion is the youngest in the Archaean granite greenstone terrain and the batholith at Borborbu is a typical example.

4.0 BORBORBU GRANITIC GNEISS BATHOLITH

Borborbu granitic gneiss is 525 acres as area measured on Sierra Leone Topographic Map seen on page 11 figure 8. It is a typical high grade metamorphic rock, formed from the metamorphism of the granite in the Granite Greenstone Terrain. In general, it was subjected to higher temperatures and pressures and displays distinct foliation, representing alternating layers composed of different minerals. The most common minerals in it are quartz, feldspar with traces of biotite, muscovite and hornblende. The appearance of granular minerals is what marks the transition into gneiss. Intense heat and pressure can also metamorphose granite into a banded rock known as "granite gneiss." This transformation is usually more of a structural change than a mineralogical transformation. Although gneiss is not defined by its composition, most specimens have bands of feldspar and quartz grains in an interlocking texture. These bands are usually light in color and alternate with bands of darker-colored minerals with platy or elongate habits. The knowledge of gneiss including its strength, deformation behaviour in conjunction with their distinct mineralogical compositions is important in geotechnical engineering. Hence, an attempt is made in the present study to understand strength and deformation behaviour of this granite gneiss (GG) along with the mineralogical composition which influences the rock properties.

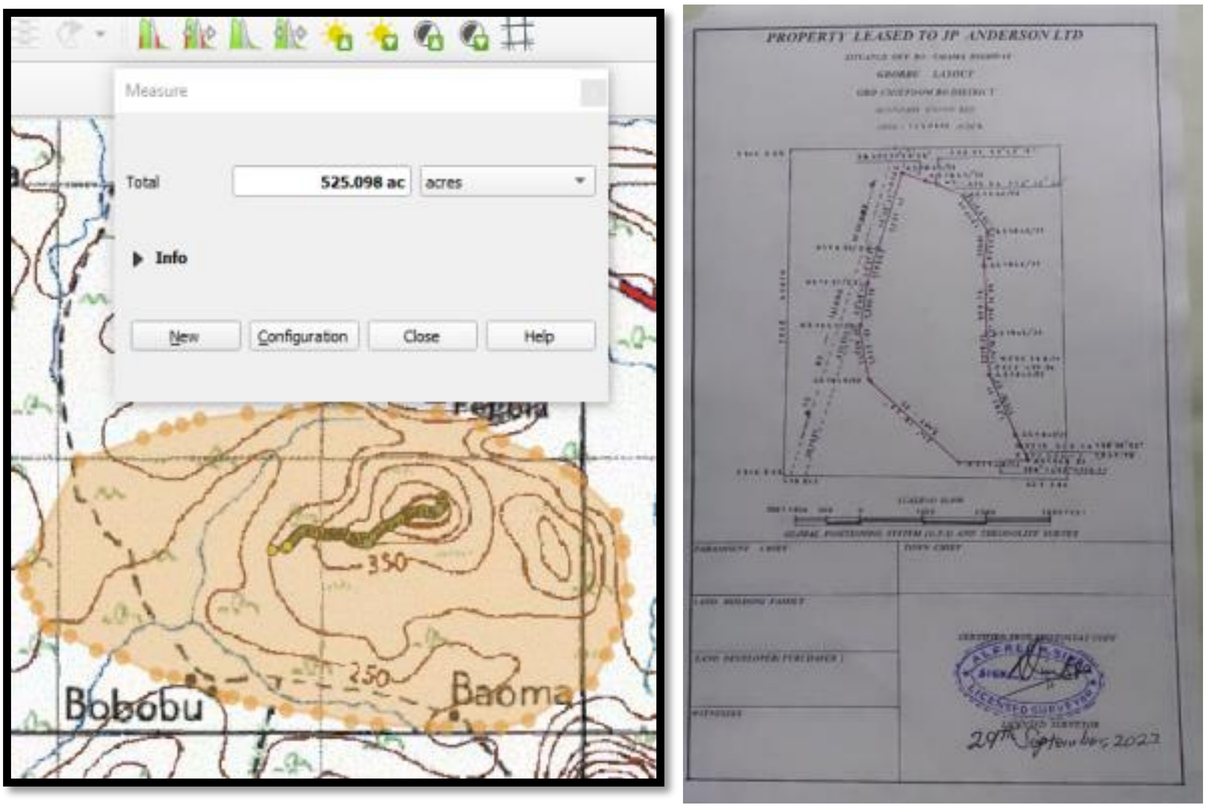

Figure 2 Showing area occupied by the batholith to be 525 acre by booth the software and the survey report

4.0 BORBORBU BATHOLITH LOCATIONS AND ACCESS

The outcrop is located in Borborbu community, Gbo chiefdom, Bo district 14.4Km North of Bo city. The main access from Bo on the main Freetown high, after which you a curve to the left and continue for 1.46m on a footpath that needs construction of road and a 5m culvert to get complete access to the site as seen on map on page 7.

Figure 3Figure 2(a) Left showing the 5m culvert to be constructed for access. 2b (right) showing map of districts in Sierra Leone

Figure 4 Showing access to quarry from Bo

5.0 METHODOLGY

With the knowledge that our aims and objectives were to observed a batholith and give its mineralogical composition which has an impact on it strength in order to be used in the construction industry. The first plan was to undertake a geological field mapping to the site. After which, the samples collected were taken to the laboratory for some set of test and a microscope observation and analysis.

However, supplementary activities were also undertaken in order to gain relevant geological and geotechnical information.

5.1. FIELD MAPPING

My team took a day in the field in order to gather every relevant geological information on the batholith and its surroundings. The batholith was tracked in order to get an accurate knowledge on its surface area also got a track from the ground elevation to the highest peak of the batholith. Once these data were collected, they were then played around with in various geological softwares as will be seen below.

The following equipment were used in the field; a GPS, geological hammer, colour chart, hand lens, and a magnetic pen, a field note book and a pen which together help us to produce the map in figure 1 below. A total area of 83 acres of land occupied by two granitic batholiths in economic quantity. The highest peak is 197m above sea level.

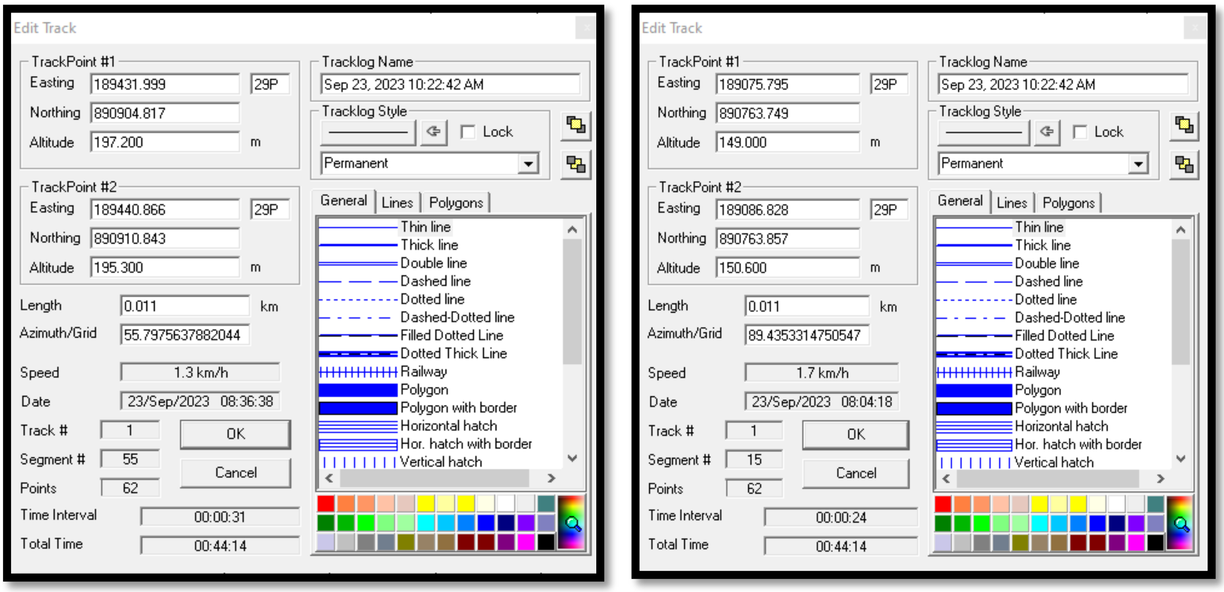

Figure 5 Showing GPS information of the location top and bottom elevation

FIGURE	RADIUS (m)	HEIGHT (m)	VOLUME (m^3)	DENSITY	TONNAGE
Cone	281	50	4,134,924	2.86	11,825,883

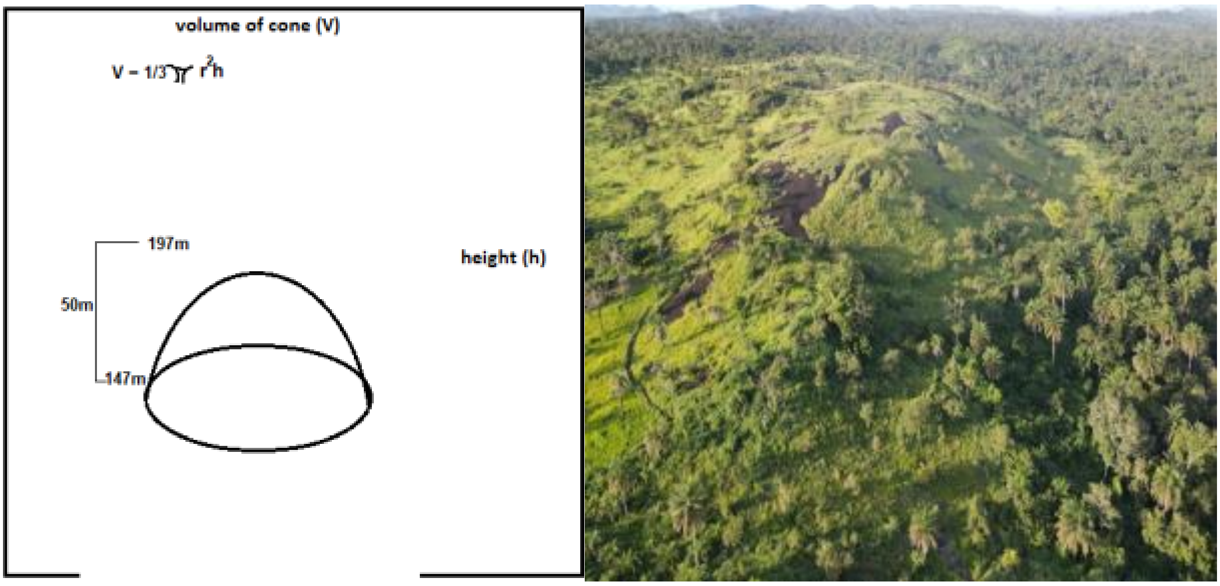

Figure 6 (left) Showing sketched figure of a cone which typified the outcrop figure (b) picture showing the cone shape batholitic intrusion

The above plotted profile was done in Surfer 12 in order to give a cross sectional view of the batholith. The contour map is in a 2-dimensional view. For a clear view of this huge mass, this same data was again plotted in a 3-dimensional view in Surfer 12 as seen below in figure 3.

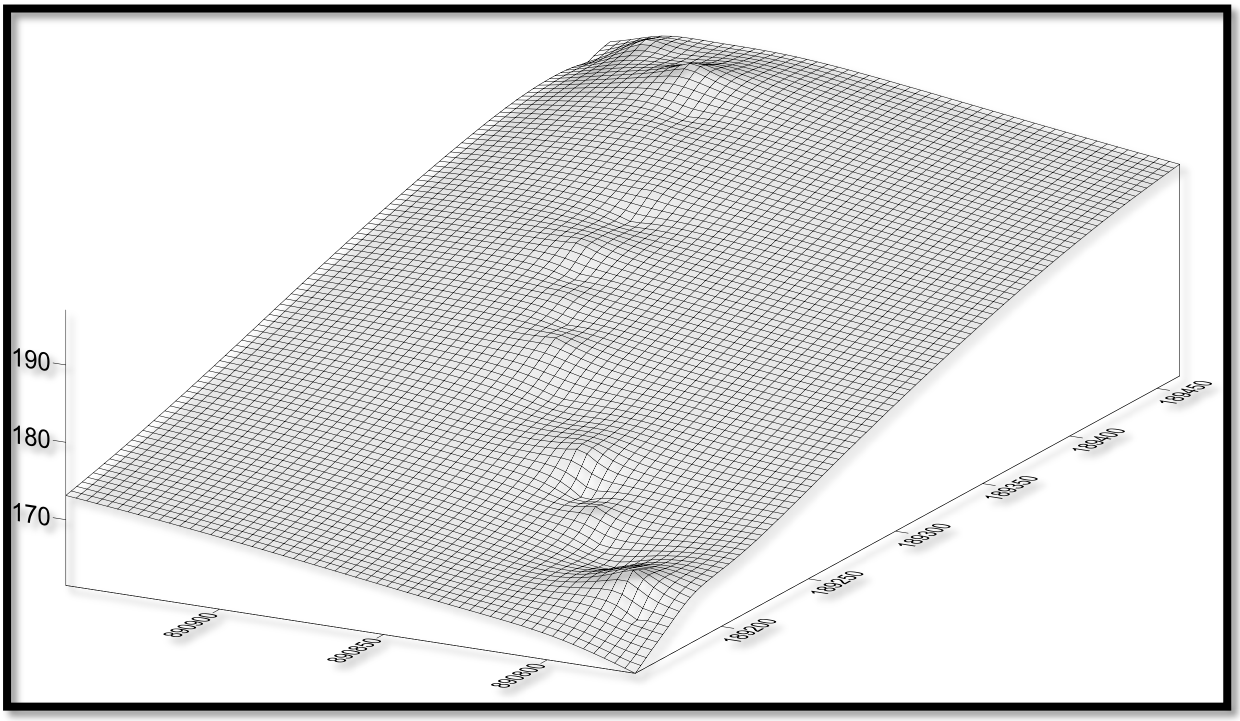

Figure 7 Showing Surfer 12 3-D display of GPS data of the outcrop

The 3-dimensional view of the biggest outcrop starts with an elevation on grand level of 149m, and the highest peak of 197m above sea level. Even though the volume and the tonnage of this mass cannot be accurately calculated right now because resource estimation drilling has not been done and which can give accurate data on ore thickness, but one thing that is very certain is that just the biggest mass which pervaded this area can last the company for over a period of 100 years.

6 GEOLOGICAL STRUCTURES OF THE BATHOLITH

One major direction of brittle structures found was the N/NW striking quartzs vein, and band of more mafic composition in the pegmatite. And E/SE striking fault crossing the above structures stated. The fault and other joints structures found on this mass are zones of weakness on which drill holes and blasting can target as seen in figure 4 (a). The 4cm width quartzs vein could be a healing to some of these joints by mineralized hot aqueous fluid scavenging the country rock and is rich in gold. Close observation will also be made during quarrying since other minerals such as cassiterite, molybdenite and columbite could also occur as vein or in the pegmatite. On the other hand, the quartzs vein can also be as a result of crystalized excess quartzs during crystallization.

7 GEOTECHNICAL PROPERTIES OF FRESH GNEISS

Hence the identification of engineering behaviour of gneissic rocks at the detailed investigation stage is a prime necessity in such projects. Laboratory testing of a large number of rock samples is time consuming and expensive. The general practice of selection of representative rock samples on visual inspection followed by laboratory destructive testing may lead to a precise interpretation of engineering properties of the entire subsurface rock strata. Non-destructive testing of gneissic rock is identified as a fast and effective method of selection of representative rock samples for a laboratory-testing programme. At least a drilling program is will be organized the entire height above the ground surface for more accurate information.

Fresh samples in particular have high compressive strength, while altered 0.1m surficial strata in patches are having low compressive strength

Figure 8 Showing gneissic samples used for petrological and geotechnical analysis

Rock Name	Mass (Kg)	Volume(m3)	Density (Kg per m3)	Hardness (Mohs)	Compressive strength (MPa)
Gneiss	2.566	0.897	2.86	5.5	210

With such a comprehensive strength and hardness, the rock can withstand any for of load imposed on it in any construction be it road or building.

Its counterpart 1.5Km across the road has served such purpose in the country as the Salcost Road Construction quarry. They both have the same mineralize and strength not only because they intruded from the same magmatic chamber at 2.8GA and underwent the same metamorphic process.

8 LABORATORY ANALYSIS OF THE ROCK SAMPLES

Fresh sample were collected from the field each composing of slightly different mineralogical composition. Literally, samples were collected based on mineralogical and textural differences base on difference in the appearance at sections on the batholith surface, such as the variation in colour, different particle size, crystal structure and chemical components. After several tests, like the magnetic test on the dark coloured minerals with a magnetic pen, and microscopic observations on the samples, we came to plausible conclusion concluded that the outcrop is granitic gneiss.

Textural difference in terms of coarse grain crystals (phaneritic texture) and medium grain crystals was noted as bands of 0.5m thick width of more dark minerals with medium grain crystals.

Essentially this graniticgneiss batholith is composed of quartz, garnet, and biotite + ilmenite. The light-coloured minerals are quartzs and garnet which the essential minerals, while the dark coloured minerals are biotite + ilmenite. The colour of the different rock sample was found to be different because of the different proportion of these dark and light coloured minerals.

The proportion of quartzs and garnet was over 90% while the dark coloured minerals are biotite + ilmenite was about 10%. The grain size is medium to coarse.

The proportion of the dark coloured minerals; biotite + hornblend was again found in some points to be over 10% while the proportion of quartzs and feldspar (microcline) was also found to be of the same amount. Even with almost this equal proportion, the quartzs and feldspar can still be identified.

9 PHYSICAL CHARACTERISTIC OF GRANITE

Borborbu granite is pure granite and therefore has the general physical characteristic like all granite has the general properties which make them fit for constructional purposes. These characteristics therefore describe Borborbu batholith as high quality and economically valuable engineering material in roads and building constructions. Borborbu batholith is qualified to be used for ornamental work, building stone, road aggregate, and cladding and as tiles.

The following physical properties of granite were not tested or conducted on the samples from Borborbu batholith. However, if so desire, we can organize for a lab abroad for the tests. At the same time, I will not neglect putting ideas into the thought of readers that these engineering properties of all garnetiferous gneiss to which Borborbu is not an exception, are the same everywhere.

Granitic gneiss showed accepted strength results which make them to widely use as dimensional and decorative stones for construction purposes both in roads and building.

compressive strength and the other strength parameters of this gneiss is good enough for all purpose. This granitic gneiss is highly resistance to weathering and erosion and has high specific density as seen on the table which reflect the hardness and compaction of its texture; therefore it is a perfect dimension stone.

Variation of compressive and flexural strength can vary due to variation in texture and mineralogical composition.
But however, compressive and flexural strength of a rock sample could be low due to micro internal deformation in the gneissic masses and alteration to its mineralization. But the rock sample collected and observed under a very high electron microscope in an anonymous lab.
Borborbu batholith is fresh and not altered, and hence possesses all the engineering strength that makes it fit to be used as dimension stones in every construction work (roads and buildings construction).

10 VARIOUS DIMENSION STONE IN CONSTRUCTION

There are various names for aggregates in road and building constructions depending on the size and shape of the aggregate.

10.1 First is the size factor

Here the aggregates are name base on its size as used in building construction

Table 1 showing aggregates name in Building construction

No	Name	Size
1	Half inch	12mm
2	One inch	25mm
3	Three quarter	16mm
4	Bold stone	100 – 300m

10.2 Sizes as used in road civil construction

Table 2 showing aggregates name as used in road construction

No	Name	Size
1	0-5mm	Sand
2	5-10mm	Gravel

10.3 General description as used in most industries

Table 3 showing aggregates name as used in other industries.

No	Name	Size
1	Fine	<9.5mm
2	Medium	20mm
3	Coarse	9.5 – 37.5mm

Fine is actually sand or crush stone
Medium is the most widely used in all construction
Coarse is the boulder size as used in building construction mostly in the foundation.

7.0 APPENDIX