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Dimension Stone Exploration and Development in Boki Area Southeastern Nigeria.

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Keywords: Rocks, dimension stone, petrographic analysis, quarrying, Boki area Southeastern Nigeria.

ABSTRACT: Rock specimens can be cut to size and used as slabs, blocks and columns, where the strong and durable stone has been correctly selected it has stand the test of time, crushed into aggregates or treated by cutting and polishing to make them suitable for display or for use in jewelling. Attractive small irregular shaped specimens can be given a high polish by hand or by thumbing them in a tumbling machine. Very hard specimens can need a great deal of work to give them a perfect polish. Flat surfaces can be given a high polish by hand using sandpaper. Polishing faceted stones can be quite difficult. All the cutting of all the faces should be completed before any of them is polished. In Boki, large deposits of quarry rocks exist which can be crushed, cut, polished, screened to various sizes and marketed for different uses such as tiles, roads, bridges, buildings, foundations and piles construction. This report outlines the availability of granite and charnockite igneous rocks and granite gneiss metamorphic rock in Boki area, processes involved in dimension stone production and investment opportunities in Boki area. @JASEM

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In Nigeria, dimension stone for both structural concrete, pavement construction and tiles are commonly obtained from Basement Complex which are distributed widely in southwest, northcentral and southeast. Also basic and intermediate intrusions (especially diabase or dolerite dyke). The Basement Complex underlies roughly one half of the area of Nigeria McCurry, (1976) and Rahaman, (1976). Pyroclastics are quarried extensively in sedimentary environment for the production of crushed rock aggregates. Ferruginized sandstones also occur and they are used as cheap sources of lower quality base aggregates for the floors of private and commercial buildings and petrol filling stations. Despite the widespread utilization and acceptance of dimension stone very little published data exist, also data on the properties of rocks suitable for large scale production of dimension stone are scarce. There is need to investigate some of these rocks granites, charnockites, granite gneisses for their suitability in building structural pavements as dimension stone.

Geological Setting: The Boki area is in the Basement Complex of southeastern Nigeria. Details on the geology of the area can be found in Egesi and Ukaegbu (2010a and b), Egesi and Ukaegbu (2011) and Egesi and Tse (2012). The rock types are phyllites, amphibolites, hornblende schists, gneisses and migmatites. The igneous intrusives are granitoids, dolerites, pegmatites. The phyllites are found around intrusive charnockitic rocks as metamorphic aurole at Intraba Hills and Ashuben-Katabang road. The schists are massive at Kekibe Hills Kakubuk area, both banded and homogeneous varieties are found in the area. Amphibolites occur as lenses in granite gneisses at Agba Osokom and relatively massive at Ubong and Begiagbah area.

The gneisses include augen at Njua Kaku and Buanchor, migmatites at Katchuan showing agmatitic and lit-par-lit features, the granitoids which includes granites, at Isobens quartz monzonite at Ebok, quartz diorite at Ebranta, granodiorite at Enyi Boje, charnockites at Ashuben hills, Katabang hills, Buanchor hills, Bakum hills, Ndamechang hills are massive, although small intrusive type showing contact metamorphism are also present. The rocks displays porphyroblastic, granoblastic xenoblastic textures in metamorphic rocks, porphyritic, xenomorphic and mortar features are present in igneous rocks (figs 1 and 2). Ekwueme, (1990) observed that polydeformation resulted in multidirectional orientations of planar and linear structures in Oban Massif. Elsewhere, in the Obudu area Ukaegbu (2003), Ukaegbu and Oti (2005,) observed that polydeformation has resulted in multidirectional orientation of planar and linear structures in the basement rocks of southern Obudu Plateau.

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Crushed rock aggregates and dimension stone are generally easily obtainable in areas underlain by the basement complex rocks, which underlies roughly one half of the area of Nigeria. Geology is so important to us that it touches every aspect of our lives. On yearly basis, we use million of tonnes of rocks to build our houses, towns and cities, roads and airports.

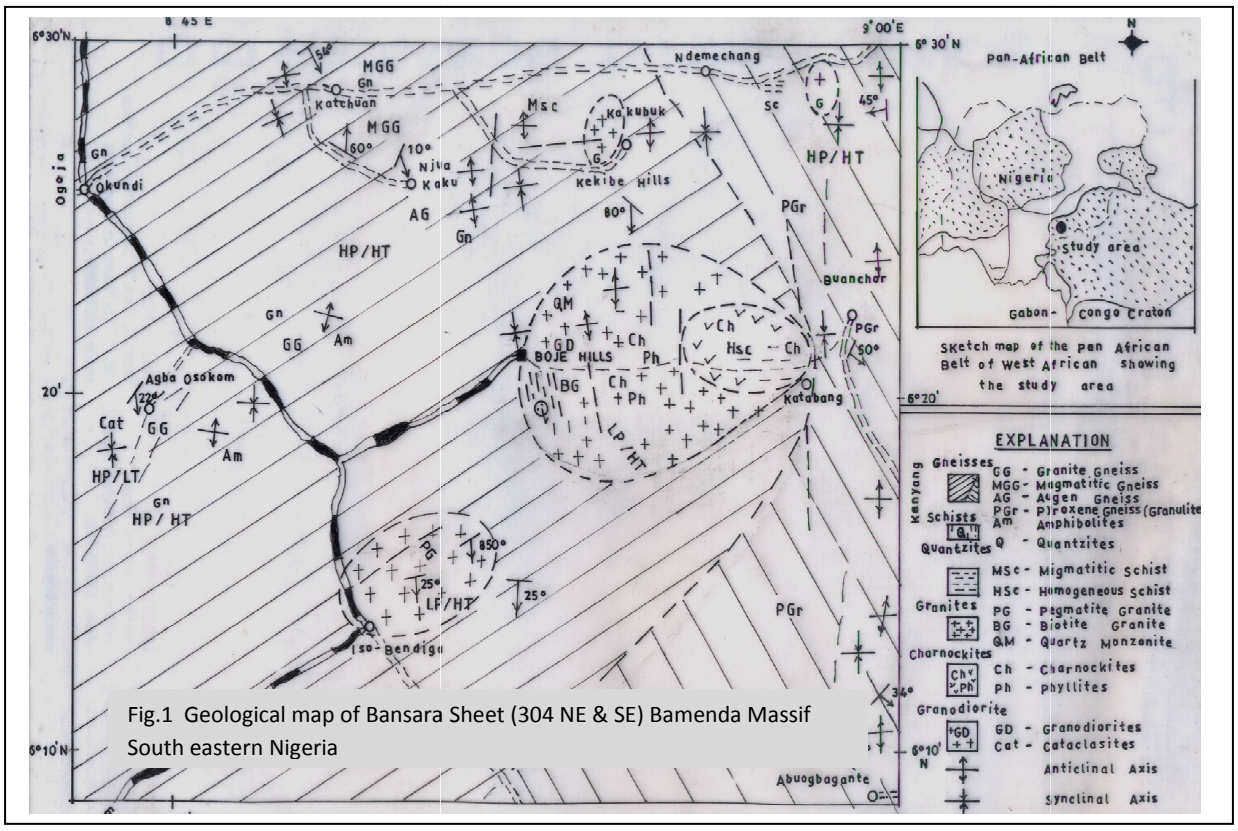


Fig.1 Geological map of Bansara Sheet (304 NE & SE) Bamenda Massif South eastern Nigeria

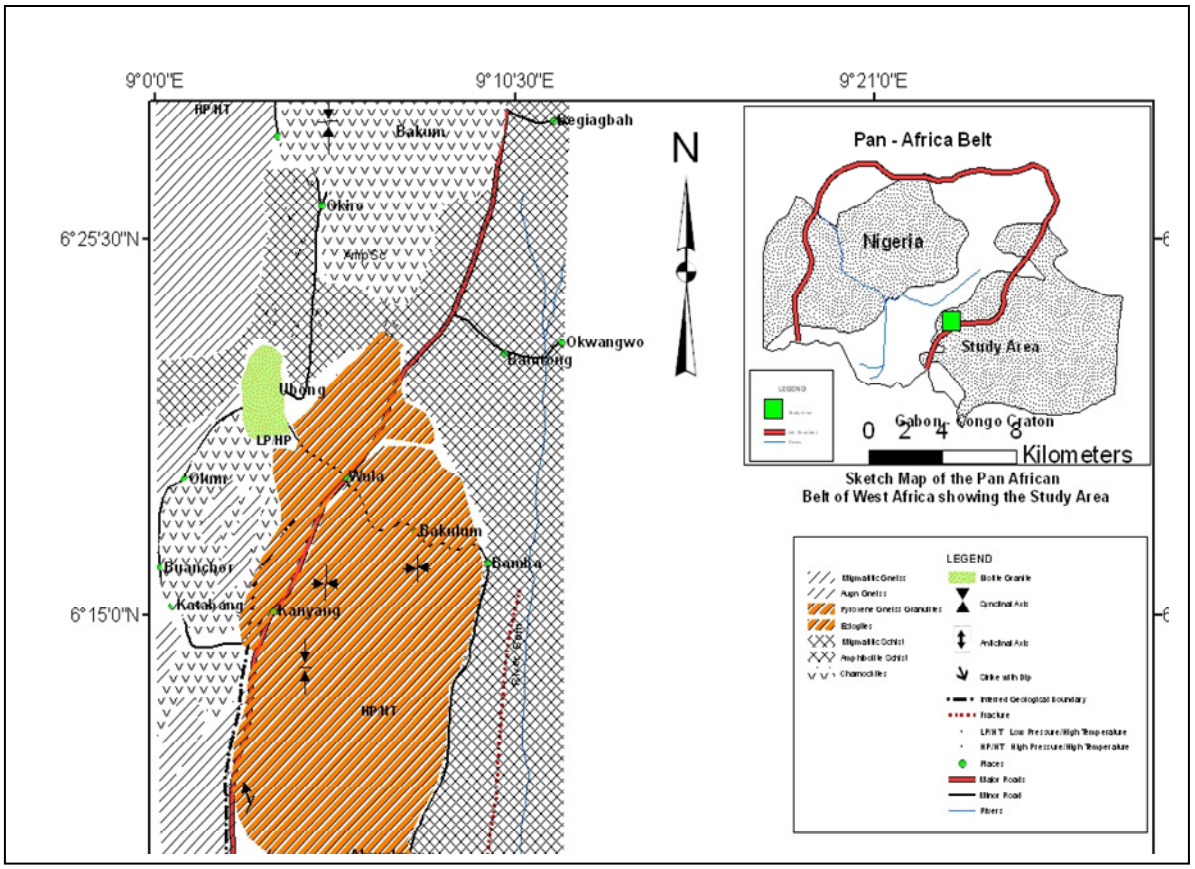


Fig: 2: Geological Map of Mukuru Area

Petrographic Analysis :In geologic surveying for locating rocks suitable for quarrying operations, the first requirement in identifying a rock for use as dimension stone is petrographic analysis Figs 3,4 and 5. This will help to identify the rock's mineralogy, grain size, texture, fabric and weathering conditions. Geological processes control the movement and redistribution of elements through the rock cycle, whereby deposition of different rocks take place by physical and chemical reactions, such as weathering and erosion of rocks at the surface and metamorphism and melting of rocks at depth within the earth's crust. Deposition of rock for processing into dimension stone are largely associated with internal processes which take place at variable depth within the earth at high temperature and pressure and largely associated with igneous and metamorphic rocks being gradually exposed to the surface by processes of denudation. Tables 1 2 and 3. Shows the mineralogical composition of the rocks, the strength and weight of the rock materials in the Boki area.

Table 1. Modal compositions of some rocks in the Boki area

Mineral	Granite Gneiss	Charnockite	Granite with Pegmatite
Quartz	25	21	30
K-spar	20	14	29
Plagioclase	22	25	15
Biotite	10	2	8
Muscovite	5	-	7
Chlorite	-	-	-
Hornblende	6	>1	-
Ortho-pyroxene	-	21	-
Clino-pyroxene	-	6	-
Garnet	8	-	-
Olivine	-	-	-
Kyanite	-	-	-
Sillimanite	-	-	-
Myrme kite	-	7	7
Perthite	2	2	<1
Opaque minerals	2	2	3

Table 2. Strength that may be expected from rocks similar to those igneous and sedimentary T= uniaxial tension CV= uniaxial compression with description recommended by Int. Soc, Rock Mechanics C = cohension and Q^1= angle of shearing resistance, both as measured in triaxial compression and in terms of effective stress.

Rock Type	**Weight Y**	**Uniaxial T**	**Strength CV (MNM-1)**		**Triaxial Strength C(MNM^{-2})**	**Q^1(Degrees)**
Gabbro	29	20	150	Very strong	30	32°
Granite	26	20	150	Very Strong	30	30°
Dolerite	28	35	350	Extremely Strong	50	35°
Basalt	27	10	120	Very Strong	25	34°
Sandstone	25	5	15	Weak	5	30°
Sandstone	22	<2	10	Weak	<5	30°
Sandstone	21	<1	<10	Weak	<5	30°
Sandstone	21	<1	<1	Extremely	<2	<15°
Sandstone	22	<1	10	Weak	5	12°
Shale	23	<5	20	Weak	<10	35°
Shale	22	<5	20	Weak	<10	35°
Limestone	24	5	30	Moderately Strong	10	35°

(**Source:** Blyth and de Freitas, 2005)

Fig.3a Charnokite undergoing exfoliation weathering at Bakum hills at a height of

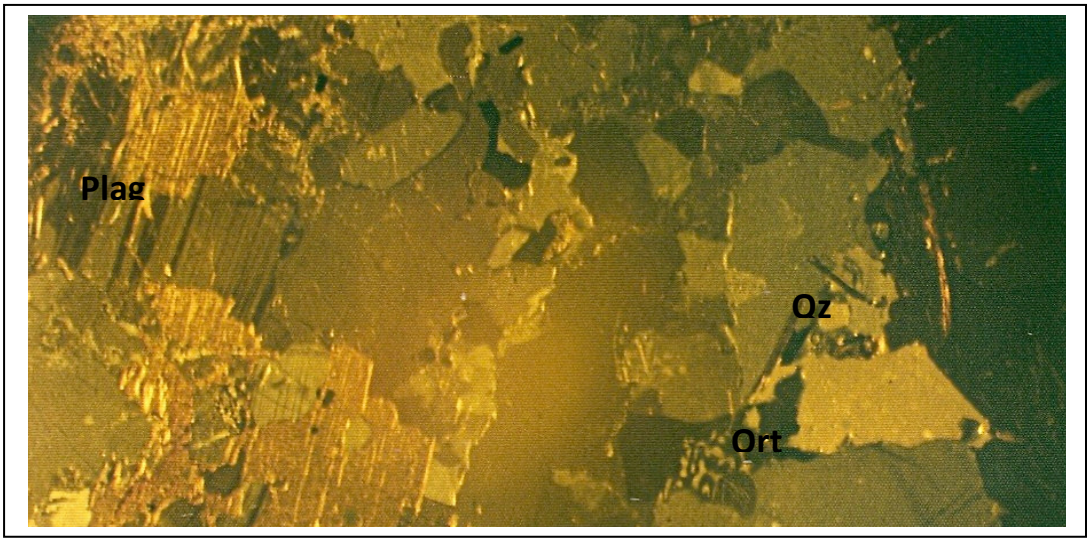
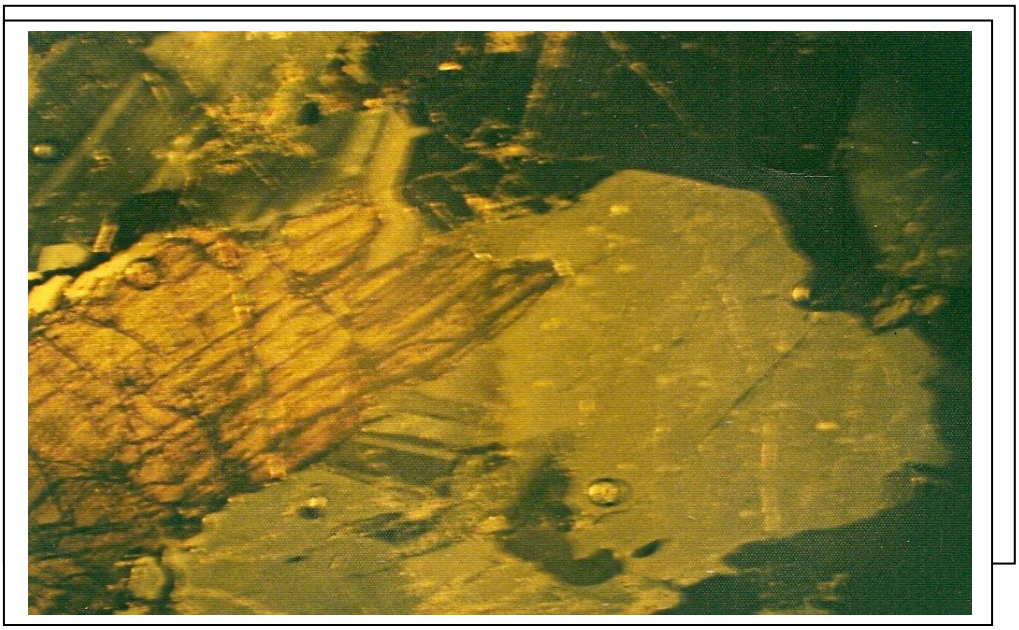


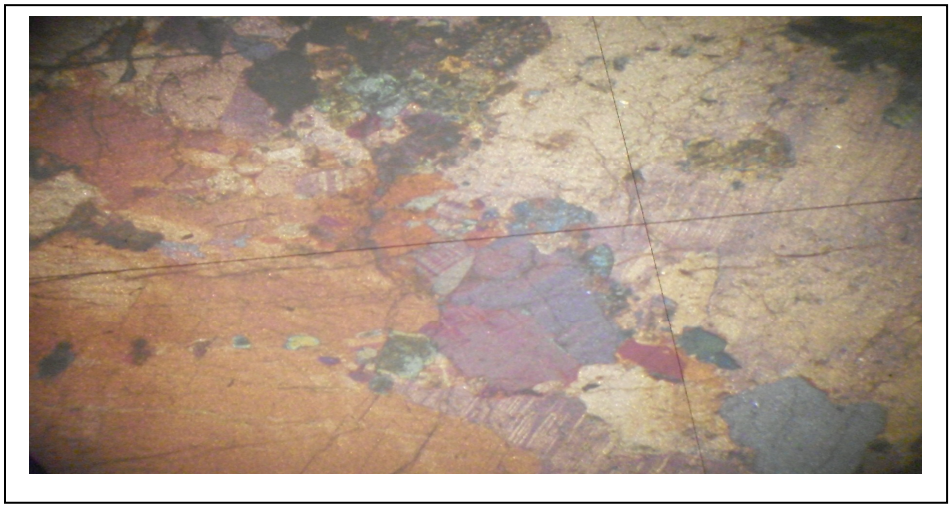
Fig. 3b This photomicrograph is porphyritic texture with brownish Feldspar (X 40) .

Fig. 4a Xenoblast of quartzofeldpathic minerals in Granite Gneiss at Agba Osokom. See hammer head



b. Feldspars are the dominant minerals showing prismatic Orthoclase and cross- hatching Microcline twinning**.** (X 40)

Fig. 5a Coarsed-grained pegmatitic granite rock at Iso Bendiga



b. Photomicrograph of porphyritic texture of pegmatitic granite

Fig.6 Dimension stone cutting machine at Octopol Quarry in Igarra

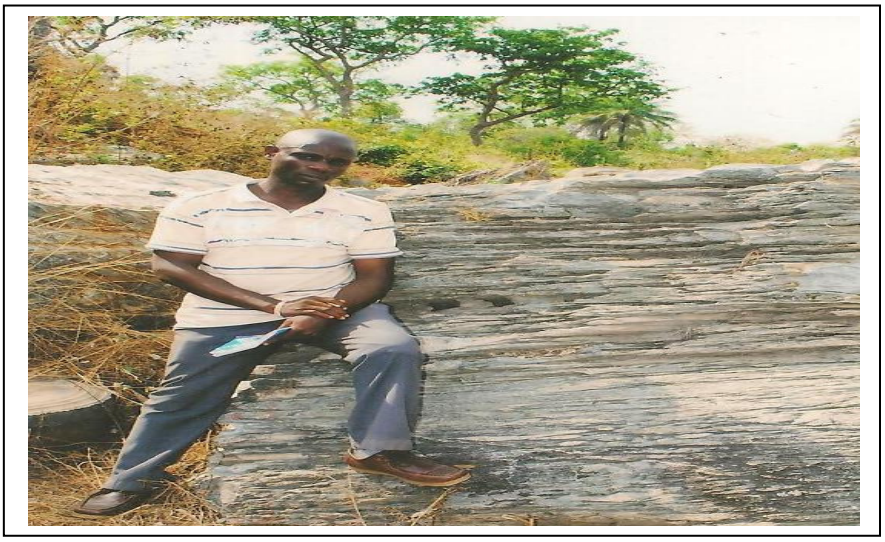


Fig.7 A block of Dimension Stone at Octopol quarry Igarra area

TABLE 3. Typical unit weights for various dry unweathered rocks (KNm^{-3}) min or max = unlikely to be less or more than mean = most frequently, N = no value can be recommended = unknown**.**

Rock Type	Min	Common Range	Mean	Max
Granite	23.7	25.1 to 27.6	26.8	29.2
Syenite	24.6	25.1 to 26.7	25.8	28.3
Diorite	26.7	26.7 to 28.3	26.8	29.8
Gabbro	26.7	28.9 to 29.8	29.5	30.1
Porphyry	23.1	23.4 to N	24.8	28.1
Dolerite	22.5	25.4 to 27.6	27.1	28.1
Rhyolite	19.5	N	N	26.8
Andesite	19.5	21.7 to 22.5	N	26.8
Basalt	22.0	25.1 to 27.5	27.1	27.9
Gneiss	23.8	25.4 to 26.8	N	27.6
Schist	18.2	26.7 to 27.6	N	27.9
Slate	26.5	27.3 to 28.3	N	N
Marble	23.9	26.7 to 27.6	26.8	28.4

(**Source:** Blyth and de Freitas, 2005)

Table 4: Test Results for some rock samples

Rock Samples	AAV in %	ACV in %	AIV in %	Absorption in %
Biotite-Granite	22.0	23.2	18.5	0.54
Granite-Gneiss	27.0	26.1	22.8	0.73
Charnockite	22.5	24.0	19.5	0.62
Acceptable Standards (BS, AASHTO,ASTM,DIN)	< 30	< 30	< 35	< 1.0

From the various test results in table 4, observations show that the Biotite-Granite posses high strength value when compared to Granite-Gneiss, although they both posses the necessary conditions for pavement in accordance to BS, ASTM, AASHTO,and DIN the charnockite shows approximately granitic composition and granoblastic texture with high strength value and higher water absorption capacity. The high resistance of Biotite-Granite to pressure, and its low water absorption value could be attributed to the interlocking nature of the crystals of minerals.

Exploration And Evaluation: Reconnaissance and detailed survey of the Boki area has been carried out by Faculty and students of the University of Port Harcourt between 2007 and 2012. The success of the survey was made possible by village heads and field guides in these localities. The chemical composition of some of these rocks in terms Major, Trace and Rare Earth Elements (REEs) has been made Egesi and Ukaegbu, (2010a and b) and Egesi and Ukaegbu, (2011). Vertical Electrical Sounding (VES) was used to identify sites for the sinking of water boreholes. Aeromagnetic survey has been carried in the area on regional basis Iliya and Bassey (1993). The density survey help to determined depth to basement, highly magnetic, electrical, or radioactive rocks cannot be used for dimension stone production.

Good deposit of granites and quartz diorites which are extensive at Ebok hills and Enyi Boje hills; charnockites massive at Ashuben hills, Katabang hills, Bakum hills, Ndemechang hills and Okiro Ubang hills; granite gneisses at Agba Osokom will be suitable for dimension stone. Role of the geologist in dimension stone exploration and production. Exploration -Find rock of quality in the market and in sufficient quantity. Evaluation -Assess quality of rock to establish suitability for market.
Market Research -Advise on the technical properties of rock, specifications and suitability for each application. Mine or Quarry Planning -
Consider shape and position of rock in relation to environment, method and ease of extraction. Advise on quality variation, which could be any physical, chemical or mechanical property.

Mineral Processing-Advise on suitable systems, bearing in mind nature of rock, markets, specification of products and nature of reject (or bi-product) materials. Assessment of quality after processing. Methods and effects of waste disposal. Water supply. Production-Advise on effects and methods to counter sudden and long term variations in quality of rock material.

Technical Sales -Advice customers on nature of rock impurities in product and their likely consequences during use, long term supply position and effects of quality changes.

Research and Development - Examine potential for new products and improvement of manufacturing techniques in which the rock is used, new methods of processing and quality improvement. Nature of transformation of rock constituents particularly in silicate and oxide systems.

Development of a quarry can be linked to building and machinery which are installed before it can commence production. Quarry development process is time and capital intensive.

For dimension stone mining, the procedure is a bit different the average size is $1m^2$ or rectangular cut in shape. These are carried with bulldozers and 30 tonnes trailers to the processing plant. The drilling pattern is square or rectangular as compared to staggered drilling before blasting for aggregates. Since most mining in Nigeria such as quarrying are on small-scale basis little or no estimates of reserves are made. The main evaluation procedure in dimension stone is by delineation or drilling to determine depth to the basement and surveying vertically and horizontally to obtain the area. Feasibility and major investment decision is taken either to continue or abandon the project. The average production of dimension stones are determined daily, monthly and even yearly. The method of drilling and cutting machine are shown in figs 6,7,8 and 9.

Fig.7 A block of Dimension Stone at Octopol quarry Igarra area

Fig. 8 Field photograph a face of Dimension stone at Igarra Edo State

Fig. 9a and b Field photograph a face of Dimension stone at Igarra Edo State

Conclusion Dimension stone is a good material for pavement construction and there is availability of granite, charnockite and granite gneiss in sufficient quantity in Boki area. Natural stone are durable with high market value and demand. Adequate knowledge of the properties of these rocks petrographic, strength, weight, characteristics in the use as dimension stone in accordance with known standards British Standard Institute BS, America Society for Testing and Materials ASTM, American Association of State Highway and Transportation Official AASHTO and German DIN. This report will be useful for a prospective dimension production firm in the area.

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