MAPPING OF LOCAL CONSTRUCTION MATERIALS FOR THE NORTH WEST REGION OF CAMEROON

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1. Introduction

The mapping project of local construction materials for the North West Region falls within the context of a circular letter No. 002/CAB/PM of the Prime Minister on the 12th of March 2007 specifying the intensification of the use of local construction materials for public works especially public buildings and roads. It was placed under the auspices of the Ministry of Public Works which is charged with the provision of funds for its execution. The Ministry on its turn lodged the project in the National Civil Engineering Laboratory (LABOGENIE) which executes the project. This project was initiated basing on the premise that, Cameroon as a whole and the North West in particular is endowed with enormous construction materials for public use but which are under exploited and not properly valorised. Thus, if these materials are identified, mapped out, categorized and valorised their use for constructions in specific localities and local economic conditions will prove very economical and effective. This will assist development planners in their regional development programmes whereby appropriate resources will be assigned to particular areas in respect to their local specificities.

According to the reference terms, emphasis was in the use of remotely sensed data and GIS tools which generated a comprehensive inventory of these materials. These tools enabled the overlay of satellite images over existing ordnance survey maps in order to circumscribe the different council areas. In this wise, the potentials of local construction materials for each council area could be identified and mapped out.

Given the quality of the results obtained for phase 1 of this project[1], phase 2 had to be approved which treats the Adamawa Region. The major objective of this convention is the research, location and mapping of local construction materials in Cameroon as a whole. The services required in this new convention have been structured into ten (10) phases which correspond to the 10 administrative Regions of Cameroon. Each of these phases covers a maximum period of 12 months and is sanctioned by:

- The production of a final report and its scientific validation by the National Institute of Geological and Mines Research of Cameroon (IRGM) and the National institute of Cartography of Cameroon (INC),
- The adoption of the final report by the follow-up committee and implementation of the above mentioned convention.

This article therefore focuses on the activities and results of this pilot phase which covered the North West Region of Cameroon.

2. Methods and techniques

2.1. Data collection

Two different means were used to acquire the data needed for this project. Firstly, there was documentary consultation where the results of previous works, especially the scientific publications on pedology and geology for the North West were consulted.

Secondly there was the use of remotely sensed data. With this, multi-band, multi-date and multi-spectral SPOT 5 satellite images were provided by the Ministry of Public Works. These images had been purchased from the ASTRIUM Group, an enterprise based in France. The images ranged from 2005 to 2010 and in order to resolve the problem of the infra red band, SPOT 4 satellite image with a resolution of 10 m grouping 91 scenes in one mosaic was added free of charge to the package commanded. The first contingent of image scenes that was commanded covered the North West and the Adamawa regions of Cameroon.

2.1.2. Image treatment and interpretation

Surfaces of at least 100m^2 that were preliminarily identified basing on pre-knowledge of the region served as references for sampling and classification with the Erdas computer software. Using image enhancements, iteration and the different adaptive filters for respective purposes (Lee, Frost, Gamma; Kuan) to interpret both surface and subsoil characteristics, three classified images were obtained – vegetal,

[1] The Ministry of Public Works is financing this project in phases. The next phase of the project is launched following the quality of the results obtained in the preceding phase. Phase 1 which concerns the North West Region has been validated and the second phase (Adamawa Region) is well advanced now.

pedological and geological formations. To validate these classifications, an intensive fieldwork was organised which lasted for 65 days. During the fieldwork, verifications of the different formations revealed by the image treatment had to be made, pits were dug using pick axes and spades to determine the thickness of some superficial formations, quarry positions, natural and planted forests (eucalyptus forest), Indian and raffia bamboo sites, outcrops of granitic and plutonic rocks were all located with the use of GPS. For purposes of accuracy, control points were taken so as to geo-reference the existing ordnance survey maps that bear the administrative units of the region. These points were taken in localities that evenly spread across the region.

Division	Council area	Locality	Ground control point	UTM map coordinates	UTM field coordinates	Error margin (in m)
Menchum	Wum	Wum	Wum centre	619017 706168	619015 706166	2 2
	Zhoa	Nyos	Nyos village	642729 714761	642728 714760	1 1
	Furu Awah	Furu Awah	Furu Awah town	762485 764415	762482 764412	3 3
Donga Mantung	Ndu	Karkar Ndu	Ndu tea Estate	696431 703118	696434 703115	3 3
	Ndu	Ndu	Ndu town centre	699233 706248	699235 706250	2 2
	Ndu	Karkar Ndu	3 corners Karkar	689996 753343	689999 755346	3 3
	Ako	Ako	Ako town centre	691579 745451	691583 745454	4 3
	Ako	Ako	Asoro river Ako	671283 728183	671281 728186	2 3
Ngoketunjia	Balikumbat	Bambalang	Bambalang centre	669904 651881	699906 651884	2 3

Table 1: Geo-referencing control/field ortho-rectification points in the North West Region

Having the ordnance survey maps geo-referenced, the treated and validated satellite images in raster layers were then converted to vector layers in order to have them opened in the ArcGIS software. In the ArcGIS, the treated image was then superimposed on the geo-referenced survey map that contained all the administrative units of the region. This was done following the different types of local construction materials identified in the region. To this effect, the vector layers of geological, pedological and vegetal formations were overlaid on the survey map one after the other so as to easily map out and determine the volumes of construction materials in each council area.

2.1.3: The search and location of the sites of local construction materials

Basing on field observations and the use of empirical methods of investigations, all the different types of houses constructed with the use of local materials were sampled and all the exploitation sites located with use of GPS. This exercise stretched from 2008 to 2012 depending on the mission order and financial means issued by LABOGENIE. In the field,

the following sites identified and located. They include: Sites of pedological, geological and vegetal origins.

2.1.4: The estimation of the average volumes of soil and rock formations

This consisted of determining the limits of each material type, the total surface area of that material type (done in square metres) within ArcGIS and the average altitude using contours. The average volumes of the materials that can be extracted (Vm) is a function of the average force (Fm) and the surface (S) following this equation:

$$Vm = Fm\ x\ S$$

With Fm in metres, S in square metres and Vm in cubic metres.

Finally, in the laboratory, samples of local construction materials extracted from the potentially exploitable and exploited sites in the region were tested geotechnically and mechanically at LABOGENIE while the physico-chemical analysis were carried out at MIPROMALO. For rocks, Los Angeles (LA) test and 4 days Water Micro Deval (WMD) were also done. For sand, sand equivalence (SE) was determined on which granulometric analysis (GA) was done and for clays and lateritic soils, the physico-chemical tests were done through mythelene blue test, cooking test, water absorption and x-rays diffractometry on one hand and 14 days stabilization granulometric analysis and the determination of Atterberg limits on the other hand.

All the data obtained were stored in a database which is diffused through two servers, one installed in the Ministry of Public Works and the other in LABOGENIE.

3. Results

A number of local construction materials were identified and mapped out in the NW Region which differs to an extent from one council area to the other. Figures 2, 3 and 4 illustrate the spatial distributions of vegetation, soil and rock formations in the North West Region. These materials are generally grouped into three classes which include rocks, vegetation and soils.

Table 2 recapitulates the major types of local construction materials used in the North Region of Cameroon.

3.1 – Spatial distribution of vegetation in the North West region

All the types of vegetation identified in the region are represented in all the divisions but the division with the most natural vegetation is Donga Mantung with about 37.64% of natural vegetation in the whole region. Due to inaccessibility, there is limited wood exploitation for construction by the local communities. Table 3 illustrates the different local construction materials and the evolution of their use in the region.

Vegetation of the North West Region	Surface area (in km^2)	%
Natural forest	3931	57.45
Secondary forest	696	10.18

Wooded savanna	1686	24.64
grassland	529	07.74
TOTAL	**6852**	
Local construction materials of vegetal origin		
Type of vegetal material	**Number of accessible sites**	
Raffia bamboos	123	
Indian bamboos	32	
Wood	35	

Table 2. Local construction materials and their uses

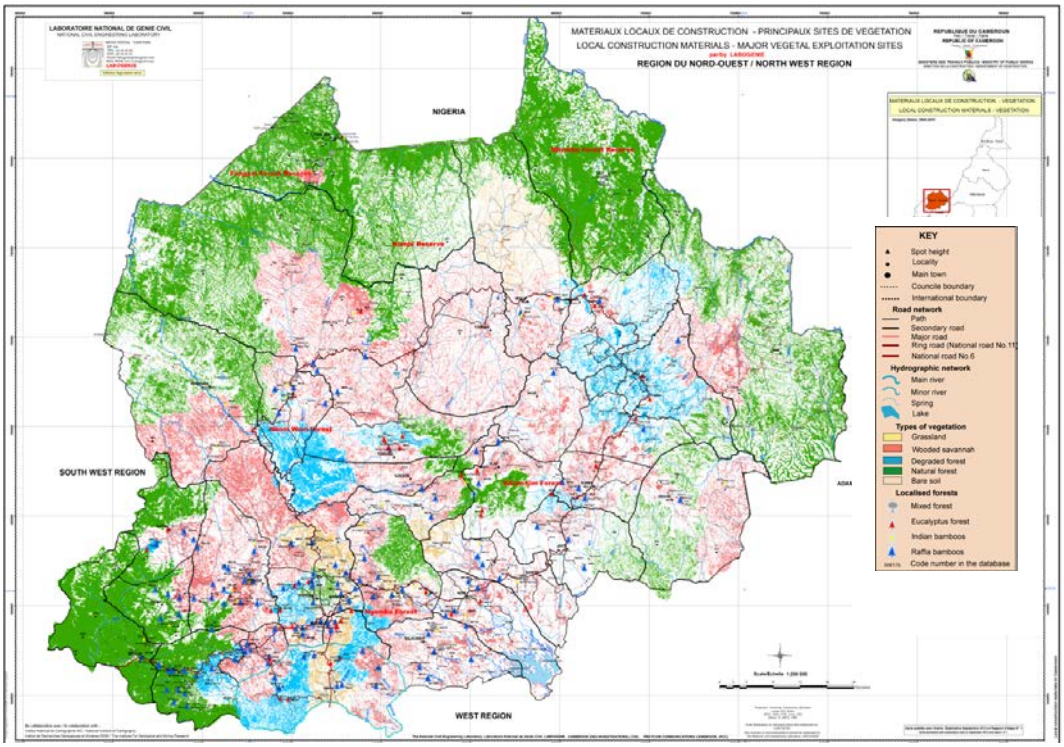

Figure 2. Spatial distribution of vegetation types in the North West Region

Local material	use		
	In the past	**Presently**	**In future**
Raffia bamboo	rafters, door, window and furniture	Cupboard Decoration of public places, ceiling and cupboard	Decoration of semi concrete and concrete houses
Indian bamboo	Construction of houses by placing the vertically and horizontally	Furniture , Decoration of public places.	Decoration of semi concrete and concrete houses
Grass straw	Construction of traditional and semi traditional houses	Roof	Decoration of semi concrete and concrete houses
Liana	Tying of bamboos	Tying of bamboos	Tying of bamboos

Wood	Serve as firewood and hedges	Construction of rafters, furniture, treated wood in planks and rafters	Construction of rafters, furniture, treated wood in planks and rafters

Table 3: Evolution of the use of local construction materials in the North West

3.2. Spatial distribution of soil types in the North West region

Generally lying along the Cameroon Volcanic Line, most of the soils of the North West region resulted from the evolution of volcanic soils.

Soils of the North West Region	Surface area (in km^2)	Average volume (in m3)	Number of sites identified
Clay	1665	8 000 000 000	73
Alluvial and plain sand	195		106
Clay sand soil	4843	13 000 000 000	65
Volcanic soil	149	1 200 000 000	15
Lateritic clay	8919	32 400 000 000	180
Gravel	2936	4 700 000 000	133
Hardpan	1979		30

Table 4: Estimation of pedological formations in the North West

3.2.1. The distribution of clays

Clays are the weathered materials from volcanic, plutonic and metamorphic rocks. Being of whitish, black greyish, reddish or yellowish and even violet colour, these rocks are often covered by lateritic clay or lateritic gravel. They occupy mostly the northern part of the region. It is estimated that they occupy about 1 665 km^2 of surface area being 8.05% of the whole region.

3.2.2. Alluvial and plain sand, found either in the form of flats in river beds or in hard deposits for example in the Ndop plain. Its colour ranges from grey to dark grey, red or black. It can be fine with a high proportion of clay or Limon particles, average or coarse with mineral composition of quartz, feldspar or sometimes ferruginous or other rock fragments. The surface area they occupy is estimated at about 195 513 005 m^2 being 0.94% of all the soils in the NW Region.

4.2.3. Distribution of clay sandy soils

Clay sandy soils are bullrings. They constitute thick layers of alterites which lie directly on plutonic and metamorphic rocks from where they were derived. They are either covered by low layers of clay laterite or gravel**.** They can be found in all the divisions of the region except in Ngoketunjia Division. The sites of this soil type were described as such in the last division. They are absent in volcanic landscape and found all over the western part of the region. They are usually light in colour looking dusty or red. The effects of erosion are very visible in zones where it is well developed. In the whole of NW Region, clay sandy soils occupy an

estimated surface area of 4 843 709 349 m^2 being 23.41% of all the soils in the region (table 5).

3.2.4. The distribution of volcanic soils

Volcanic soils are either pyroclastic products which are at the early or advanced stage of weathering (pouzzolanes, blocs, scories, etc...). They can mostly be identified in Menchum Division and in low quantities in the divisions of Boyo, Bui, Donga Mantung and Mezam. Sometimes they are constituted of low stratified deposits of pouzzolane (mixture of blocs, rock fragments and scories) around the crater lakes. They occupy an estimated surface area of 149 878 267 m^2 being 0.72% of all the soils in the NW Region (table 5).

3.2.5. Distribution of clay laterites

Clay laterites are red or brown soils. They exist in abundance and occupy the central part of the region and can also be found in all the divisions of the region as well. Clay laterites are homogenous soils and result from the weathering of volcanic rocks and to a limited extent from plutonic and metamorphic soils. They are sometimes associated with lateritic gravel**.** Their essential mineralogy include: kaolinite, quartz, goethite and hematite while at 100°C their cohesion is variable. With those of good cohesion, at 16 to 18% of water absorption, they become baked at 950 to 1000°C where baked bricks and tiles are fabricated.

Their estimated surface is 8 919 500 935 m^2 being 43.11% of all the soils in the NW Region (table 6).

3.2.6. Distribution of gravel

They are laterites and/or quartz. When the two are put together, they become the most represented rocks. They cover the region in a band that is oriented NE –SW, stretching from Bui Division in the Nkum council area in the north to Mezam in the Santa council area in the south. They either result from the weathering of volcanic rocks or from the destruction of lateritic hardpans. In contrary to laterites, they are heterogenous red soils and are either constituted of granules, pisolites or fragments of the mother rock, hardpan or minerals especially quartz found within clay**.** In the whole region, gravel occupies an estimated surface area of 2 936 368 821 m^2, being 14.19% of all the soils in the NW Region (table 6).

3.2.7. The distribution of lateritic hardpans

Lateritic hardpans according to (Vallerie M., 1970) are hard soils. Large deposits of hardpans have been identified in Donga Mantung Division, especially in the north of the Ako council are right to Abonshe at the frontier with Nigeria. They can also be found at the base of lateritic clay or lateritic gravel in the north of Nkum council area in Bui Division. They occupy an estimated area of 1 979 487 672 m^2 being 9.57% of all the soils in the region (table 3). Looking at the mechanical, geotechnical and physic-chemical characteristics of the basement complexes, laboratory tests revealed the following results for the construction materials (table 5).

QUALITY MATERIAL	Los Angeles	Micro Deval
Very good quality Agregates of categories A and B	LA <20	MD < 10
From good to average quality Agregates of category C	LA: 20 - 35	MD: 10 - 13
From bad to very bad quality Agregates of categories E and F E	LA>35	MD > 13

Table 5: Mechanical, geotechnical and physic-chemical characteristics of the basement complex

Types of soil	Boyo	Bui	Donga Mantung	Menchum	Mezam	Momo	Ngoketunjia	Total (m^2)	%
Clay	71680 478	228675134	186276858	225 590 112	65909776	11492170	876 065 131	**1665689659**	**8.05**
Alluvial/ Plain sand	6 060 321	2770000	16774 000	32 086 301	8987383	817 000	128 018 000	**195 513 005**	**0.94**
Clay sandy soil	304 249	679397528	2252595259	946 602 896	309129405	655680012		**4 843 709 349**	**23.41**
Volcanic soil	7 561 099	4024919	3 788 305	134 459 099	44 845			**149 878 267**	**0.72**
Lateretic clay	1102 355 080	246251568	1 461362856	3477244049	722749911	1091119877	818 417 595	**8 919 500 935**	**43,11**
Lateritic gravel	554 293 750	1178320043	146 219 357	68 755 738	795313156	28118221	165 348 556	**2 936 368 821**	**14,19**
Lateritic hardpan		63631535	1915856137					**1979487672**	**9,57**
Total surfaces (m^2)	**1742254976**	**2403070727**	**5 982872772**	**4884 738195**	**1 902 134 476**	**1 787 227 279**	**1 987 849 282**	**20690 147 708**	
%	8,42	11,61	28,92	23,61	9,19	8,64	9,61		

Table 6: Surface areas of soil types per Division in the North West Region

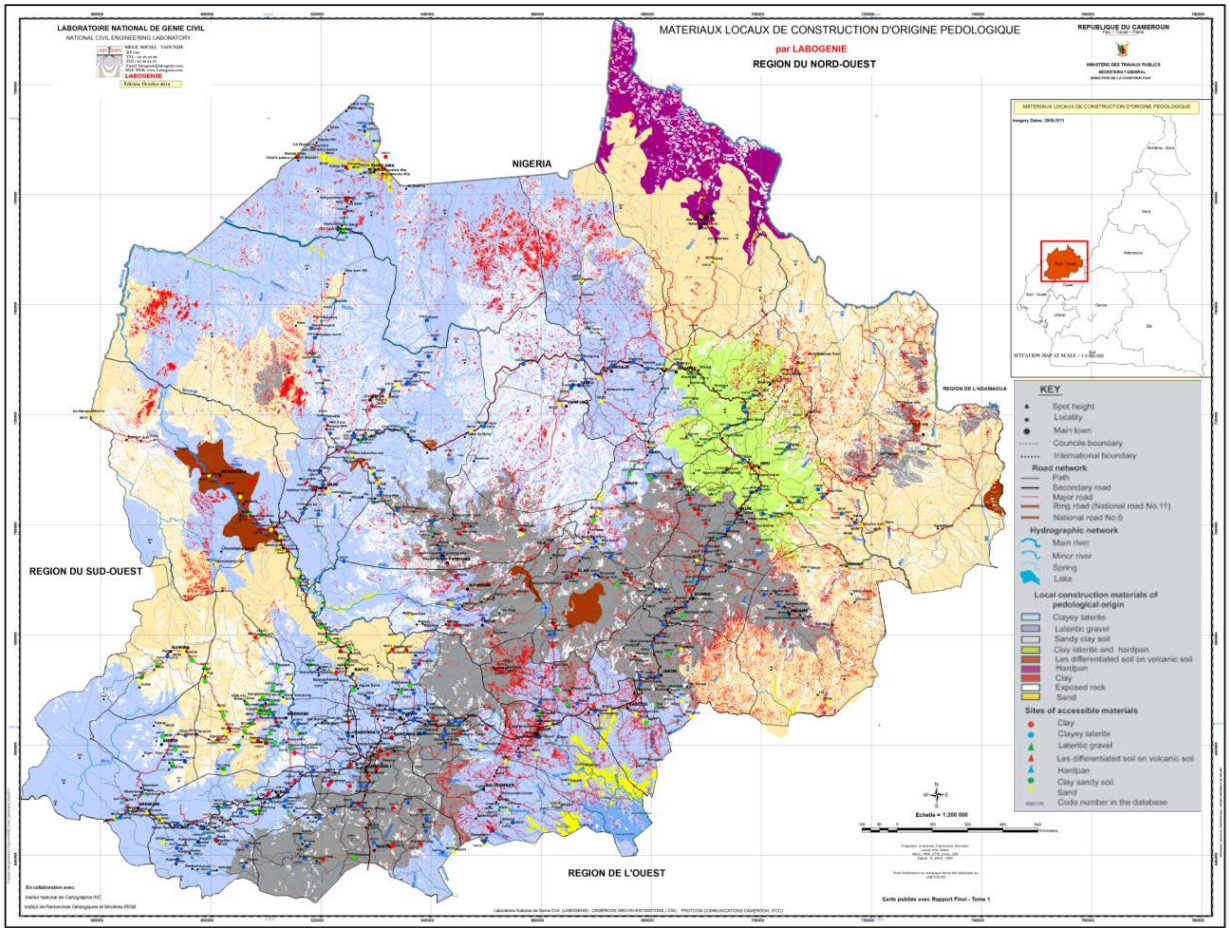

Figure 3. Spatial distribution of soil types in the North West Region

3.3. Geological formations for local construction materials

Geological formations of the North West Region comprise of volcanic, plutonic and metamorphic rocks (figure 4).

3.3.1. Volcanic rocks: they occupy an estimated area of 4 637 791 377 m^2, being 29.18% of all the rocks in the region (table 5). They belong to the volcanic formations of the Cameroon Volcanic Line (Njila, 1991; Lissom, 1991). They appear in the form of domes and flow domes, cones of high accumulation of basalt, trachyte and phonolite. They are being released from metamorphic and granitic formations. Pyroclastic products (volcanic rocks) are found at the immediate surroundings of crater lakes where they are associated with cones and less extensive basalt formations.

3.3.2. Plutonic rocks: they are intrusive rocks found within orthogneiss, gneiss and migmatites. They occupy an estimated area of 4 595 474 961 m^2, being 28.91% of all the rocks in the region (table 5). They are mostly coarse grain granite of pink or white feldspaths and scarcely diorites. They form a large massif in the central part of the region covering especially the councils of Zhoa and Furu Awa; the whole of Fonfuka council and more than half of the southern Misaje council. These plutonic rocks also cover the whole eastern part of the Ako and Nwa councils and ends in the east of the Mbiame and Nkambe councils. They are covered by

volcanic flats in the Nkambe and Kumbo councils. They often contain pockets of metamorphic dips of varying sizes.

3.3.3. Metamorphic rocks: they constitute the substratum of the North West Region. They occupy a surface area estimated at 6 661 922 855 m^2, being 41.91% of all the rocks in the region (table 6). They are orthogneiss, gneiss and migmatites on which slabs of amphibolites appear. Some dykes of dolerite are also present. The plutonic rocks of this region have intruded into the metamorphic rocks and in some places they are covered by volcanic rocks that stretch from Batibo in the SW to Nkambe in the NE passing through Bamenda, Belo, Fundong, Elak, Jakiri, Kumbo, Nkum and Ndu.

Division	***Volcanic rock (m^2)***	***Plutonic rock (m^2)***	***Metamorphic rock (m^2)***	***Total (m^2)***
Boyo	843 213 463	750 180 966	63 600 915	8 456 995 344
%	**50,89**	**45,27**	**3,84**	
Bui	1 353 198 159	396 137 748	63 600 915	**1 812 936 822**
%	**74,64**	**21,85**	**3,51**	
Donga Mantung	555 308 527	2 759 736 511	1 009 042 981	**4 324 088 019**
%	12,84	63,82	23,34	
Menchum	9 967 212	584 436 017	3 714 628 440	**4 309 031 669**
%	**0,23**	**13,56**	**86,21**	
Mezam	1 191 304 653		587 754 598	**1 779 059 251**
%	**66,96**		**33,04**	
Momo	447 397 411		1 310 538 191	**1 757 935 602**
%	25,45		74,55	
Total	4 637 791 377	4 595 474 961	6 661 922 855	
%	29.18	28.91	41.91	100

Table 6: Estimated volumes of geological formations of the North West Region

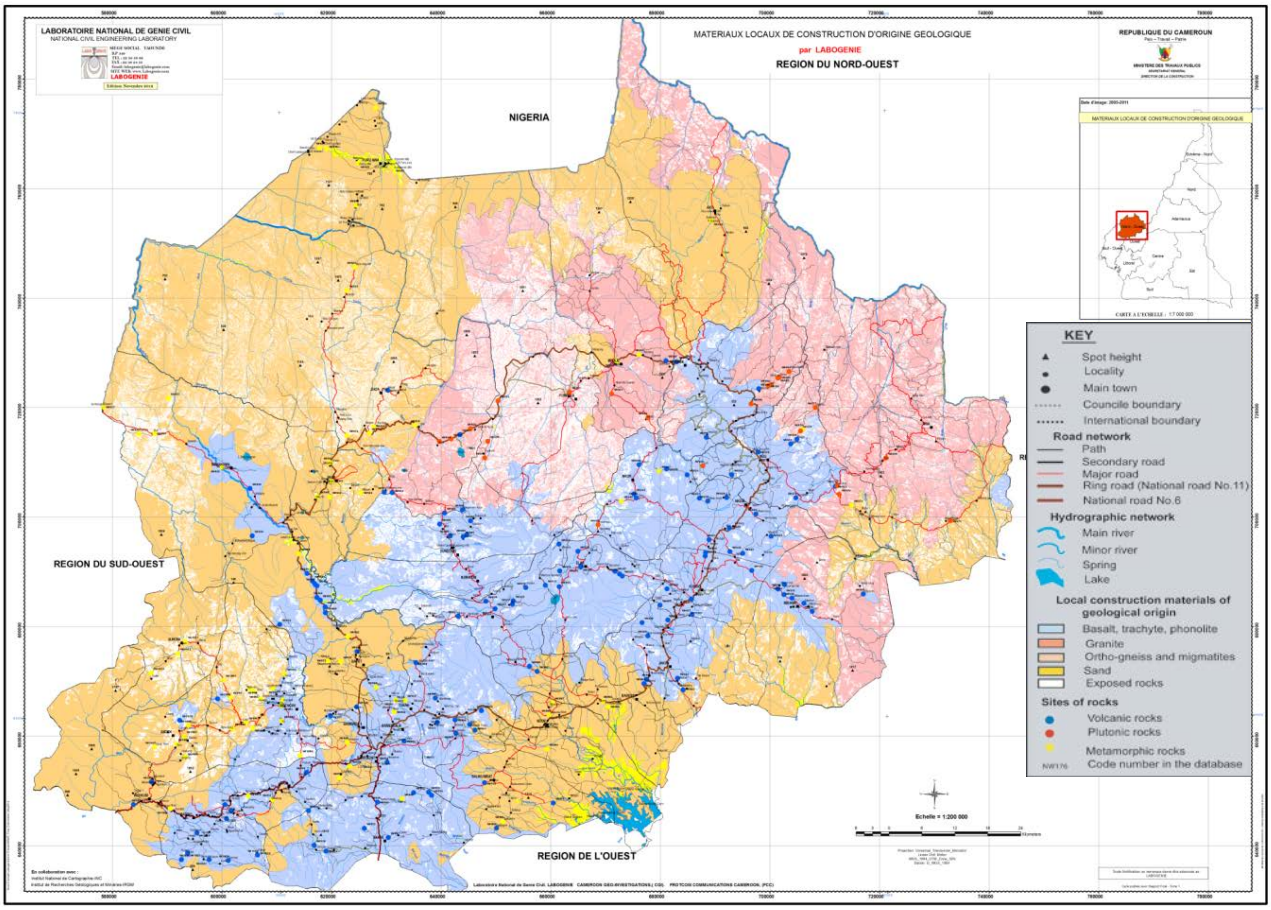

Figure 4: Spatial distribution of geological types in the North West Region

4. Constructions realised with the local construction materials

Note should be taken that two main types of residential homes are constructed with these local construction materials in the North West Region of Cameroon. These include huts and houses.

4.1. Huts

Three different types of huts are observed all over the region (photos 2a and b).

4.1.1. Grass huts: They are constructed with non-timber vegetal materials where there is no foundation. The walls are constructed in raffia straw weaved according to ancestral practices that have long existed. In some cases the walls are supported with bamboos sticks and eucalyptus pegs. The whole structure is tied up with raffia ropes or liana. The doors and the windows, if there are any are made up of eucalyptus wood. The rafters, since they are often in conical form and rarely in two slopes

constitute the roof which is perforated with raffia straw. Grass huts are owned by average or low income earners, nomads and semi nomads who live and basically practice agro-pastoral activities (enclosures for livestock, shelter for the farmer banes etc). With less than 1% of representation of all the residential homes in the North West, grass huts are in the course of disappearing.

4.1.2: Bamboo huts are mostly found in chief's palaces or in some ritual constructions. These types of modest homes today portray cultural and anthropological relics of the people. The architecture respects some geometry in the spacing of the local construction materials used. With these types of huts, there is a stone foundation which is deep into the ground. The walls are made of raffia bamboos which are tied together following a well structured architecture. The doors and windows are equally made of raffia bamboos. The rafters often in conical form are supported by strong eucalyptus pegs. The roof, made up of grass, covers the whole building.

4.1.3: Wood huts in their turn are a little scarce. With no foundations, they have walls constructed with sawn eucalyptus planks. The rafters mostly in two slopes are supported by strong wood pillars and the roofs covered by corrugated iron sheets. Most of the wood used is untreated thereby being vulnerable to insect attack, humidity and rotting. Being of recent appearance, these types of huts are mostly found in market places (photos 1 and 2).

Photo 1) Ancestors' bamboo hut in Ndu Palace

Photo 2) Architecture of a wood hut

4.2: Houses

Five different types of houses have been identified in the North West Region. They include mud houses, brick houses, stone houses, semi cement block and cement block houses.

4.2.1: Mud houses: These types of houses represent about 5% of all the houses in the North West Region. They are mostly found in villages far off the major towns. These houses are made up of thatches that are filled with

mud. The foundation is made of a large stone. This stone is placed on another one and are held together by laterite or clay mortar.
The walls of such a house are first constructed in raffia bamboos or grass placed horizontally in relation to the eucalyptus pegs and held together by raffia ropes. The spaces in between the bamboos are manually filled with laterite mud. The doors and the windows are made up of raffia bamboos and rarely in wood. The rafters, in conical form are also either made in Indian or raffia bamboo with a few wood pegs. They are roofed in grass, wood slaps or corrugated iron sheets.

4.2.2: Brick houses: These are the most popular houses in the whole North West Region. They represent about 45% of the houses. These houses can be divided into two types: Brick houses with grass roof and Brick houses with corrugated iron sheet roof.

Most of these houses have their foundations built in large shaped stones. These stones of various forms are placed on one another following a certain order. They are held together by laterite and clay mortar. The walls of these houses are constructed sun dried bricks placed on one another sometime following the present construction norms and held together by laterite and clay mortar.

The doors and windows are either made of eucalyptus wood or glass. The rafters can either be in bamboos and supported by wood pegs placed either inside or outside the walls. The rafters are made of grass or eucalyptus planks when it is to be roofed with corrugated iron sheets. In the case of a stone house (photos 5G and 5H), the walls are erected with stone shaped with cutlasses or with chain-saw in rare cases. Their rafters are also in wood planks while the roofs are in corrugated iron sheets.

Besides the stone houses the other sub types present long term disadvantages especially due to erosion and alternation of the dry and rainy seasons.

To overcome inconveniences, the walls of some of these house scan be plastered with concrete or reinforced by concrete pillars.

4.2.3: Stone houses: These date back to the colonial period. Some still exist today and they have undergone light modifications in the arrangement of the structure. In these houses, the foundations and walls are a continuous set up that is very resistant. The same stones are used for the edification of these structures. The dimensions and the forms of these blocks can either be variable when they have been shaped with a hammer or almost identical when the blocks have been sawn. Theses blocks are placed one after another and are held together by clay during the colonial

era and today by concrete. The doors of these houses are mostly in wood. Rafters are made sawn planks which support roof made of corrugated iron sheets. Most of these houses are the remains of colonization and are better represented through churches or other religious establishments due to the high cost of shaped stones; this construction technique has greatly lost grounds giving way to more solid modern houses.

4.2.4: Semi bloc houses: They are of recent creation. They can be found in all the divisions of the North West Region with an average of about 45% of all the houses of the region.

All these houses are constructed with well dug foundations and these foundations are built with stones that sometimes attain 30 cm in size. These stones are held together by mixed cement and the solidity of the structure is reinforced by pillars and iron rods.

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