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Urban Expansion and Implications on the Exploitation of a Non Metallic Mineral (Rock) in the Yaounde Metropolis, Cameroon

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Abstract:

The rate at which non-renewable natural resources are being exploited in sub-Saharan Africa is alarming. This is being observed especially at a time when most of the countries in this zone are witnessing rapid population increase and urbanization. The exploitation of non-metallic minerals in the Yaounde metropolis exemplifies situations where expansion has imposed the excavation of non-renewable resources. Utilizing a research methodology that entailed deductive and inductive approaches with specific reference to field observation, analysis of questions from focus group discussions, topographical maps and aerial photographs, we could establish some findings. The results show that stone quarries have greatly led to the construction of the city of Yaounde amidst the rapid population increase. The stones from these quarries are crushed to produce building materials. They are also used for the construction of roads, bridges and other public infrastructure. Quarries have equally grown from the simple artisanal cracking of rocks to the more sophisticated industrial exploitation by the use of explosives and crushing machines. Study equally found out that there has been a multiplication of the number Quarries. The massive exploitation of rocks has been imposed by population growth, from natural increase and in-migration. Meanwhile this situation has made some areas of the city to be stripped of vegetation and to even stand out with landmark scars. These scars serve today as topographic traps since they distort the homogeneity of the landscape. They also contribute to the existence of interstitial spaces in the city with their own ills. Since rocks are non-renewable resources, it means that they should be managed sustainably

Keywords: Population growth, urban expansion, quarries, conventional methods, traditional methods

1. Introduction

The phenomenal rate of urban expansion over the globe today has got untold impacts on the renewable and non-renewable resources. Of major importance is the impact on Non-Renewable Natural Resources. The Yaounde metropolis serves as a true testimony of areas where natural resources (with specific reference to rocks) have been greatly exploited. Most works that exist on the metropolis such as those of Bopda (1985), Bopda(1997), Franqueville (1968), Mougoue(1982 & 1992), Youana (1983), either talk of urban growth and expansion or the causes of urbanization. The few deal with the consequences of urban expansion have dwelled more on the impact on environmental degradation in general and soil erosion or vegetal depletion in particular such as Tchotsoua, (1989), Nkwemoh, (2011), as well as Nkwemoh, & al.(2017). There is only some meager and scattered stuff about the depletion of non-renewable mineral resource in some of the above literature. This is a clear testimony to the fact that is research is relevant.

The quarries have however brought about a modification of the original scenery. In some places where the mining is open cast on slopes, the resulting declivity accounts for spectacular landmarks. Abandoned quarries equally serve today as interstitial spaces that increase crime waves in the city. The main objective of this research paper is to show how urbanization imposes the exploitation of this set of Non-renewable Natural resources.

2. The Physical and Human Background

Yaounde metropolis (Figure 1) is found between latitudes 3° 45' 50" and 3° 59' 55" North of the Equator and Longitudes 11° 22' 40" and 11° 30' 25" East of the Greenwich Meridian. It is bordered to the north east by Mefou and Afamba Division, to the North West by Lekie Division and to the south by Mefou and Akono Division. Its surface area is 304 km² and this occupies the Mfoundi Division in the Centre Region.

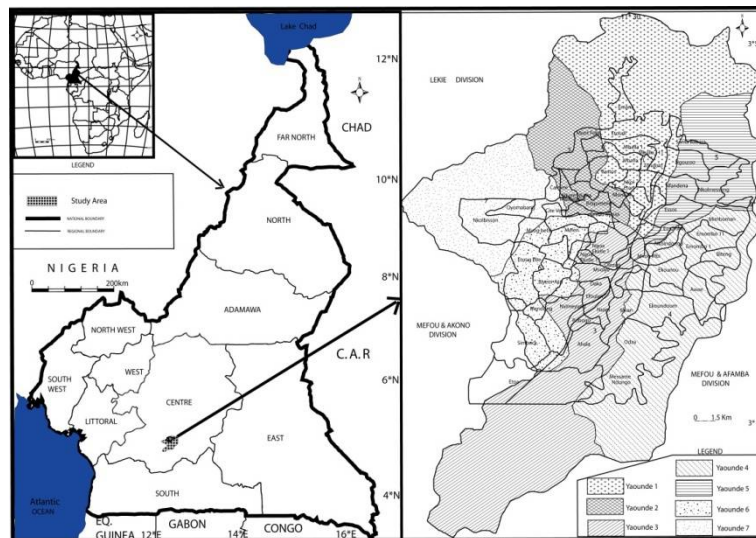


Figure 1: The Administrative Divisions of Yaounde Metropolis

The Yaounde Metropolis is part of the western sector of the Southern Plateau of Cameroon. It is made up of gentle rolling chains of hills, and numerous valleys. These topographic elements depict a contrasted relief. With regards to the morphology, there is a contrast in the topographic lay out of the Yaounde Metropolis. This difference in the nature of the relief can be viewed from the local relief of the area. The Yaounde metropolis is characterized by interfluves as part of the Southern Plateau. The topographic map of Yaounde and field observation gives the impression that the Yaounde Metropolis is on a water divide. This water divide appears like a crest line according to Fritz and Kuete (1974) cited in Tchotsoua (1989). It is a crest-line with a width of about 100-800m that moves in a zig-zag manner from the Atlantic Ocean to Maiganga.

The substratum of the Yaounde metropolis is characterized by the outcrop of the basement complex. This is basically made up of igneous and metamorphic rocks. This basement complex constitutes part of the Southern extreme of the grand assemblage that covers the South of Cameroon. On the Geological map of Africa, it is composed of gneiss (Nickel, 1952). The Geological map of Cameroon by Gazel et al, (1952) denotes a series of rocks that is common. Amongst these, are *echnite* and *migmatite*. These authors say that these rocks are very complex and their origin is very difficult to be traced. The nature of these types of rocks readily explains the establishment of the major quarries in the area. The area under study is found in the Equatorial region where the sun is constantly overhead and with high atmospheric humidity. Yaounde is of the bimodal system with four seasons (two dry and two rainy seasons). The temperature is highest in the months of December to February when maximum temperatures are of 27°C. During the short rainy season, the average temperatures drop to 24°C. Temperatures are low from the month of July to August, during the short dry season when skies are overcast with clouds. During the long rainy season, from September to November the temperatures are not equally high.

Just like many Bantu countries in Africa, the aborigines of Yaounde were Pygmies. These Pygmies were pushed out by the invading Ewondo. Similar to the Fang (Beti, Bulu, and Fang) where they constitute a major part, the Ewondo came from Northern Sanaga to seek refuge in the hills of the South. They were escaping from the Foulbe in the North who constituted their main threat of the Century. They formed the 'Mvog' who are found distributed on the hills that constitute the present Yaounde town. Yaounde, was founded in 1888 by the German Colonial Administration. It became the capital of the French territory under the League of Nations in 1922. During the 2nd World War, it was temporarily shifted as the capital of the former East Cameroon Province. With the independence of the Country in 1960, the city has remained the political capital. The Yaounde metropolis plays double administrative roles. It is currently the Regional and National capital.

3. Materials and Method

The basic materials and methods used in this study involved the interpretation of aerial photographs and topographic sheets of Yaounde 3b, 3d and 4c (Oveng, Nkolbisson etc.) at the scales 1:50.000. Then came field observations, analyses of questionnaires on core elements such as quarrying techniques and socio-cultural welfare. Other data collection was by way of interviews to rock exploiters. Internet information greatly facilitated the upgrading of data view points and conclusions arrived at in recent studies. The population was projected using the formula:

$$P_x = P_2 + N/n (P_2 - P_1)$$

Where P_x = Projected Population

N = Period between P_1 and P_x

n = Period between P_1 and P_2

P_1 = Initial Population

P_2 = Last known Population

4. Results and Discussions

4.1. An Astronomical Urban Expansion of the City of Yaounde

According to the IFORD (Institute for Demographic Studies) data of 1976 the population of Mfoundi was 313206. This figure rose to 703588 in 1987. The figure went up to 1372 800 in 2001 (Encarta 2006). The population has risen to 1.881.876 inhabitants according to BUCREP (2010). The bulk of this population is contributed by in-migrants. They come from the villages and towns around and all over the Country. The 2001 population figure qualifies the area to be a millionaire city. The density for 1987 was 2748.4 which in 2001 was 5362.5 and 5900 persons per square kilometer in 2010. This makes the area to be one with the highest density in the country.

The surface area of Mfoundi was 256km² (25600ha) before the new administrative divisions were created in 1992. Currently, the surface area (from planimetric measurements on topographic maps at the scales 1:50 000) stands at 304 km² (30400ha).The evolution of the population of the area was computed for 1939, 1945,1960,1965,1967,1976,1987,1995,1998,2001,2008 and 2010completed with projections for 2018 as can be seen in figure 5

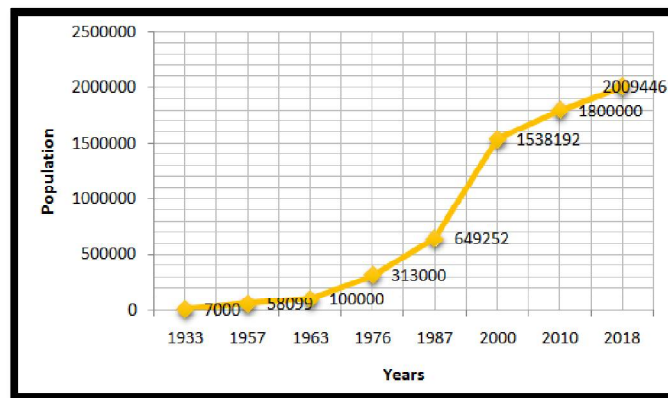


Figure 2: Evolution of the Population of Yaounde (1939-2018)
 Source: Franqueville (1979) & Nyangono (2008) and BRPH (2010)

A presentation of the sprawl of the Yaounde metropolis is clearly seen in Figure 2 shows that the situation of land occupation according to the periods, 1951, 1988, 2002 and 2008 clearly illustrate the above situation. Within the town, there is still the possibility of increased density of vertical buildings. Meanwhile in the outskirts the engulfment of rural space is very evident. This is clearly seen around the Mvan and towards Mbankomo, Mesame Ndong and Odza and towards Nsimalen Airport (South); Biteng, Mimboman II (East); Mvog Ebanda and towards Soa, Santa Barbara (North East); Emana towards Olembe on the Yaounde Bafia High way (North), and then Simbock and Ahala (South West). As for the expansion towards the North West and West, the sprawl is limited. The inhabitants are either climbing unstable slopes or moving along narrow valleys.

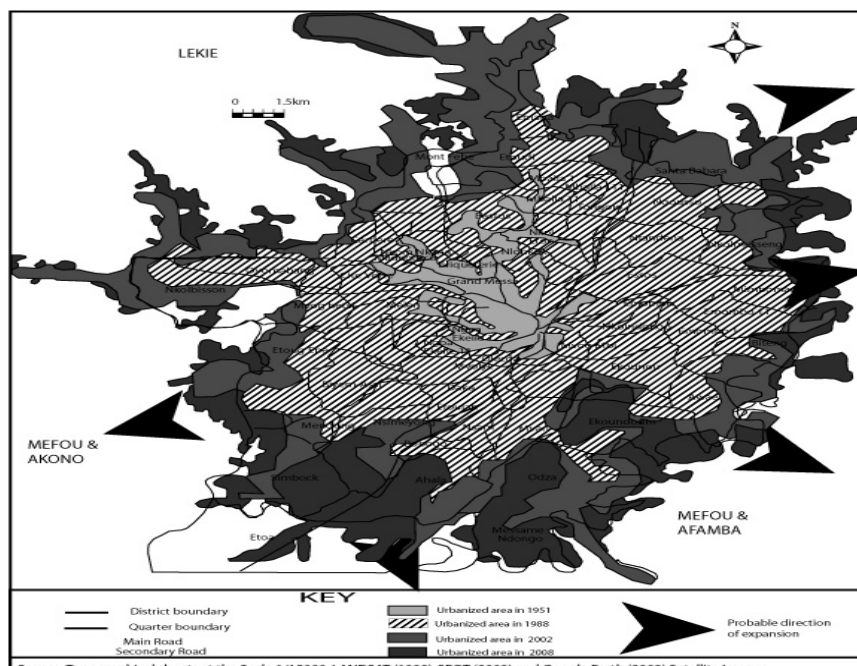


Figure 2: Various Stages of Sprawl/ Expansion in the Metropolis

Figure 2 shows various stages of sprawl meanwhile, Table 1 shows the evolutions of the extent and rate of urban expansion of the Yaounde metropolis.

Year	Surface area (ha)	Rate of growth during the period in %
1956	1.740	
1964	2.250	1.29
1968	2.920	1.29
1974	3.830	1.30
1981	5.300	1.38
1990	12.300	2.32
1992	13.500	1.00
2000	18.000	1.33
2010*	22.501	1.33
2018*	27.002	

Table 1: The Expansion of Yaounde Town from 1956 - 2018
Projections

Source: Augea International-Iris Conseil-Arcauplan in
Sdau & Pdl De Yaoundé, 2001 and Projections

As can be seen in the above table, there has been a stable rise in the magnitude of expansion of the study area over the past since the 1950s to 2010. This past figure could permit projections conveniently to even deduce a steady upward trend. This situation is bound to increase the need for building materials with specific reference to rocks or stones.

4.2. Main Quarries and Evolution in the City

An increase in population in the metropolis is bound to have resounding repercussions not only on the vegetation and soil in an effort to cultivate to feed the additional number of mouths but also on other natural resources of the area. The resultant increase in the need of houses for settlement has forced city dwellers to exploit the rocks of the crust. This has imposed invariably, the establishment of new quarry sites for the extraction of rocks. Meanwhile it is realized that this type of Natural resource is classified under the aggregate minerals of the Non-Metallic minerals of the Non-renewable resources as classified by Zimmerman (1933) (Figure 3).

The exploitation is carried out in the main quarries. There are two types of Quarries in the metropolis. They include the industrial and traditional Quarries. As seen in the figure rocks are classified under aggregate minerals that constitute one of the nonmetallic minerals (Industrial metals) of the nonrenewable natural resources over the globe. The main types of rocks exploited in the Yaounde area include, mica-schist and gneiss. The principal minerals of the rocks here include; quartz, biotite, amphibole, disthene and feldspars amongst others (Tchotsoua, 1993).

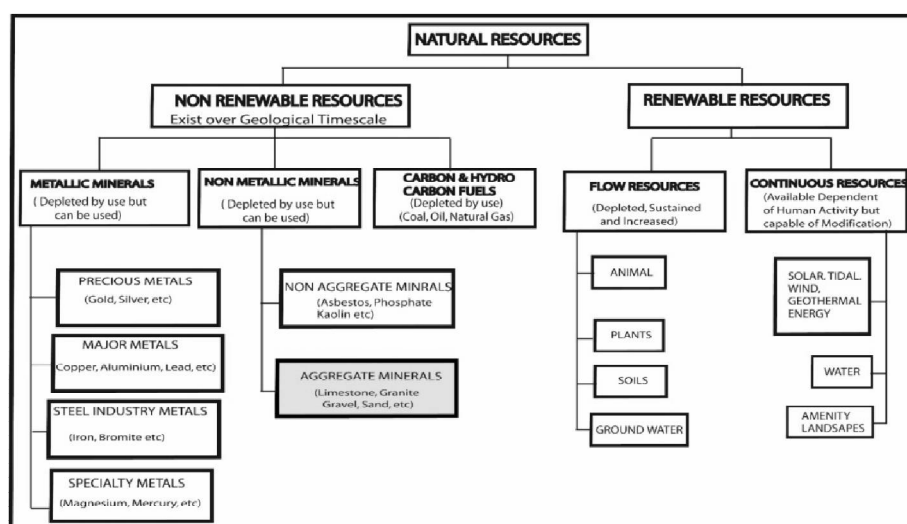


Figure 3: A Categorization of Natural Resources
Source: Zimmerman (1933)

4.2.1. Industrial Quarries

These are rock exploitation sites that are operated by big companies. The exploitation is large scaled and employs mainly the use of machines to crush the rocks. Holes are drilled or bored into the outcropping basement complex. Dynamites or explosives are then inserted. Upon explosion, the rocks are torn into fragments of stones. After this, the pieces of stones are picked up and taken for crushing into appropriate dimensions. Four main (industrial) Quarries have

been used in this study to epitomize the work of Quarry sites in the Metropolis. They include the Quarry at Carrière, Ngoa-Ekelle, GRACAM in Nkolondom, and the Quarry at Nkozoa

4.2.1.1. The Quarry at Carrière

This Quarry was created since 1948. It is found on a rocky massif that forms one of the seven hills – precisely the Messa Meva hill. According to GPS location this Quarry is found at the intersection of Latitude 03°53'16.9" North of the Equator and Longitude 011° 29'09" East of the Greenwich meridian. The main rock types traced here include igneous and metamorphic rocks with specific reference to granite, mica-schist and gneiss. The nature of these rocks can equally be appreciated from the mineral composition, color and manner of fractures. The Quarry is now closed was exploited by the Dragage Company from creation until 1984. The products from this Quarry have permitted the development of settlement sites and road infrastructure in the area. Stones from here were used for the construction of houses. Meanwhile, crushed rocks provided concrete for tarring most of the roads in the Metropolis.

Realizing that this quarry could not meet up with expenses and because of the ecological impact, quarrying was halted. The machines were then moved by the company, abandoning the site. This zone was declared a green belt in 1980 but today, the site is still occupied by some individuals who exploit it using rudimentary methods.

4.2.1.2. The Quarry at Ngoa-Ekelle

This Quarry is found between the University of Yaounde 1 and the Military Headquarters. According to GPS location this Quarry is found at the intersection of Latitude 03°51'16.4" North of the Equator and Longitude 011° 30'07.4" East of the Greenwich meridian. It was created after independence in 1960. Holes were drilled into the core rock and explosives were inserted. Upon explosion, the rocks were shattered. The procedure then continued as in the case of the Quarry at Carrière. Most if not all the original stone buildings in the University of Yaounde that was created in 1962 were erected with stones from this Quarry. Concretes and stones of various dimensions were also extracted for the construction of roads around Ngoa-Ekelle and the Atemengue plateau.

Realizing the damage that rock exploitation was to cause compared with other lucrative aspects such as roads that assure connectivity, this quarry was closed. Even the rudimentary exploitation by local inhabitants that followed, was short lived. Today the scars as seen on Plate a and Figure 4b are potential accident sites for those with no idea about such areas. There is no warning sign to indicate that there is a ditch below for those from Chateau for instance. Just like in the case of Carrière, this Quarry sometimes serve as hideouts for some criminals since they are almost abandoned sites. Meanwhile these sites contribute a lot to interstitial spaces of the city that depict inadequate urban planning.

4.2.1.3. The Quarry at GRACAM (Les Granulats du Cameroun) at Nkolondom

GRACAM was created in 2009 and the head branch is located at the main Quarry at Nkolondom at an altitude of 755m above Sea level. According to data obtained by the use of GPS, it is found precisely at Latitude 03 57' 50.2" North of the Equator and Longitudes 011 30' 23.2" East of the Greenwich Meridian. This Quarry was laid down by a group of experts from Cameroon and Europe. The site is based on a massif of Metamorphic rocks and specifically of gneiss of difference varieties (Pra, Ortho and Meta) with 65 – 75% of the rock minerals being quartz, Feldspars and Biotite with black mica as opposed to muscovite which is more of white mica. The exploitation process at the quarry entails the removal of vegetation, followed by drilling and placement of explosives/dynamites. After blasting, there is transportation for crushing /concasting. The products from Quarries are presented on table 3

Size of Stones	Prices Ranges at Source	Best uses
1-2 cm also called 18/12	300 000 to 350 000 frs CFA	For concreting beams, binding codes and slabs and bridges
3-4 cm also called 5/15 and 15/25	250 000 to 300 000 frs CFA	For pillars and for outer and floor concreting
5/15	75000 / ton x 40 = 300000frs CFA	Used for pillars, decking and floors and bridges
50 cm+ also called moelon (Moelon trier ou sauvage)	110 000 frs CFA	Used as foundation stones, side walls and some pillars
0.5 or Quarry Sand (Sable Carrière)	4000 / ton x 40 = 160000frs CFA	Used for fabrication of Cement Blocks
10/14, 4/7 and 6/7 (Produit Routier)	9000 / ton x 40 = 360 000frs	For Road works and Bridges
031.5 (Tous Venant)	7000/ ton x 40 = 280 000frs	Used at some instances on road, house and other infrastructural constructions.

Table 3: Classification of Double--Twenty-ton Crushed Rocks according to Prices and Uses

Source: Carrières du GRACAM, Nkozoa et Messebe & Fieldwork/Interviews 2018

4.2.1.4. The Quarry at Nkozoa

It was created in 2014 by the Chinese Mining company. According to tracking by GPS apparatus is found at Latitude 03°58' 34.0" North of the Equator and Longitudes 011° 32' 55.4" East of the Greenwich Meridian. It is found at an altitude of 709m above Sea Level. The Mining procedure entails the perforation of the country rock mass and the

insertion of dynamites while a cord links this to the safe area where the electric detonator is placed. After fissuring and shattering the rock mass, small dynamites are further used to continue with the breaking process. The next stage is called “concasting”. At this level, the rock fragments are then broken into small sizes and are then moved towards the conveyor belts where they are distributed into sub-belts to be broken down and sifted/ sieved and classified into appropriate sizes as seen on Figure 4c- 4f. After these stages the finished product is now carried by Caterpillars to load the trucks of Customers or consumers to get them ready for weighting.



Figure 4: Different Sites and Activities of Industrial Quarries

It is worthwhile remarking that the creation of Mining/Quarry sites had strongly been imposed by the rise in the demand for quarry products due to urban peripheral extension.

The rest of the quarries in the Yaounde area, such as ‘Les Carrière du Cameroun (LCC)’ at Messebe (Nkolbisson), The Quarry at Leboudi and those of Mbankomo Run by both the Arab Contractors and Chinese companies are all equipped with ultra-modern machines. The procedure for the exploitation of rocks in these Quarries are not very different from those of our study examples. Even the products that are exploited are all similar to those presented in table 3.

A common characteristic with industrial quarries is the fact that some of them can; load as much as 50 to 200 hundred or more truck per day. This is as opposed to the tradition quarries that may not load up to 20 trucks per week. According to the exploiters, the rocks are extracted depending on the needs. Inquiries permits a classification of crushed rocks according to different prices and uses as shown in table 3. The prices listed in this table are just those at the quarry. The truck that transports the load is paid per kilometer. This makes the product to be very expensive when the utility site is far from the Quarry. Sometimes, the exploiters are asked to shape the stones to suit the particular needs of the construction. In this case, the client is levied a greater amount for the extra task. All of this depends on the bargaining power of both parties. Exploiters say they can supply just 4-10 truckloads per week from this local site. The figure can rise during the peak of activities. It is worth while noting that the number of Industrial Quarries has been steadily on the rise as seen on Figure 4.

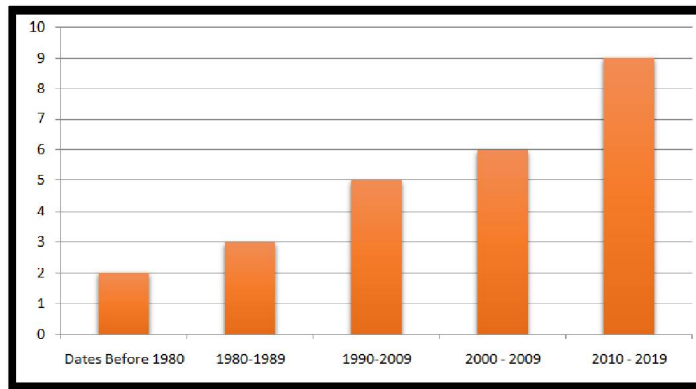


Figure 5: The Evolution of Industrial Quarries in the Yaounde Metropolis
Source: Ministry of Mines Water and Energy Resources and Fieldwork 2019

4.2.2. Traditional Quarries

Traditional Quarries are those that are basically pre-occupied with the exploitation of rock outcrop at a local level and using basically rudimentary methods. This type of exploitation is mainly carried out by some individuals in the capital who are known as stone diggers. They are found spotted all over the metropolis and especially around areas of rock outcrops that cannot be exploited by industrial companies. A good example that has been studied in this research is the case of the Quarry behind College Vogt.

According to GPS location this quarry is found at the intersection of Latitude 03°50'29.2" North of the Equator and Longitude 11° 30'07.1" East of the Greenwich meridian. The quarry started in the year 2008 and exploitation started around the area behind the Vogt college. In 2009, the authorities of the school asked the stone exploiters to leave because of the incessant vibrations of buildings in the school. The exploiters then shifted to the area still under the mission but controlled by Church authorities of Mvolye.

Inquiries conducted at the site indicate that the area was covered by forest but with the outcrop of the country rock at certain spots. Exploiters soon came to know that the whole layer is underlain by parent rock that is shallow. The exploiters used rudimentary methods to crack the rocks (Figure 6a 6b, 6c)

. Logs of wood and/or car tires are burnt on the massive rock outcrop. The heat from the fire permits physical disintegration of the rock just as in mechanical weathering. The exploiters then use their experience to understand and exploit the lines of weakness as they use their hammers and sledge hammers. The rocks have varied appearance and mineral colour. On the whole, the rocks are similar to those of the other quarries with a presence of mica-schist, gneiss and granite.

Given that the population of city dwellers is increasing every day and that there is an increasing need of stones and cement as opposed to traditional materials for construction, the Quarries are indispensable. Meanwhile, they have a great adverse effect on the ecology of the area since they deplete the vegetation and cause the disappearance of Fauna.



Figure 6: Rudimentary Quarrying Technique Behind
College Vogt
May, 2012

Quarries in the Yaounde Metropolis are both causes and consequences of urbanization. They are causes where rocks are used as material for the construction of new houses to accommodate the ever increasing population. On the other hand, Quarries are the consequences of urbanization. This is seen where the expansion of the urban space generates

the need for more rock/stones. According to Tarr (1996), the relationship between city and the natural environment has actually been circular, with cities having massive effects on the natural environment while the natural environment in turn, has profoundly shaped urban configuration. After this study, it is important to hold that it is the need of initial urbanization that has orchestrated and sustained quarrying in Yaounde. Meanwhile the product from these quarries are guaranteeing urban peripheral extension

5. Conclusion

The study of the impact of urban expansion on non-metallic minerals in the Yaounde Metropolis permits some salient conclusions. First, the rapidly increasing population has orchestrated an increase in the need of space for settlement. Second, the need for more house and road infrastructure has imposed the need for rocks/stones (for foundation, walls, bridges and roads). Third, the wanton open cast exploitation has laid down landmark scars. And fourthly the abandoned Quarries have contributed greatly to the existence of interstitial spaces that serve as hide out for criminals.

Irrespective of whether it is urbanization that necessitates Quarries or there are Quarries that necessitate urbanization, it is obvious that the scars distort homogeneity of the surface. It is equally obvious that population increase is the both the causal perpetuating factors for both forces of urbanization and quarrying. Meanwhile, the fact that rocks are non-renewable resources is a clear indication the resources should be managed sustainably.

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