GEOLOGY, SOILS AND MINES

Diagnostic Report

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INTRODUCTION

This report, relating to the mining and geology sub-sector, is a sub-section of the sectoral, territorial and institutional diagnosis carried out as part of the mission to draw up the Schéma Régional d'Aménagement et de Développement du Territoire (SRADDT) for the West Region.

The preparation of the inventory of the mining and geology sub-sector is in line with the government's desire to:

- give mines a lead role in the fight against poverty;
- ensure economic growth and the achievement of the Millennium Development Goals.

The potential of this sector must be exploited in order to increase its contribution to regional development.

The objective of this contribution is to provide a reference framework to better articulate and monitor the sector's actions, which must make mining a sub-sector likely to meet the requirements for emergence by 2035.

This work takes into account the sub-sector's anchoring to the DSCE and focuses on an analysis of the main components: geomorphology, geology, soils and mines.

An assessment of the main constraints, strengths, weaknesses, opportunities and threats of the sub-sector and the main challenges it will have to face, conclude this part of the regional diagnosis.

1. GEOMORPHOLOGY OF THE WEST CAMEROON

Through its two components, orography and hydrography, geomorphology will first of all be treated using a structural approach; this one focuses on interpreting the spatial arrangement of the relief in relation to the geological frame, i.e. in relation to lithology and tectonics, through satellite altimetry from the Shuttle Radar Topography Mission (SRTM) 90 m resolution. The processing of the SRTM Digital Elevation Model (DEM) produced orographic, hydrographic and slope maps.

1.1. Orography

1.1.1. Spatial Organisation of the Reliefs

The West Region's Digital Elevation Model (Fig. 1) shows a contrasting landscape where the elevation levels from about 200 m to over 2700 m highlight the main types of terrain: plains, plateaus and mountains.

Map 1: *Visualization of the West Region's relief*

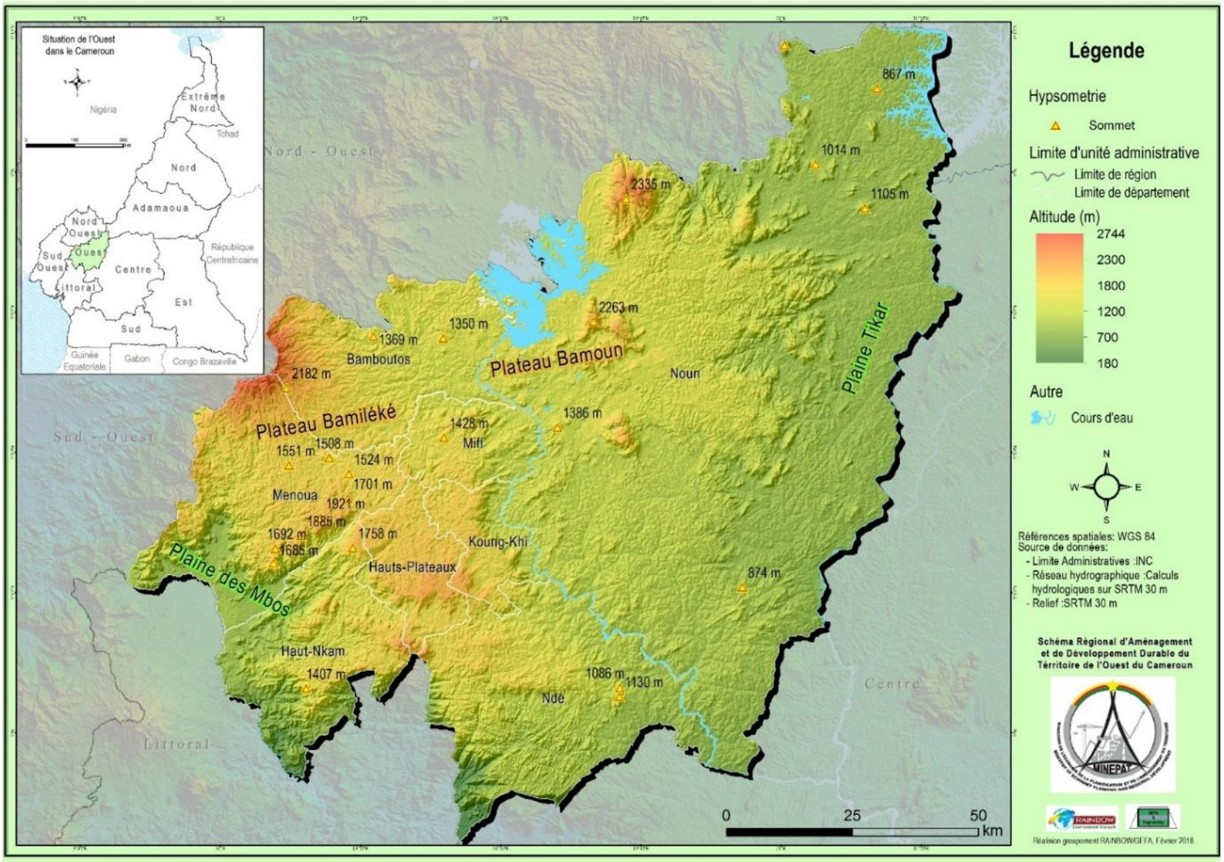
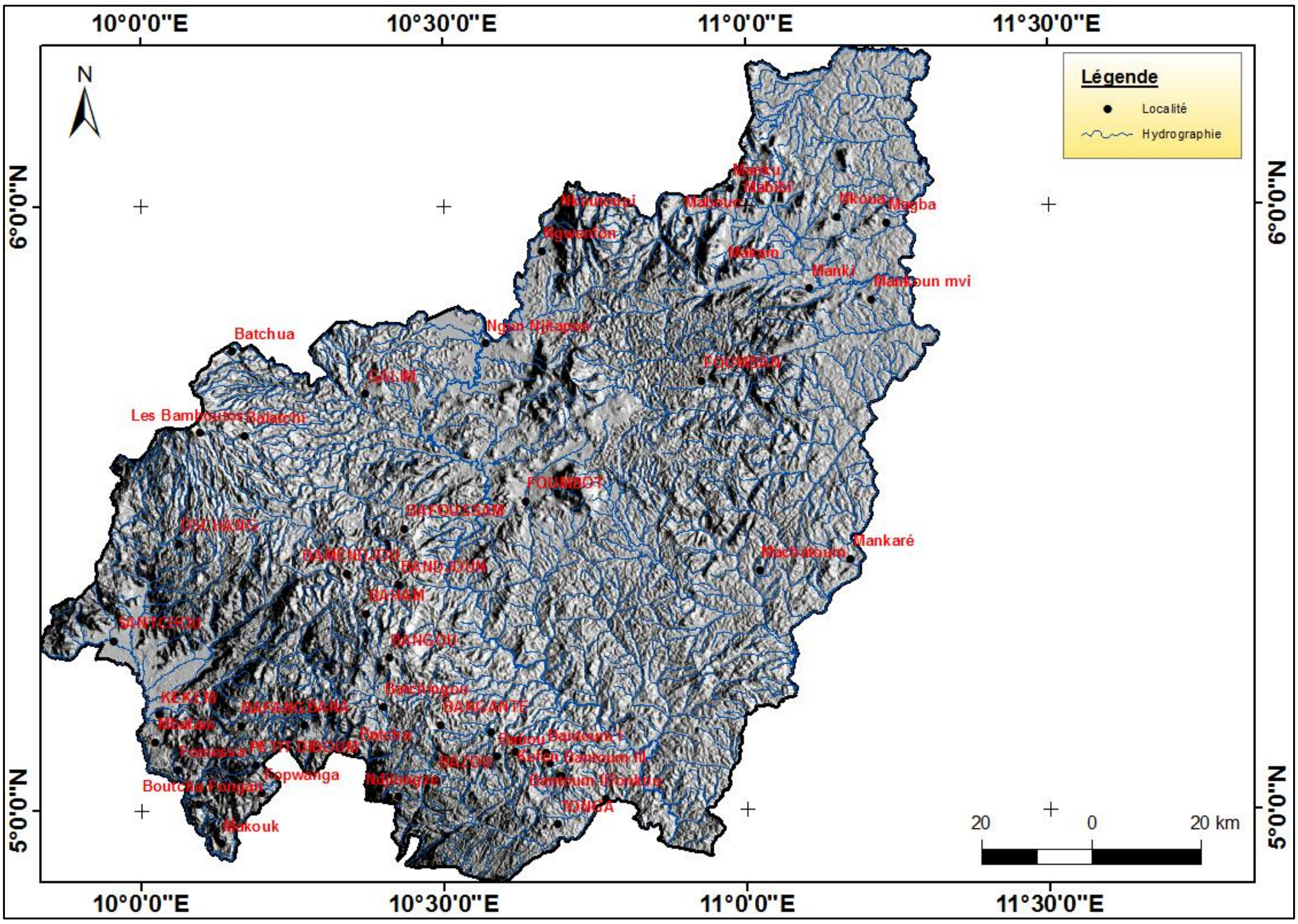


Figure 2, representing an overview of the DEM at a 45° angle, highlights at first glance, the essential role that geology plays here in the organisation of the relief, particularly through the structural linearity of most of the hydrographic network and numerous ridges, as well as the strength of the relief associated with buildings and volcanic products.

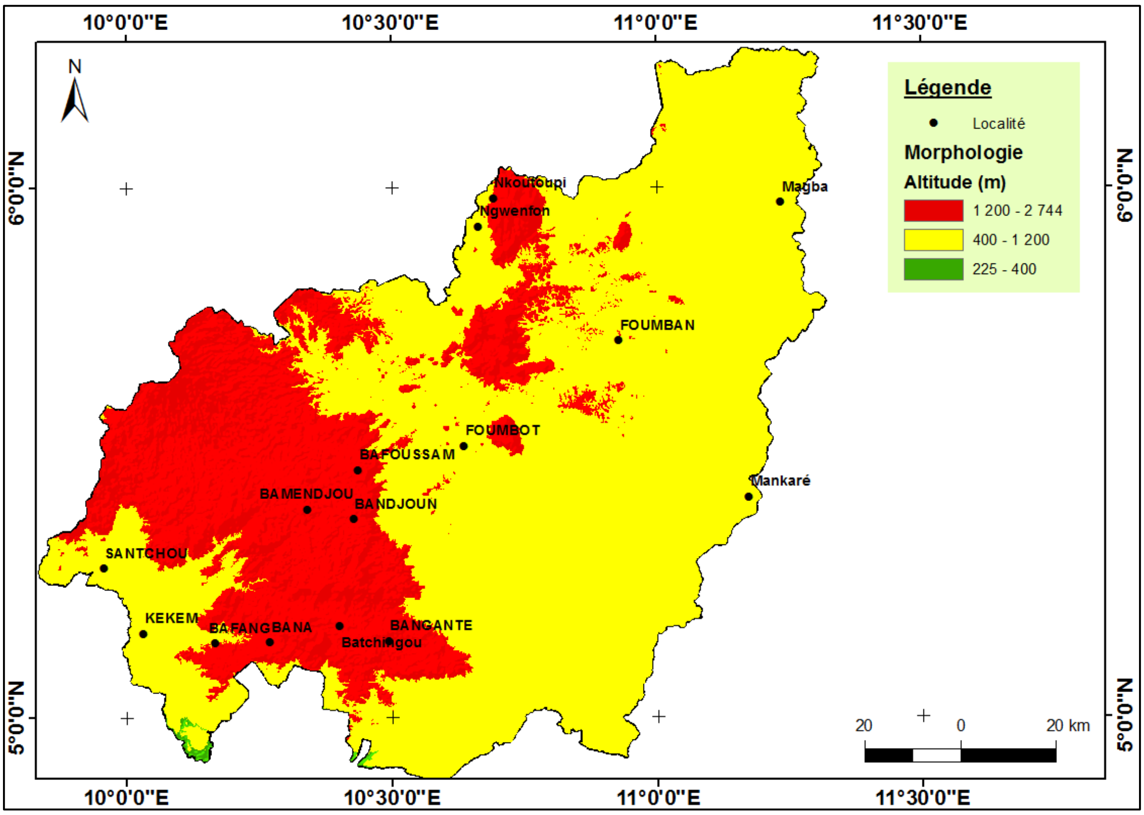
Map 2: *Visualization of the West Region's geomorphology (DEM at 45°)*



On this essentially geological basis, the West Region can be broadly characterized by three litho-morphological units (Fig. 3), namely:

- The low altitude unit, 225 m - 400 m, which is the signature of the small band of sedimentary formations of the Southwest (SW of Makouk, Haut Nkam Division);
- The intermediate altitude unit, 400 m - 1200 m, which is the extension range of the crystalline basement;
- The high altitude unit, 1200 m - 2744 m, which represents the volcanic cover of the West

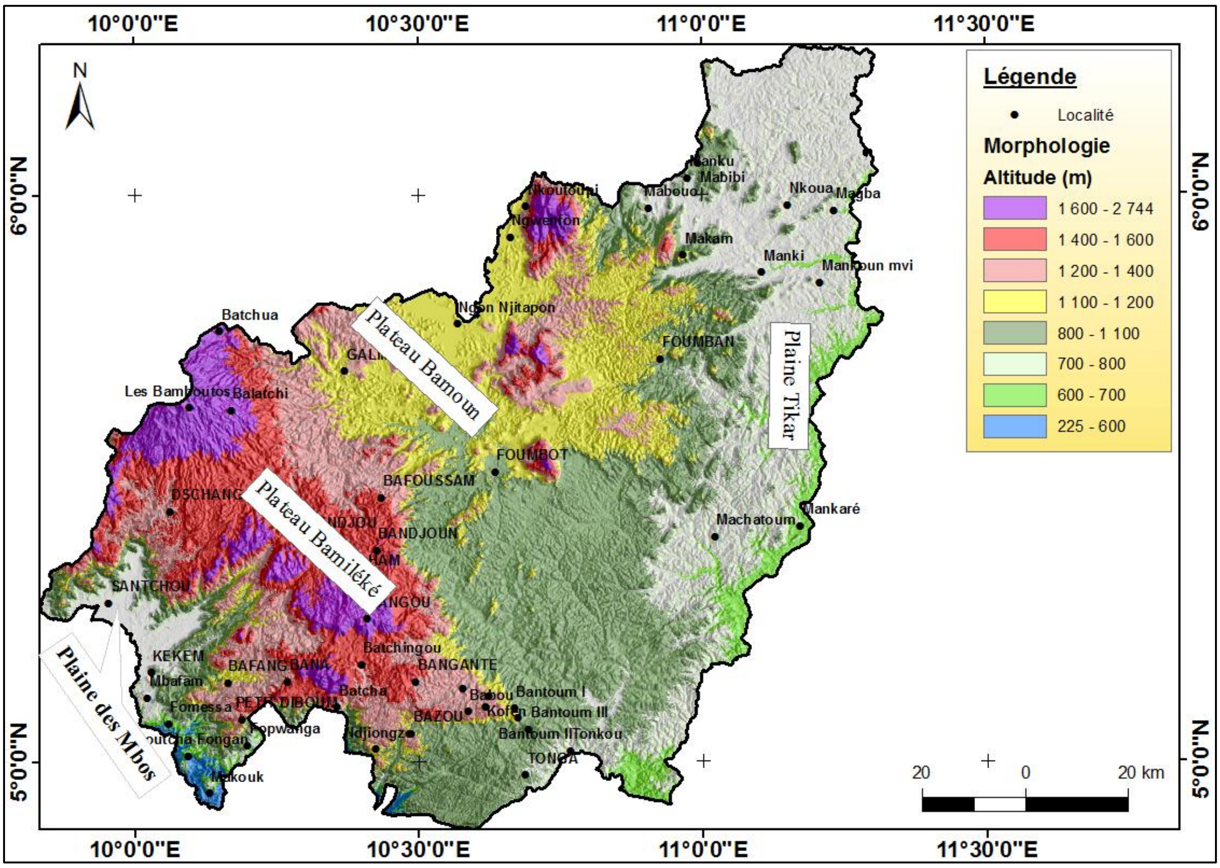
***Map 3:** Map of litho-morphological units in the West Region*



1.1.2. Spatial Configuration of the Main Units

The litho-morphological entities thus differentiated integrate the four geomorphological units characterizing, from the South-West to the North-East, the West Region: the Mbo plain, the Bamiléké plateau, the Bamoun plateau and the Tikar plain (Fig. 4).

Map 4: *Visualization of the relief: differentiation map of the West's geomorphological units*



1.1.3.Mbo Plain (700 m - 800 m)

Stretching over the Pan-African crystalline basement in the southwest of the region, the Mbo plain is a flat area whose altitude varies between 700 and 800 m. It is drained from north to south by the Nkam River. Recent volcanic events have significantly impeded the exit of water from the plain, and most of it is occupied by a large marsh.

The Mbo plain is enclosed by steep slopes with significant altimetric amplitudes (between 800 m and 1200 m) towards the bamiléké plateau, which are:

- to the West by the Manengouba massif;
- to the North by the heights that connect Manengouba to the Bamboutos Mountains;
- to the East by the Bamiléké plateau;
- to the South by a series of waterfalls, Ekom being the most famous; the Nkam reaches the Wouri coastal plain very quickly at an altitude of about 300 m.

1.1.4. Bamiléké Highlands (1400 m – 1600 m)

1.1.4.1. Spatial extension and configuration

The Bamiléké Plateau is an orographical entity oriented North-West - South-East, of which more than 60% is made up of strong reliefs of volcanic structures and products, which reveal basement windows in some places in the area. With an altitude varying between 1400 m and 1600 m, it starts towards Bafang and develops from Batié through Dschang, Bangangté, Bafoussam and Mbouda.

1.1.4.2. Shape of the slopes

The slopes of the plateau are largely cut by deep valleys such as those of the Ménoua and Metchié-Nkam (to be marked on a map).

The shape of its borders is characterized:

- to the North and North-West by volcanic massifs, the most important being the Bamboutos, whose flow marries, in a gentle slope, the plateau itself, made up of real planèzes; with series of peaks above 2700 m, the Bamboutos Mountains reach 2744 m at Mount Melétan (Olivry, 1973);
- to the East by a plain on basement windows and volcanic effusions, with a soft relief between 1100 m and 1200 m, gradually inclined towards the East, up to the limit of the plateau materialized by the Noun valley (400 m); in between 1200 m and 1400 m, a volcanic massif above the plain and a slope connecting to the gradual sloping plateau (North-West of Bafoussam) or in the steepy form (South of Bafoussam - East of Banganté) extend NW - SE;
- to the South by connecting slopes with an altimeter amplitude ranging from 1100 m to 1200 m, oriented East-West, on a gentle (South-East of Banganté) or steep (South of Batchingou) slope, the plateau thus dominates the Kondjok and Tonga Region by slopes of about 1000 m.
- to the West by slopes connecting to the plateau with high amplitudes between 1100 and 1200 m, then 1200 and 1400 m.

1.1.4.3. Shape of the plateau's centre

On the plateau itself, the valleys are not very steep and the landscape shows soft undulations. In addition, the Bamiléké plateau is dominated within it and on its borders by massifs with high reliefs such as:

- the Bani massif to the west (1921 m);
- the Batié massif (1924 m) and the Bana massif (2037 m) in the South;
- the Santa peak or Mount Léfo (2550 m) which dominates the Mbouda area in the North;
- the ridge of the Bamboutos Mountains and the Santa peak in the Northwest.

1.1.5. Bamoun Highlands

1.1.5.1. Spatial extension and configuration

The Bamoun plateau has an irregular shape, preferably oriented NNE - SSW. Following the Bamiléké plateau, it has an average altitude of 1100 to 1200 m and extends to more than 70% over the volcanic cover which allows crystalline basement windows to emerge at the western limit. The latter constitutes its substrate to the NE and SE of the unit.

1.1.5.2. Shape of the slopes

To the North and the East, the Bamoun Plateau is bounded by a 400 m escarpment (altimeter amplitude from 800 m to 1200 m), notched by the deep valleys of the Mbam tributaries in the NNE - SSW, NE - SW and ENE - WSW (Fig. 4).

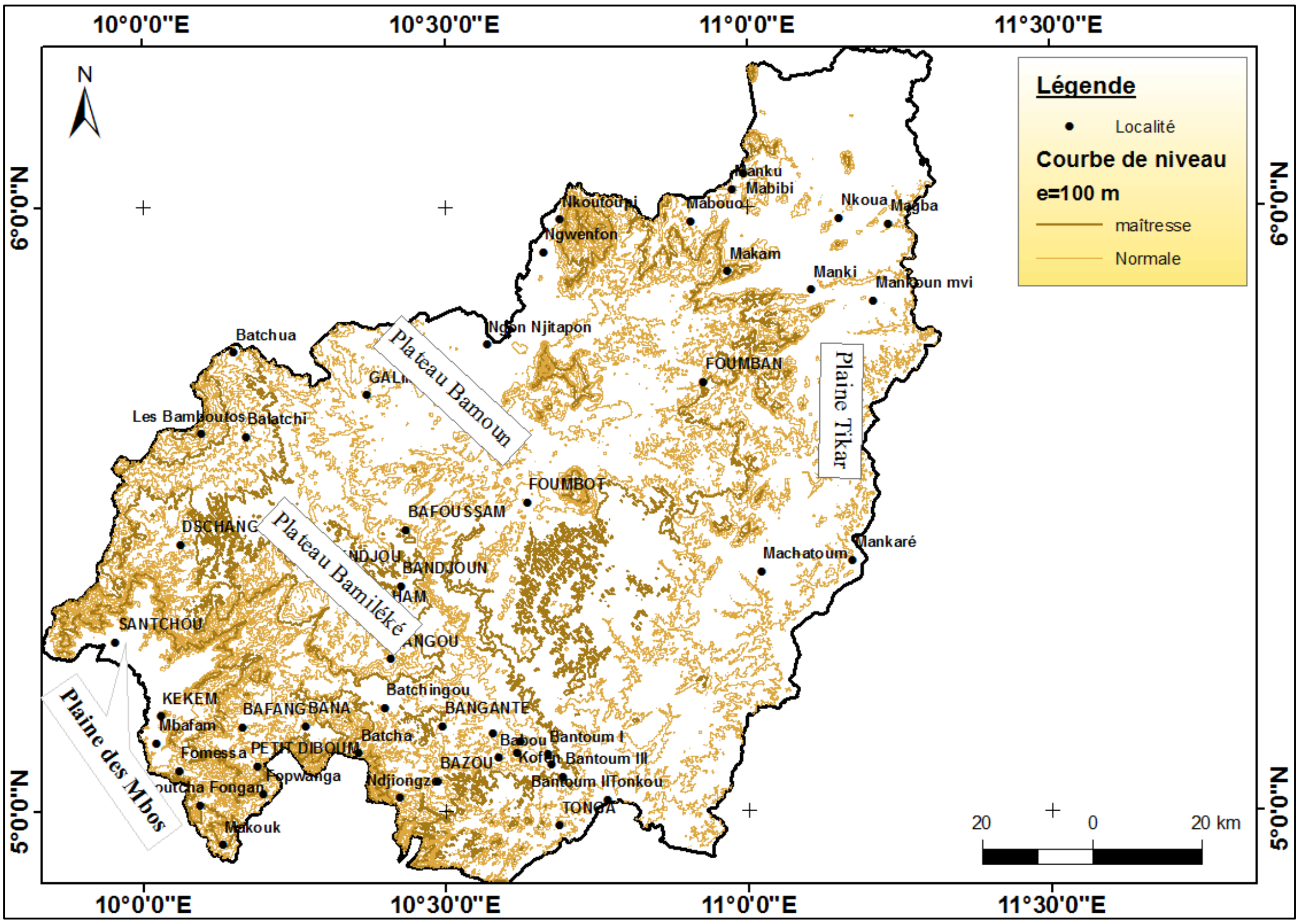
To the South and South-east, a vast plain extending over the crystalline and soft-relief bedrock marked by mostly NE - SW ridge lines follows the Bamoun Plateau; the average altitude (1100 to 1200 m) of the latter gradually decreases to 900 m towards the confluence of the Noun and Mbam.

To the Northwest, the Ndop plain continues the Bamoun plateau to the Bamenda and Okou volcanic massifs (3070 m).

1.1.5.3. Shape of the centre

As can be seen in the maps in Figures 4 and 5, isolated massifs such as the Mbam (2335 m), Nkogam (2263 m), Mbapit (1989m) and recent volcanic tools of moderate sizes dominate the Bamoun Plateau from their strong relief, thus breaking its monotony.

Map 5: *Visualization of the relief: orographic map in contour lines*



1.1.6. Tikar Plain

1.1.6.1. Spatial extension and configuration

The Tikar Plain, on average about 20 km wide, forms a N-S to NNE - SSW band at the boundary of the West and Centre Regions. It extends exclusively over the geological formations of the Pan-African crystalline basement.

1.1.6.2. Shape of the slopes

When leaving the Bamoun Plateau to the east, a 500 m cliff leads to the Tikar Plain, which is directly linked to the Centre Region. Drainage is provided by the Mbam which, descending from Adamawa, represents the eastern limit of the West Region.

On the eastern edge of the Tikar Plain, an altimeter amplitude of 600 m to 700 m highlights the shape of the right bank of the Mbam and its tributaries, whose linearity, in the directions N - S, NNE - SSW, NE - SW, ENE - WSW and NW - SE, reflects the tectonic structures.

1.1.6.3. Shape of the centre

The altitude of the Tikar Plain varies between 700 and 800 m. The altimeter amplitude "800 m - 1100 m" shows that many residual massifs aligned or extended N - S, NNE - SSW and NE - SW are scattered along this plain (Fig. 4 and 5); their altitude can be compared to that of the neighbouring Bamoun and Adamawa plateaus.

Conclusion

The genesis of these different geomorphological units involves both cycles of erosion, as well as tectonics. A resumption of erosion at the beginning of the Cretaceous led to the general levelling of a post-gondwana surface with a 1,100 - 1,200 m altitude. In the tertiary, tectonic dislocations caused the graben collapse of the Mbo plain and the elevation of the Bamiléké plateau, and some isolated horsts such as the Mbam and the Nkogam in the Bamoun area (1,400 - I,600 m). Major basaltic effusions protect all the Bamoun and Bamiléké areas from a new cycle of erosion that brings the flattening of the African surface to 600-700 m (Tikar plain, Central Cameroon). The recent trachytic and basic volcanism, accompanied by the undoubtedly serious recurrence of tectonics, remodelling the landscape while preserving the various geomorphological units acquired.

1.2. Hydrography

1.2.1. General Characteristics

The West Region is part of the Sanaga drainage basin (the Mbam being its largest tributary) which is, in itself, an integral part of the vast domain of the Atlantic watersheds. The tributaries of this large basin start from the Bamboutos Mountains.

The West Region is only concerned by the Nkam basins and especially the Noun, which drains most of the region. These basins are drained by four main rivers (Olivry, 1976), namely:

- the Mapé in the North, tributary of the Mbam;
- the Nkam in the Southwest, a coastal river, Wouri, which flows into the Douala sea. It drains the southwestern edge of the Bamiléké plateau and the Dschang Region, with its Menoua, Metchié, Mou tributaries, etc.;
- the Ndé in the Southeast, tributary of the Noun;
- the Noun, which drains most of the West Region, after having originated in the Oku massif (3,070 m), then diverts into the Ndop plain, which is now flooded by the Bamendjin dam. On the right bank, the Noun receives the Mifi-Nord (Babadjou-Mbouda) and the Mifi-Sud formed by the Metchié and the Mifi-Sud itself (Bandjoun), two tributaries of equal importance draining the Bamiléké plateau. On the left bank, the Noun receives small tributaries from the Bamoun area; it flows into the Mbam, one of the major branches of the Sanaga.

It is difficult to talk about privileged directions in the orientation of the various branches of the network. They are indeed a large variety of them. However, it can be noted that the main rivers of the Nkam and Noun are NNW-SSE oriented and that the tributaries are often perpendicular. The radiated network that starts from the Bamboutos Mountains (Ménoua, Choumi, Toumongoua, Mifi-Nord, etc.) is characteristic of the planezes.

Volcanism is often responsible for the irregularity of the longitudinal profiles of the watercourses in the region. It takes several forms.

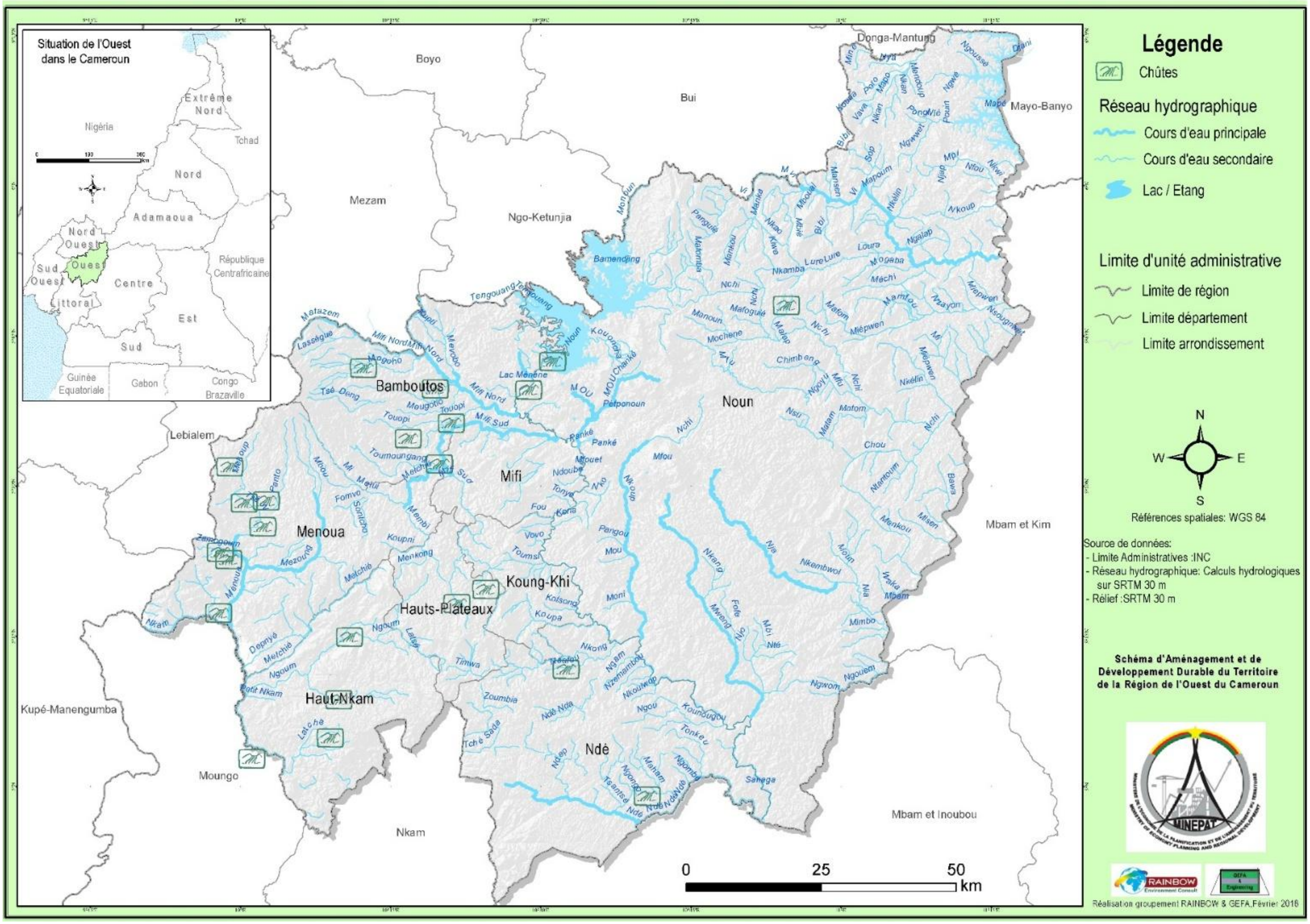
- Many falls cut the course of the rivers at the level of the flow fronts:
  - ✓ Basaltic: Ekom-Nkam Waterfalls (75 m high), Mouankeu in Bafang, Choumi and Metchié Waterfalls in Bafounda;
  - ✓ and trachytic: the Bamboutos trachytic cliffs cut the upper courses of the streams, causing beautiful waterfalls like that of Marnmywata near Djuttitsa;
- Many of the rapids are due to basalt flow dams, which are now open but have caused a difference in levels between the upstream and downstream. Upstream of these rapids (Noun in Bamendjing, at the Bafoussam bridge, Nkam in Mélong, etc.), these natural dams have led to the formation of vast swamps: the Ndop plain and the Mbo plain are the best examples of areas where hydrography has been totally modified by the Bamendjing and Mélong flows. On a more modest scale, one can mention the marshes of Bamendou, Wassa, the two Mifis and in the Bamoun area, those of Panké, Nja and Nkoup.
- Two lakes of volcanic dams are found in the Foumbot Region (Monoun and Paponoun Lakes).
- Nine crater lakes are also reported in the West Region: Monoun Lake, Baleng Lake, Tchoua Lake, Pêt-Ponoun Lake, male and female twin lakes, Ngouondam Lake, Dschang Municipal Lake...

1.2.2. Morphology of the Hydrographic Network

The layout of the hydrographic network is as a result of the simultaneous interactions between several form factors (climate, vegetation, human action), including geology, which plays an important role in the evolution of the course of watercourses. Indeed, two fundamental aspects of geology, the behaviour and organization of the hydrographic network, will be different depending on the lithology and structure.

The spatial organization of the West Region's river system highlights two main types of river channels: the single channel and the meandriform channels.

Map 6: *West Region's stream system*

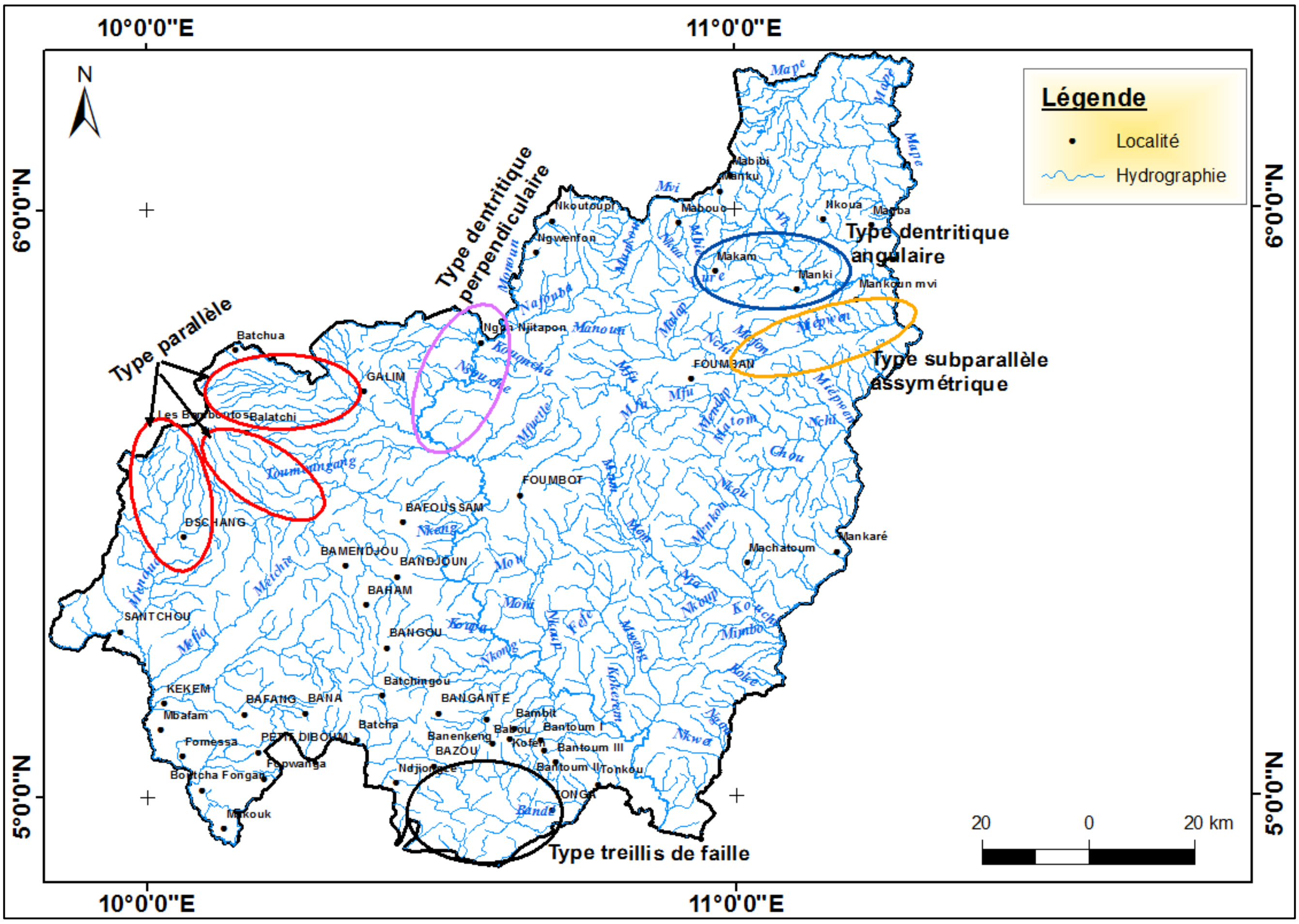


The most well-known and obvious part of the single channel is the stream system (plotted on a topographic map representing a branch identical to a hair, filamentous part of a root) shown in Figure 6 and 7 for the West Region. These hairs show channels.

The organization of the stream system tree according to gravity flow rules, shows particularities and abnormalities that make it possible to differentiate, following the geometric aspect, several types of unique channels, reflecting lithology and tectonics at different degrees. In the West Region, the hair in Figure 6, 7 and 8 show, one after the other, the types of hydrographic network:

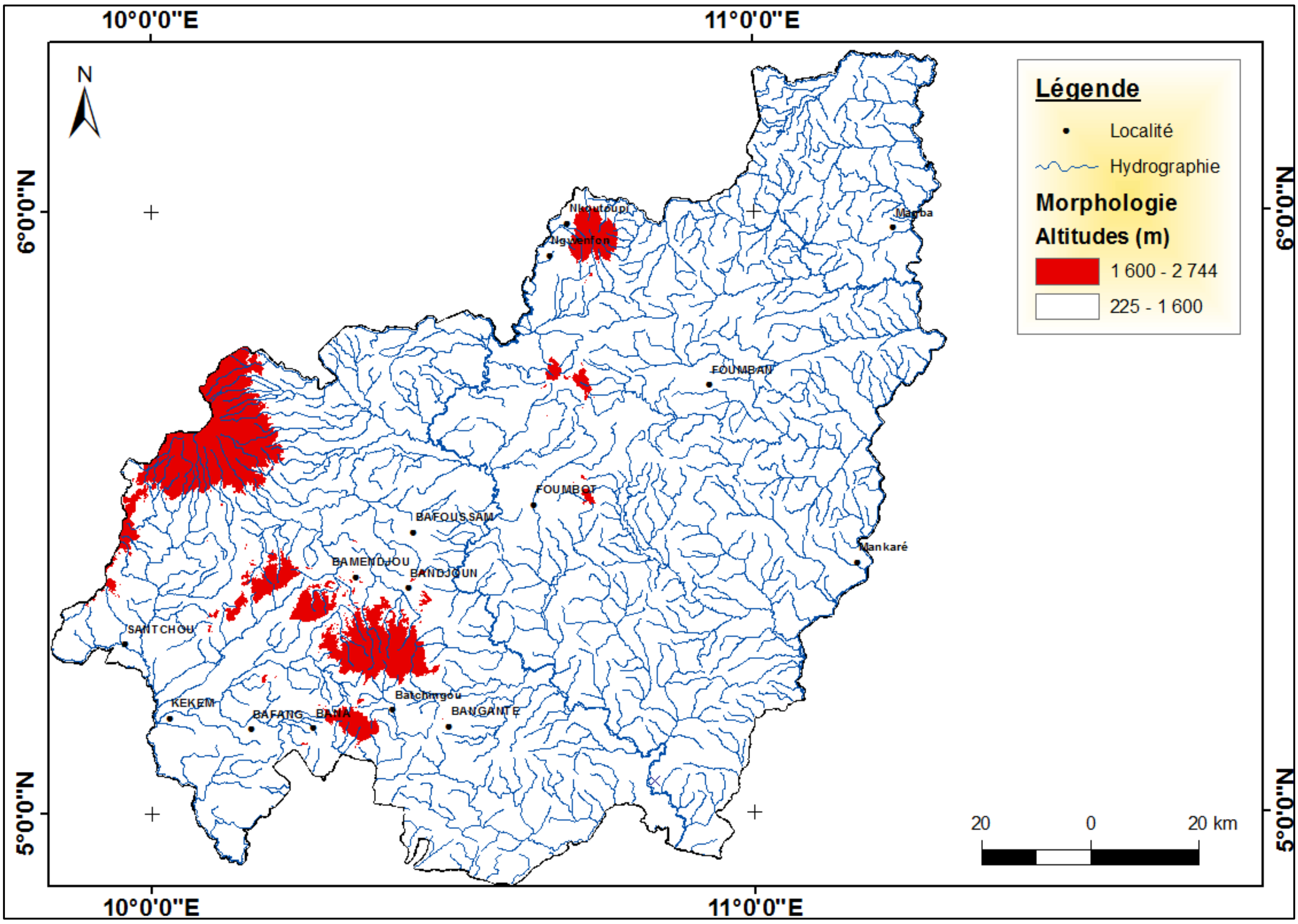
- tree branches with a dendritic appearance, predominant in the extension area of the crystalline substrate (eastern part of the region). This type shows local changes with:
  - ✓ a rectangular tendency established on the base with joints and faults perpendicular to the NE of the region;
  - ✓ an angular tendency characterizing intersecting joints or faults at non-right angles;
- in lattice, a modification of the dendritic type, with parallel elements on which tributaries are grafted perpendicularly, encountered sporadically at certain volcanic massifs of the Bamiléké and Bamoun plateaus or basement fault zones; the modified variant in lattice of faults and joints can be observed in areas of substratum affected by roughly parallel faults and joints;
- parallel, with a main collector indicating the existence of a fracture or characterizing the slopes with elongated topographic structures on the sides of the Bamboutos volcanic massif;

Map 7: *Types of river systems in the West Region*



- radial, a type of drainage associated with isolated volcanic massifs in the heart of the Bamoun and Bamiléké plateaus (Fig. 8); it has a significant multi-radial character of the complex radial drainage of the flanks of the Bamboutos mountains (Fig. 7 and 8) with a range of parallel types around the massif;

Map 8: *Altimeter amplitude 1600 - 2744 m (in red) and associated radial drainage type*



- asymmetrical, with tributaries grafted mainly on one side of a collector to the detriment of the other side.

The straight portions or hydrographic lineaments of the hydrographic network with the morphology thus characterized show 7 preferential directions: N - S, NNE - SSW, NE - SW, ENE - WSW, E - W, NW - SE and NNW - SSE deformation tributaries affecting the crystalline basement of the West Region.

Conclusion

Thus presented for the West Region, the morphology of the hydrographic network, which is a morpho-structural object, made it possible to establish the relationship between the type of drainage and the geological environment of the drainage basins.

1.3. Slopes

The relief of the West Region offers a particularly rugged topography, with really mountainous volumes, where neighbouring slopes or slopes above 40° are abundant. This topography affects the susceptibility of landscapes to erosion, combined with the effects of a monsoon climate on the various ecological zones.s.

1.3.1. Types of Slopes

The map in Figure 9 is a slope model derived from the SRTM DEM with slope classes calculated in %. It helps highlight areas with relatively moderate, medium and steep slopes.

1.3.1.1. Gentle slopes

Gentle slopes are found in the Tikar and Mbo plains.

The Mbo plain has a fixed flatness that does not allow any massif to emerge over its extension area, unlike the Tikar plain, which is sporadically overhung by isolated elongated ridges and reliefs aligned in structural directions.

1.3.1.2. Moderate slopes

They characterise:

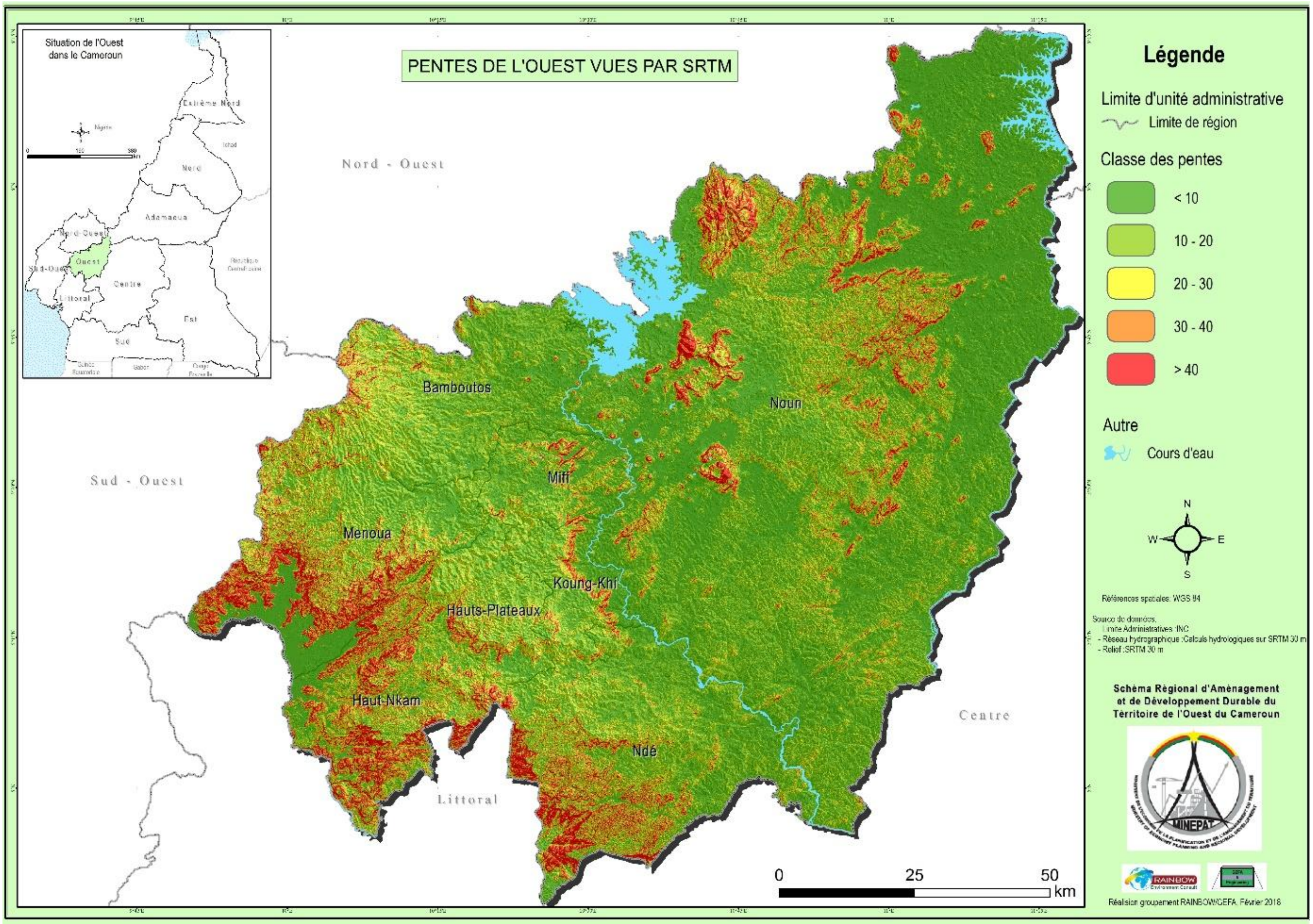
- the strings of linear ridges dotting both the volcanic plateaus and their crystalline bedrock; the linearity of these ridges in the directions N - S, NE - SW and ENE - WSW shows their origin which is basically tectonic (fault relief or foliation trajectories);
- the slopes connecting the plains with the edge escarpments of the mountain massifs;
- the plateau extending north and west of Foumban;
- the slopes of the Bamboutos Mountains.

1.3.1.3. Steep slopes

The steep slopes correspond to the cliffs:

- the edge of the Bamoun plateau with the Tikar plain to the north and east of Foumban;
- edges of the massifs and ridges emerging from the Tikar Plain;

***Map 9:** Spatial configuration and distribution of slopes in the West Region*



- Mbapit, Nkogam and Mbam massifs overhanging, in the N - S direction, the Bamoun plateau;
- NE - SW, ENE - WSW, NNE - SSW aligned ridges SE of Foumban and NE - SW aligned ridges SE of Foumbot;
- the South (SW of Bangou) and East (East of Bandjoun and SE of Baham) flow edges or fronts of the basaltic bamiléké plateau, the South (SE of Bana) and West (NE of Bafang) flow edges of the volcanic cover on the crystalline substratum;
- bands of crystalline massifs E - W south of Bazou; N - S east of Batcha - Ndjiongze; ENE - WSW, NE - SW and W - E west of Tonga; NE - SW and NW - SE south of Bana; of the area including the Fomessa - Petit Diboum, Boutcha - Fonga, Makouk municipalities; NE - SW south of Fomessa;
- from the edge of the Mbo plain across the steep slopes of the deep valleys NE - SW of Metchié and N - S of Menoua, tributaries on the left bank of the Nkam;
- the summit of the Bamboutos Mountains.

1.3.1.4. Slopes - hydrographical network - geology

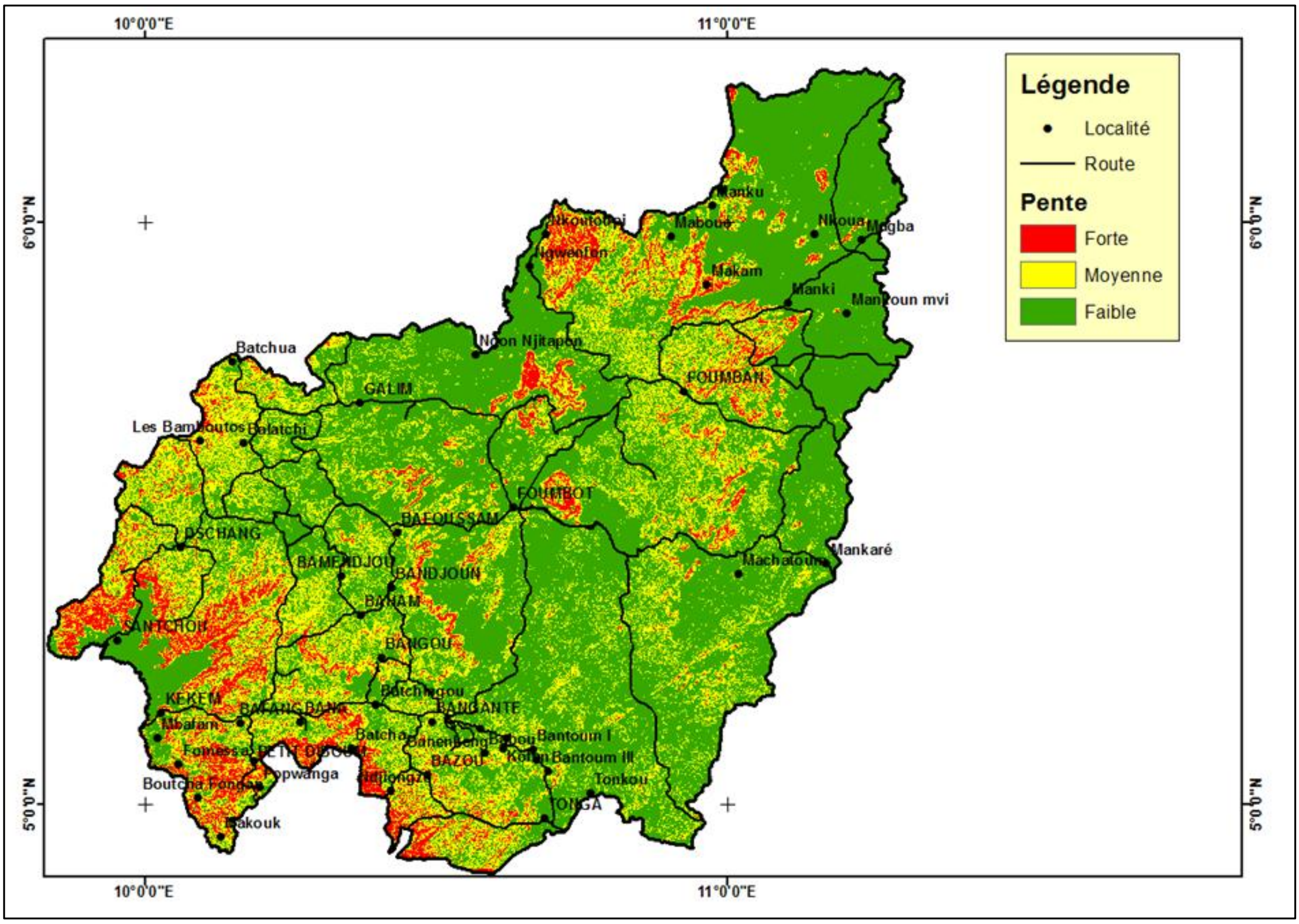
The escarpments of the massifs marking the festooned boundary of the West Region with the Nkam Division (Littoral Region) to the South of Bangangté - Bana are of tectonic origin; they highlight either fault escarpments oriented here N - S, W - E, WNW - ESE, NE - SE, or ridges whose lines have NNE - SSW and NE - SW directions parallel to the trajectories of the regional foliation or axial planes of the map layers. As for the cliffs of the banks of the tributaries on the left bank of the Nkam (ENE - WSW and NE - SW of

Metchié, NNW - SSE and N - S) marking the zigzag border of the Mbo plain, they result from gullying along the fault lines to which these watercourses are signatures.

1.3.1.5. Slopes and road network

In most of the West Region, which has many volcanic massifs with steep slopes, the accentuated reliefs have a direct impact on land use planning, particularly through the layout of road infrastructure. The road network illustrated in Figure 10 shows how its axes wind around and bypass steeply sloping mountain ranges to connect one urban area to another

Map 10: *Impact of slopes on road network configuration*



2. GEOLOGY OF WEST CAMEROON

The West Region is geologically composed of a volcanic cover and a sedimentary cover band in the extreme southeast, which are based on a crystalline basement with intrusive plutonic massifs in a deformed metamorphic substratum.

2.1. Lithological Bodies

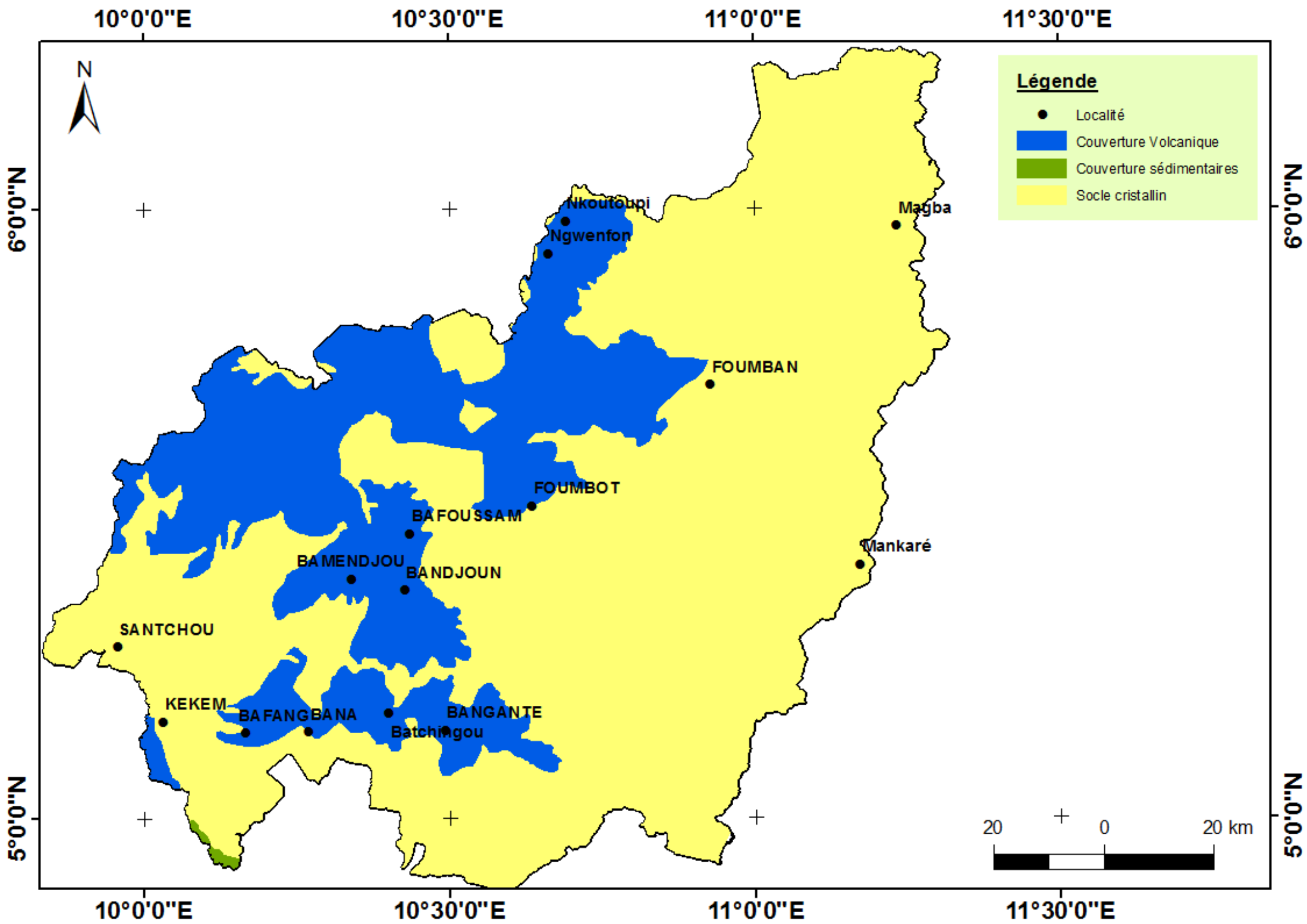
The simplified lithological map in Figure 11 illustrates the spatial configuration and extension of the 3 lithological bodies in the region, each representing a volumetric rate of:

- less than 1% for sediment coverage;
- 20% for volcanic coverage;

- 80% for crystalline basement formations.

The base and cover thus differentiated have contrasting morphological signatures as highlighted earlier in the chapter "Geomorphology".

Map 11: *Spatial configuration and distribution of the 3 lithological bodies in the West Region*



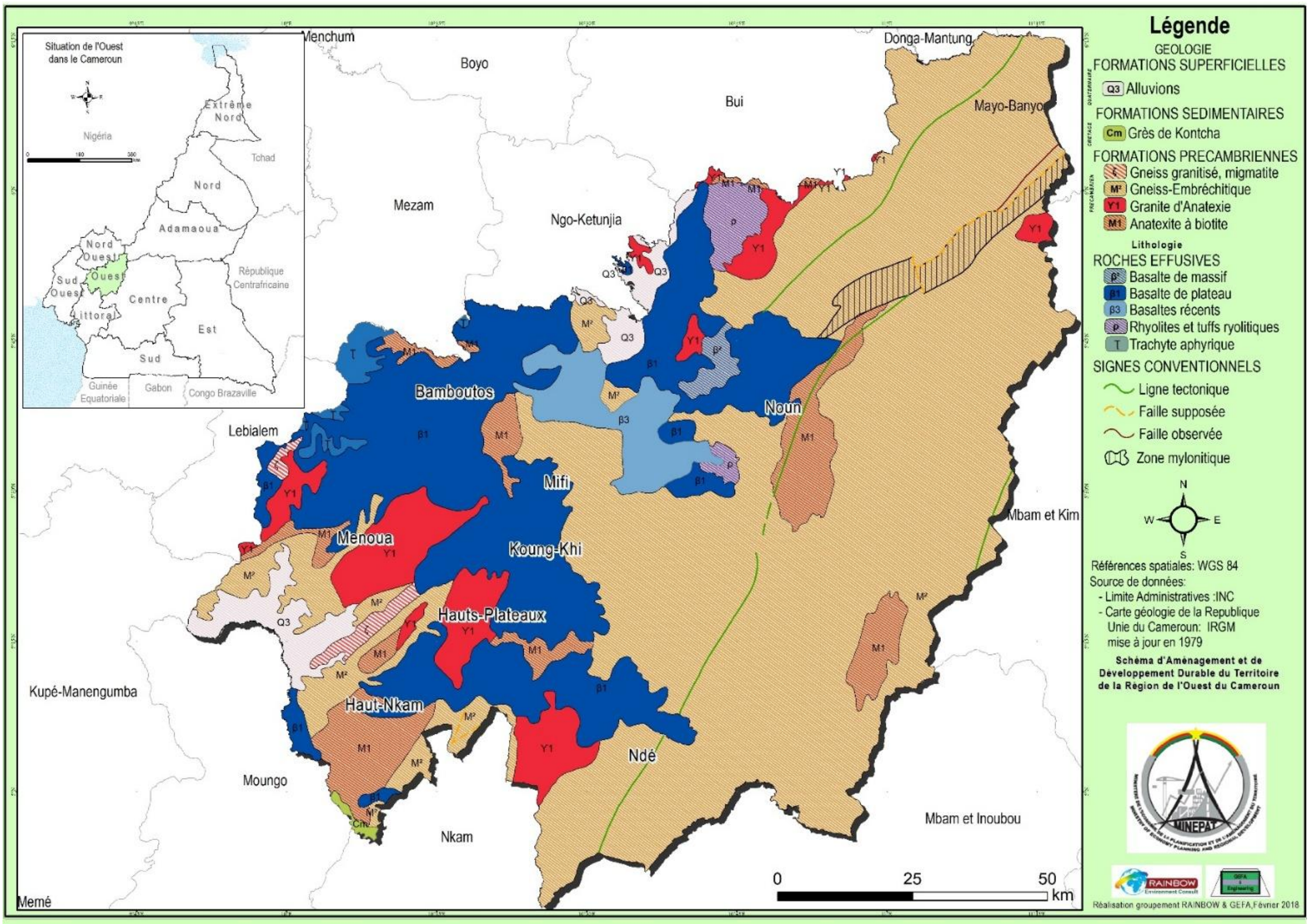
2.2. Crystalline basement

In detail, the basement formations consist mainly of metamorphic rocks crossed here and there by plutonic massifs.

2.3. Metamorphic Rocks

Metamorphic rocks are represented here per migmatites or granitic gneisses. The highly granitic gneisses (anatexites) constitute elongated North-South cores (strip stretching west of Foumbot to the NE of Foumban) or North-East - South-West (strip from the Bamiléké plateau to the Bamoun plateau south of Foumbot). Most of the bedrock (95% of the metamorphic bedrock) consists of biotite granitic gneiss. All these metamorphic rocks are potential deposits of quarry materials and, because of their abundance in the field, are of economic interest.

***Map 12:** Map of lithological formations in the West Region*



2.4. Plutonic Rocks

They are represented by ortho-amphibolites, syenites and granites. Ortho-amphibolites are found in the form of small elongated NE - SW massifs south of Maga.

The syenites form a massif oriented N - S partially covered by basalt to reveal only its extremities to the North and South of Banganté. The spatial extension of the massif and the mechanical properties of its rocks make it a potential deposit of viable materials.

The basement of the West Region contains syntectonic granites (ancient and late), deformed, which can be exploited in quarries. The former syntectonic granites form:

- windows through the basalt roof like the one on which Dschang Town is built;
- small sub-circular massifs such as the one to the west of the Mbapit volcano-plutonic massif to the NE of Foumban;
- a NE-SW massif along the Ngoum river (tributary of the Nkam) to the NE of Bafang and a N-S band to the SW of Banganté.

As for the late syntectonic granites, they appear in the form of an elongated N - S massif covered in its western part by the rhyolites/trachytes of Mbapit.

2.5. Volcanic Cover

Volcanic formations belong chronologically to three main series:

- of Eocene age, the lower black series or "plateau basalt", because it is widespread on the Bamiléké and Bamoun plateaus, is composed mainly of aphysical basalts and, subsidiarily, of porphyry andesites; this early volcanic phase had 3 major emission centres, including:
    - ✓ one located towards the Bamboutos massif;
    - ✓ a second one to Bamenyan north of Galim;
    - ✓ and a third one in the southeast towards Bayangam.

The basalt's prismatic flow is frequent (Bandjoun, Bangang and Batcham quarries, Choumi Falls). This ancient basalt cover is deeply altered. Lateritic breastplates are common. Erosion has also opened large windows where the base appears;

- of pliocene age, the intermediate white series, corresponding to a trachyto-rhyolitic acid phase, is mainly located in the Bamboutos Mountains. Phonolites are frequently associated with these trachytes, particularly at the peak of the Bamboutos. In the Bamoun area, this series results in rhyolitic arrivals in the Mbam, Nkogam and Mbapit massifs;
- of quaternary age, the upper black series which corresponds to a complex basic phase punctuated by several dynamics:
    - ✓ an ancient Hawaiian phase whose basalts cover the rhyolites of the Nkogam;
    - ✓ a new Hawaiian phase for the Koundja Koutaba area;
    - ✓ a Strombolian phase that gave rise to a multitude of small volcanoes surrounded by projected blocks around and found in large numbers in the Foumbot area and the Noun Valley;
    - ✓ a volcanic phase that projected ashes through several centres, including the Nkouofon volcano on the Baleng chiefdom and those of Foumbot and Paponoun. The ashes covered a large area, rejuvenating the soil.

2.6. Sedimentary Cover

2.6.1. *Alluvium*

The basalt flows of Bamendjing and Melong have established dams on the Noun and Nkam courses respectively. Upstream of these natural dams, vast swamps have formed, now representing the alluvial plains of Ndop for the Noun and Mbos for the Nkam. The marshes of Bamendou, Wassa and the two Mifis in Bamiléké area and those of Panké, Nja and Nkoup in the Bamoun area are examples of the same process, but on a more modest scale.

2.6.2. Kontcha Sandstones

These consolidated sedimentary formations form a band oriented NW - SE southwest of Makouk (Haut Nkam Division).

2.7. Tectonic Features

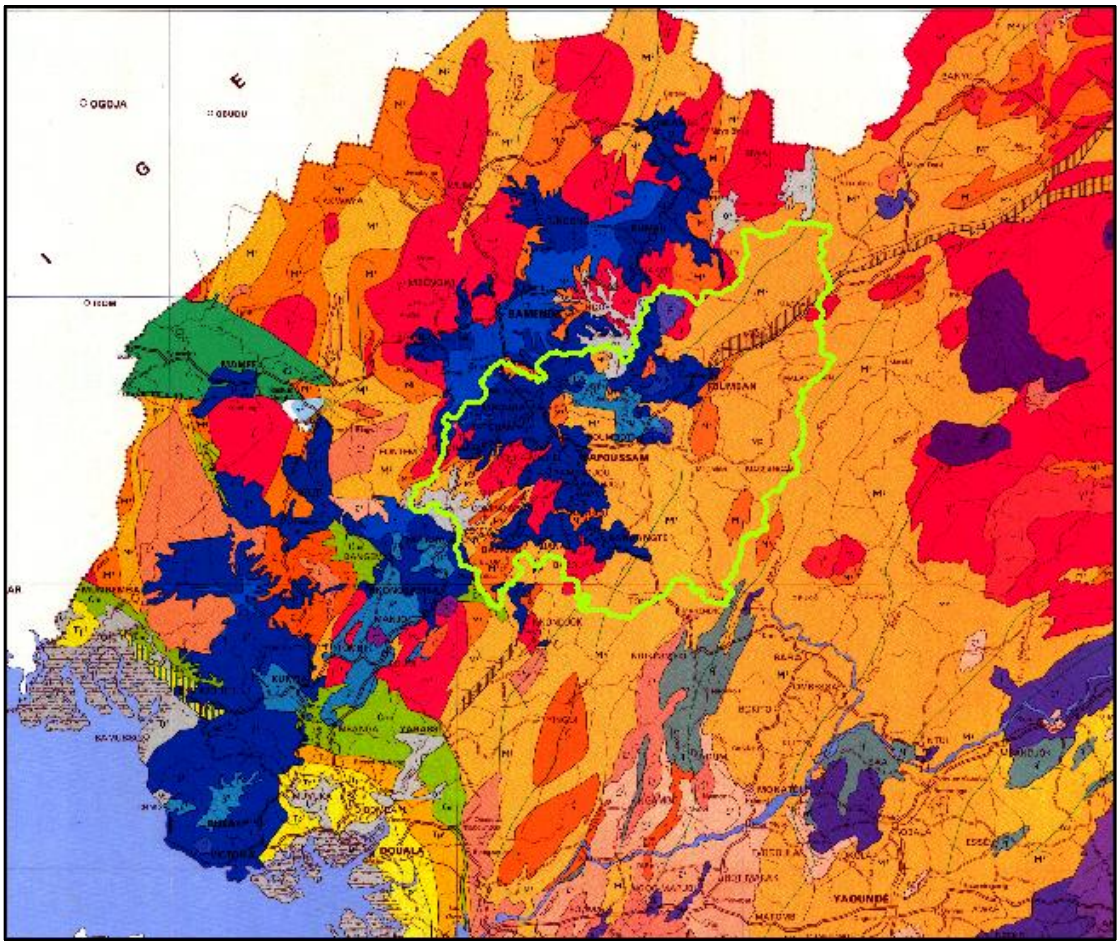
On the available geological map, the West Region is structurally characterized by faults affecting the basement in the directions NNE - SSW to NE - SW and NW -SE. There is also a mylonite zone oriented ENE - WSW to NE - SW in the North-East of the Noun Division.

The structural sketch drawn up from the DEM/SRTM (Fig. 13) shows how:

Ductile structures:

- a regional foliation of predominant NE - SW direction, highlighted by sections of streams and straight or curved ridge lines;
- cartographic folds drawn locally by foliar trajectories and which admit foliation as an axial plane;

Map 13: *Recognition geological map (J.Gazel 1956)*

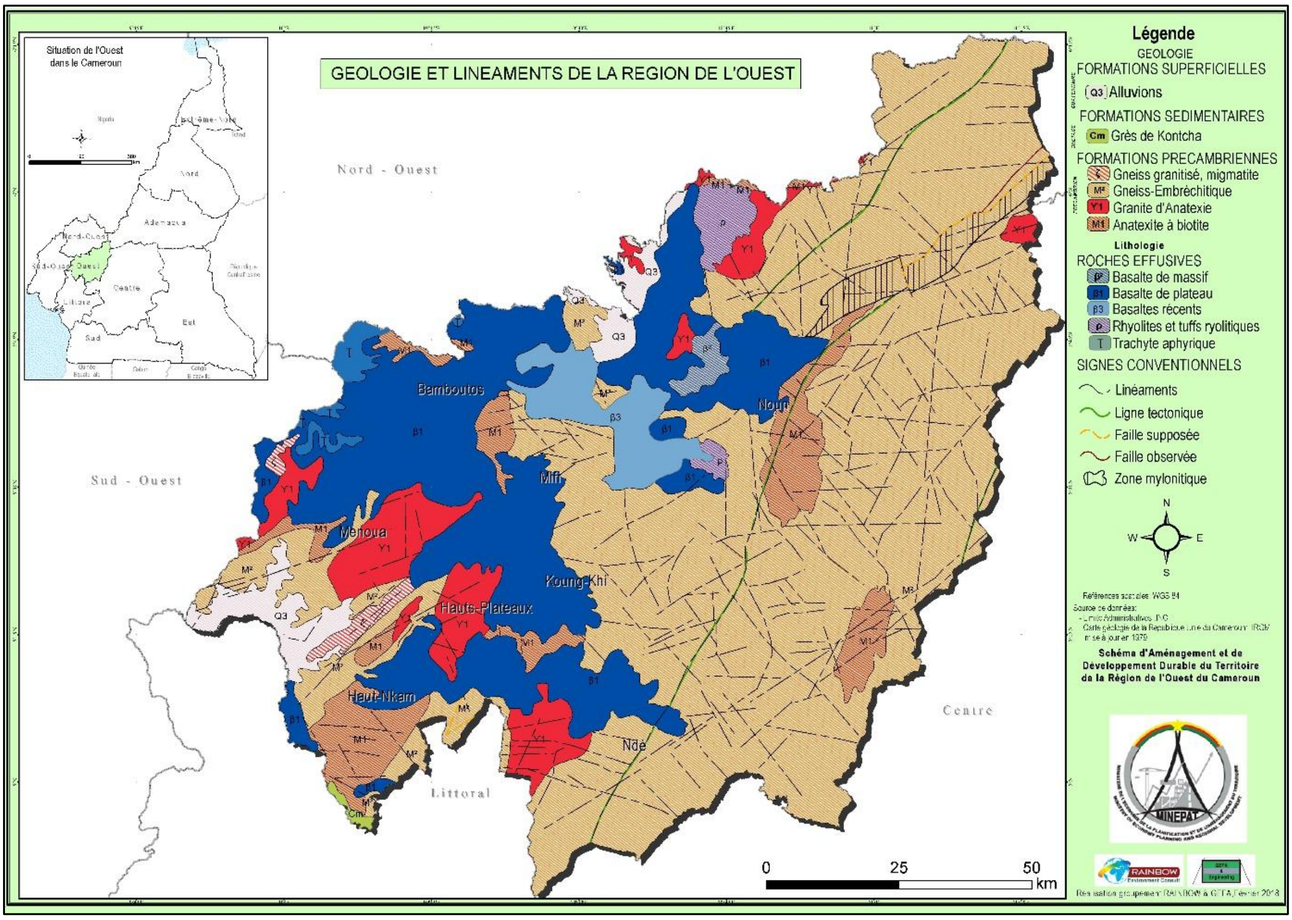


Fragile structures: a network of main ENE - WSW dexterity drop-outs in line with the "Cameroonian centre shear" with its satellites:

- proverse NE - SW dexter and N - S sinister;
- retroverse E - W dexter and NW - SE sinister.

The modified geological map in Figure 14 takes into account these teleanalytical data from the DEM-SRTM processing.

***Map 14:** Modified geological map with fractures identified by DEM-SRTM treatment*



3. GEOTOURISM

The volcanic plateaus of the Bamiléké and Bamoun regions offer beautiful landscapes studded with sites and other attractions linked to volcano events and having touristic interest. Therefore, one can mention: :

- waterfalls caused by dams in river courses at basalt flow fronts, such as those:
  - ✓ of Ekom in Nkam (75 m high);
  - ✓ of Mouankeu in Bafang;
  - ✓ of Choumi and Metchié in Bafounda;
- the falls at the level of the trachytic cliffs of the Bamboutos such as those of Marnmywata near Djuttitsa;
- the volcanic dam lakes of the Foumbot area: Monoun and Paponoun Lakes;
- Crater lakes such as: Monoun Lake, Baleng Lake, Tchoua Lake, Pêt-Ponoun Lake, male and female twin lakes, Ngouondam Lake; Dschang Municipal Lake;
- typical and representative volcanic structures such as Strombolian cones and other cratered cones...

4. SOIL / PEDOLOGY

Soils in the West Region are the result of alteration of rocks both of ancient metamorphic basement and of volcanic cover of different ages; they are essentially ferralitic. In addition, several types of hydromorphic soils and soils with little development of pyroclastic inputs or derived from ash on basalt are particularly fertile (Segalen, 1966; Segalen, 1967; Martin and Muller, 1972)

4.1. Ferritic Soils

Ferralitization concerns all the Bamoun and Bamiléké plateaus. The soils are related to the class of moderately desaturated ferralitic soils where the typical, altered, penetrated groups are widely represented. All bedrock has been transformed by the process.

4.1.1. *Ferralitic Soils on Base Materials (gneiss-granite) Crystalline*

It is all about:

- either typical nodal soils found in the Noun valley on the outcrops of the base: the horizon A is brown, clayey-sandy. Horizon B is red, more clayey (60 to 70%). Its pH level is acidic (5.5);
- or typical reworked soils. They are characterized by a very clear discontinuity at the upper part of the profiles (50 to 60 cm), marked by a bed of very compact quartz stones line. There was probably a spreading of coarse material on a gently sloping surface that was then covered with weathering products. This type is not very well represented in the Bamiléké area.

4.1.2. Ferralitic Soils on Plateau Basalt

They are differentiated through:

- typical nodal soils: these thick soils come from the very deep alteration of the basalt; their colour varies from brick red to very dark red. The clay content ranges from 40% towards the surface to 60% over the entire profile, decreasing towards the bedrock. The silt content is very high over the entire profile: 25 à 35 %. Organic matter contents vary from 4 to 5% in the surface horizons and fertility varies according to the existence and thickness of a humus horizon. Their high thickness, high porosity, friability with no stones, high content of clay (kaolinite) and iron oxides and hydroxides (gibbsite, goethite and hematite) allow good water retention. They can be found in the northern part of the Bamiléké plateau, with important interruptions that reveal the base (north of Bafoussam, near Bangangté, around Batié);
- typical indurated soils: In many places, they govern the upper part of the Bamiléké plateau. They are found in the Foumban, Bana, Fongo-Tongo and Bangam areas. They are marked by highly aluminous breastplates (also likely to develop on gneiss) or ferro-aluminous. The Bangam and Fongo-Tongo lateritic bauxites are attached to these soils. When the indurated horizon (armour) is exposed or very close to the soil surface, agricultural interest is very low. The essential components here are goethite, gibbsite and kaolinite.

4.1.3. Ferralitic Soils on Trachytes and Mountain Basalt

These are high altitude humus ferralitic soils, which vary greatly in appearance according to altitude, topography and vegetation (Muller and Olivry, 1976). Horizons A range from black to reddish brown, horizons B from dark brown to yellowish red.

They are all characterized by a silty texture passing to clayey-silty in the B horizons. The structure is often lumpy. The examination under a magnifying glass shows many pseudo-particles or pseudo-sand reduced to partially clayey after crushing. In horizon B, one can note, in the sub-prairie soils of the slopes of the Bamboutos Mountains, the presence of quartz and trachyte gravels (facial features weakly rejuvenated and altered).

These soils generally have a very high porosity. The volume of voids between the aggregates is large and cohesion is ensured only by a dense root division. The organic matter content is greater than 10% in the first 10 centimetres of the humus horizon and is still 1% at a depth of 1 m.

4.2. Hydromorphic Soils

They were formed in areas with poor drainage either due to:

- a provisional base level resulting from a resistant threshold: the case of the swampy areas of Choumi and Metchié, Mifi and the Mbo plain;
- or volcanic flow obstructions: the case of the Ndop plain, the Nja and Nkoup marshes.

Whatever may be the cause of their origin, these soils are classified into organic hydromorphic soils and moderately organic hydromorphic soils.

4.2.1. Organic Hydromorphic Soils

Characterized by a tangle of plant debris more or less decomposed to a thickness of 60 cm and a black to grey plastic clay in the lower horizon, these soils contain more than 30% organic matter.

4.2.2. Moderately Organic Hydromorphic Soils

These are humic gley soils. The upper horizon up to 60 cm is black to grey, silty-clayey, highly porous and of low to medium cohesion. The lower horizon is black or grey with ochre or rust, clay and plastic spots of strong cohesion. These soils contain between 10 and 20% organic matter.

4.3. Poorly Developed Soils

4.3.1. Erosion Soils

They can be observed on the slopes of the Mbam, Nkogam and Mbapit mountains.

4.3.2. Pyroclastic Input Soils

These are young soils derived from basic loose rocks (ash and lapillis) emitted in the Quaternary by the Foumbot, Paponoun and Baleng volcanoes and which are located in the Noun valley in the broad sense. The materials were transported southwest of the emission sites, suggesting that either the ashes were expelled at high elevations to be carried by the N-E wind or were emitted during the dry season (dominant NE wind).

In the Foumbot area, the morphology of these soils shows:

- a black upper horizon of 25 cm, sandy-silty, fine lumpy, not very coherent;
- an average horizon of 25 to 75 cm, dark brown, sandy-silt, lumpy, porous and weakly cohesive;
- and below, sometimes over several metres, very permeable ash and lapillis, rocks very rich in organic matter, nitrogen and exchangeable bases.

4.3.3. Black Soils on Ashes on Basalt

These soils pass through with the penetrated ferralitic soils. Having been rejuvenated by the addition of ashes, they are very fertile. Their morphology varies greatly depending on the thickness of the ash layer, the alteration of which is sufficiently severe for a real soil to develop. They have a high surface permeability.

Young or rejuvenated soils by pyroclastic inputs and black soils on ashes on basalt, these soils have allowed the development of intensive agriculture. They are all the more interesting because the ashen soil is not too thick. Indeed, the high permeability of the latter has the disadvantage, when the clay soil with good water retention is too deep, of letting the crops wither in the dry season. It is common to see coffee trees reach their wilting point at the end of a long dry season in some areas around Foumbot.

4.4. Agricultural Value of Soils in West Cameroon

The Regional Agronomists had schematically divided the soils in the Bamoun area into three categories:

- the red lands;
- the brown lands;
- the black lands.

This classification is appropriate because red lands correspond to red ferralitic soils derived from basalt, brown lands to penetrated ferralitic soils, black lands to soils with little evolution on ashes.

In Bamileke country, red soils have very often received a moderate amount of ash, resulting in a fairly large black surface horizon (which is not often the case in the Bamoun area).

It is also common for the undeveloped black soil to be thin and for the coffee tree's roots to explore two superposed soils.

The red ferralitic soils of the Koundja Region were the oldest cultivated. They are loose, permeable, with often high levels of total organic matter and nitrogen, very low levels of exchangeable elements and very limited reserves. The plantations set up there have not satisfied the hopes that had been placed in them. Several European growers, who had created them, abandoned them, and several were later destroyed by bush fires. However, a small number have been maintained, and they continue producing yield through appropriate cultural practices.

Penetrated ferralitic soils are frequent towards Bamenjin and Bati in the Bamiléké area, and Bankwop, Malanden in the Bamoun area. The soils come from fairly recent volcanic materials: slightly cemented ash towards Bati, flows of different sizes in some valleys. They seem to achieve the optimal soil conditions for coffee growing: medium depth soils, sometimes with some rocky debris in the profile, a significant content of fine elements, abundant organic matter, high levels of exchangeable elements in the humus horizon, often high mineral reserves; they can retain moisture in depth that is lacking in the dry season and ensure adequate mineral nutrition of the trees.

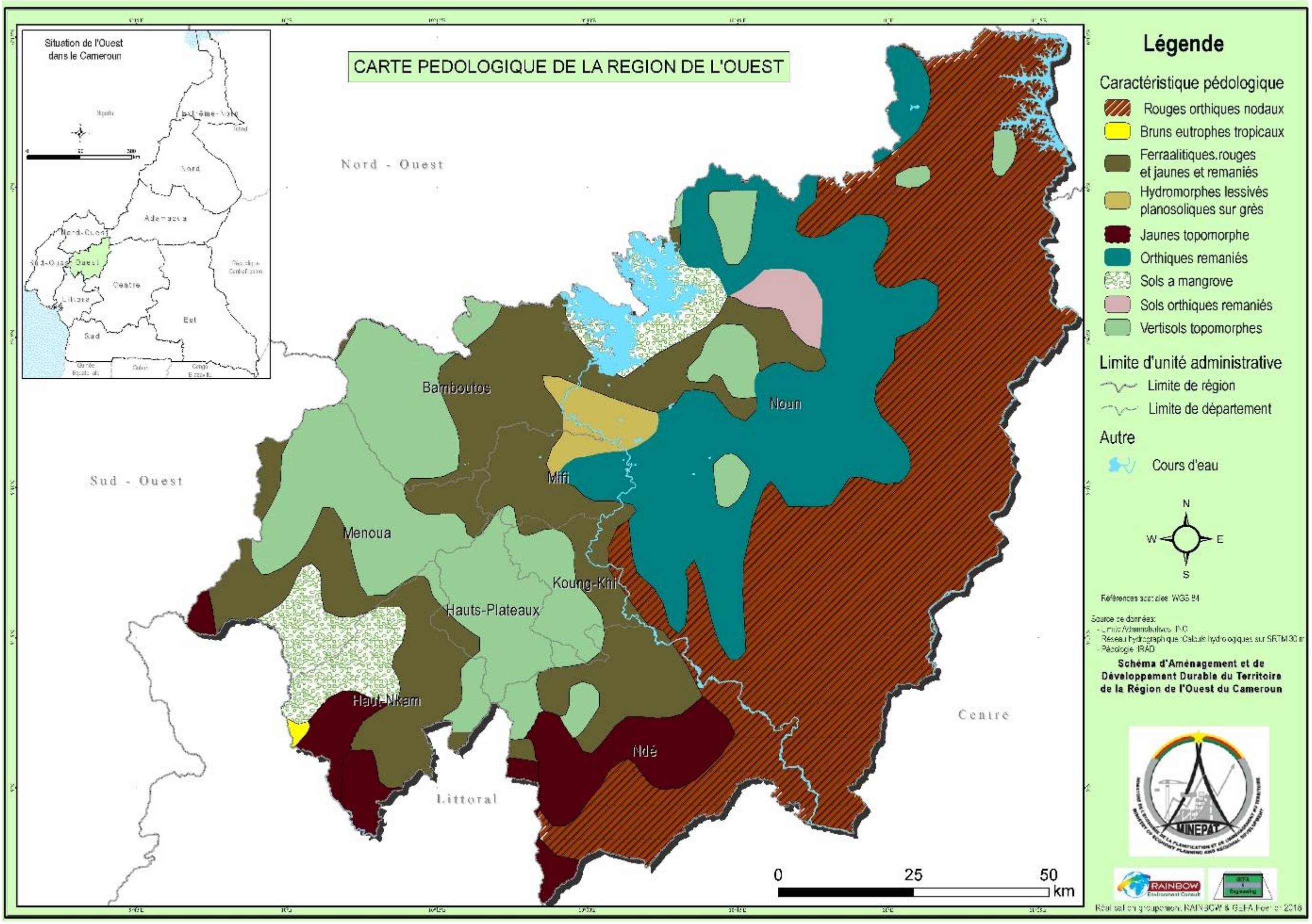
Black soils occupy large areas around Foumbot near Paponoun, in the Noun loop and near Baleng in Bamiléké area. Their organic and nitrogen content, in exchangeable and total bases, is very high. However, the thickness of the soil itself is low and the clay content very low, resulting in a limited water reserve during the dry season. Trees planted on these soils will be likely, in normal climatology, to lead to very good yields, but quickly suffer from drought.

Soils with complex profiles (black soils on ashes resting on red ferralitic soil) are particularly interesting for coffee cultivation. Indeed, in the upper part of the profile, the crop finds a soil rich in organic matter, nitrogen, exchangeable and total bases. Depth-wise, the red clayey or clayey-sandish soil is a suitable environment to retain moisture during the dry season, as well as the bases leached from the upper part of the profile. Once the coffee tree's pivot has reached the underlying red clay, it is guaranteed to find both the fertilizing elements and the water it needs to develop.

As a result, the Arabian coffee tree seems to have found a suitable climate in the vicinity of the Noun, with the risk of excessive drought from the northeast due to the wind.

Soils have very variable qualities. The richest have a very low thickness, coarse grain size and reduced water retention capacity. The rejuvenation of some ferralitic soils by volcanic ash are at their maximum and this can be observed precisely in the vicinity of the Noun. One can significantly increase plantation yields with proper fertilization techniques (Segalen, 1967).

Map 15: *Soil map of the West Region*



5. MINES AND QUARRIES

The West Region is geologically constituted of a crystalline basement covered with more than 20% of volcanic formations. The basement can host mineral deposits associated with both the plutonic granitoid massifs that pass through it and the zones of falling faults that affect it. As for the volcanic cover, it is likely to shelter mineral concentrations inherent in the geodynamic phenomenon of volcanism. The supergene alteration of bedrock rocks and bedrock covers can also contribute to the formation of mineral deposits of economic interest. In addition, some petrographic features of both the crystalline basement and the volcanic cover are potentially exploitable as building, servicing or ornamental materials.

Before outlining the real scope of this mineral potential in the West Region, it is important to first present the legal and institutional context regulating mining activity in Cameroon.

5.1. Legal, Regulatory and Institutional Context

5.1.1. *Legal and Regulatory Context*

Mining activity in Cameroon is governed by:

- Law No. 2016/17 of 14 December 2016 instituting the Mining Code ;
- Decree No. 2012/432 of 1 October 2012 organizing of the Ministry of Mines, Industry and Technological Development (MINMIDT);
- Decision No. 238/MINMEE/CAB of 1 April 2003 establishing CAPAM.

Table 1: *Relevance of legal and regulatory texts to SRADDT*

Laws and rules	Relevance to SRADDT
Law No. 2016/17 of 14 December 2016 instituting the Mining Code;	It governs recognition, research, exploitation and custody
Decree No. 2012/432 of 1 October 2012 organizing of the Ministry of Mines, Industry and Technological Development (MINMIDT);	Through its central, decentralized and attached services, MINMIDT is the repository of all mining and geological information
Decision No. 238/MINMEE/CAB of 1 April 2003 establishing CAPAM.	In charge of mining crafts, CAPAM is an important stakeholder in the management of the mining sector

5.1.2. Institutional Context

The Ministry of Mines, Industry and Technological Development (MINMIDT) is responsible for developing and implementing the government's mining policy. The main directorates operating in the field of geology and mining are:

- the Directorate of mines, created by Decree No. 2012/432 of 01 October 2012, responsible for the development, promotion, formulation and implementation of the national mining policy;
- the Geology Department, created by decree No. 2012/432 of 01 October 2012, responsible for the recognition of the soil and the national subsoil and the inventory of its potentialities;
- The National Mining Control Brigade, which reports directly to the Minister and is responsible for implementing the government's mining control strategy;
- decentralized services (Regional Delegation for Mining, Industry and Technological Development; Divisional Delegation for Mining, Industry and Technological Development), responsible for coordinating mining activities;
- related services, which include the Geological and Mining Information Centre, responsible for the collection, analysis, synthesis and publication of geological, mining, oil and gas reports and data, and the Centre des Analyses, des Essais et de la Métrologie industrielle.

Two structures have also been created and should gradually become key players in the management of the mining sector in Cameroon:

- The Artisan Mining Support and Promotion Framework (CAPAM), established by decision No. 238/MINMEE/CAB of 1 April 2003 of the Minister of Mines, Water and Energy and by order No. 064/PM of 25 July 2003 of the Prime Minister. It is responsible for coordinating, organizing, facilitating, promoting and developing artisanal mining.

- PRECASEM, the Mining Sector Capacity Building Project, started in 2012 with funds from the World Bank and the Government of Cameroon. It is managed by a structure reporting directly to the Minister of Mines, Industry and Technological Development.

5.2. Status of Research and Mineral Exploration Activities in the West Region

5.2.1. Activities Carried Out by the Government

Inventory work on the mineral potential of the Cameroonian subsoil began in the first half of the last century and was carried out mainly according to a very loose observation and sampling grid, with exploration based mainly on alluvial deposits.

After independence, more detailed recognition work was also carried out by several assistance and cooperation missions. Aeromagnetic surveys covered part of the national territory. This work was continued by mining inventory operations that covered barely 40% of the Cameroonian territory and were carried out in partnership with BRGM (France) and UNDP. It is important to note that the work on the inventory of the mineral potential of the Cameroonian subsoil has been almost exclusively concentrated in the extreme south and east of the country. The West Region does not currently have sufficiently detailed cartographic documents that could be used as a basis for research and prospecting operations.

In order to increase the area covered by the mining inventory in Cameroon, a major recent effort is being made by the Mining Sector Capacity Building Project (PRECASEM), co-financed by the State of Cameroon and the World Bank, to carry out a 160 km² airborne geophysical survey campaign in the Centre, East, Adamawa, North and West. The awaited results of the project's work will further define the mineral potential of the West Region.

5.2.2. Exploration Activities Carried Out by Mining Companies in the Region

Attracted by its geological and mining potential, a few companies have established themselves in the West Region to carry out reconnaissance and exploration work.

Table II shows the nine (09) mining exploration permits granted to five (05) concessionaires from 2009 to 2014. Their spatial extent is illustrated on the map in Figure 15. No recent permits are registered from 2014 till date. These mining permits mainly concern:

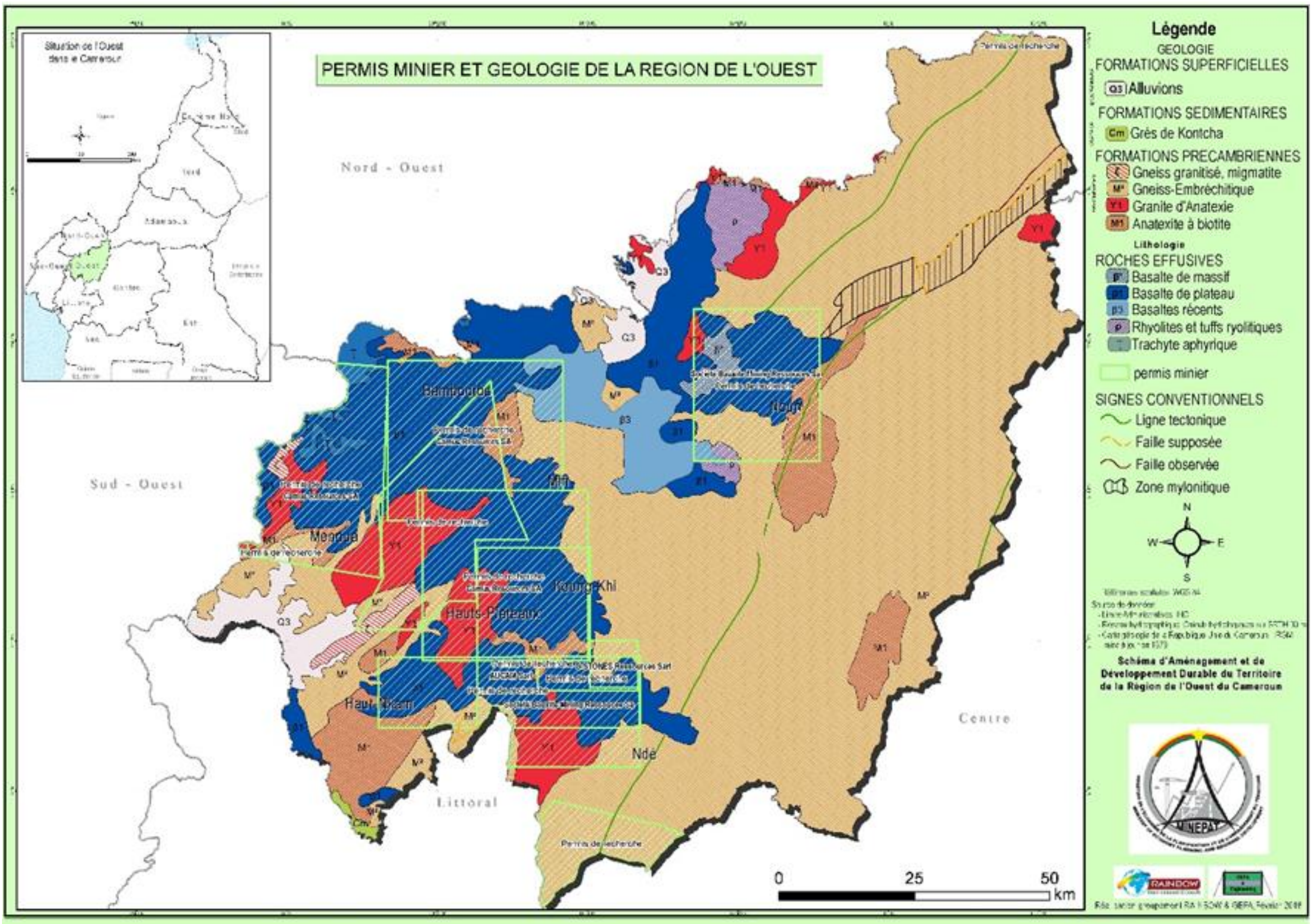
- bauxite (alumina ores) in the Menoua (03 permits), Noun (01 permit), Bamboutos (01 permit), Haut-Nkam (01 permit) and Mifi (01 permit) Divisions;
- gold (Au), copper (Cu), gems, base metals, Platinum Group Metals (PGM), molybdenum (Mo) and Rare Earths (RE), which are the subject of two research permits granted in the Ndé Division

As for recognised mining permits, two (02) were awarded for pozzolana, in the Noun Division, to DANGOTE and CIMENCAM.

Table 2: *List of mining research permits issued in the West Region*

No.	Holder	Name of title	No.	Nature of the substances	Surface area Km²	Attrib/ Renew - expiry
1	CAMUS RESOURCES S.A B.P. 152 YAOUNDE	BAMBOUTOS	165	Bauxite	1000	17/05/11 – 16/05/13
2		FONTEM	190	Bauxite	428	09/09/2009 – 08/09/2012
3		BAFOUSSAM	205	Bauxite	1000	13/07/2010 – 12/07/2013
4		BANGAM	219	Bauxite	1000	12/08/2010 – 11/08/2013
5	CAMER STEEL	BANGAM 2	181	Bauxite		
6	G-STONES RESSOURCES SARL BP 20119 YDE	BAGANGTE	224 A	Gold, u, Cu, gem, base metals, PGMs, Mo and RE.	178	16/09/2010 – 15/09/2013
7	AUCAM	BANGOU		Gold, u, Cu, gem, base metals, PGMs, Mo and RE.		19/03/2010 – 18/06/2013
8	BAUXITE MINING COMPANY	BAFANG	252	Bauxite and substances related	1,000	04/06/2011 – 03/06/2014
9	RESOURCES SA B.P. 152 YAOUNDE	FOUMBAN	253	Bauxite and substances related	1,000	04/06/2011 – 03/06/2014

Map 16: *Map of research permits granted to a few mining dealers*



5.3. Mining Potential of the West Region

5.3.1. Geological Potential

In terms of diversity of geological formations, the West is one of the richest regions in Cameroon, as it contains the three types of rocks differentiated in geology, namely magmatic rocks, metamorphic rocks and sedimentary rocks. The different internal geodynamic activities that have taken place there have favoured the formation of magmatic rocks, mineralized water sources, volcanic projections, sedimentary deposits, mineralizations, maars, some of which are occupied by gas producing lakes.

The granito-gneissic base, in this case, is Pan-African. The Magba shear zone as well as the ENE - WSW lineal disengagement of "Kekem - Foumban" in the North and its symmetry of "Bantoum III - Mankaré" in the South highlighted by DEM/SRTM processing represent potential reservoirs for gold, manganese, copper and other minerals. In addition, the granitoids and granitic gneisses (or migmatites) that make up the crystalline basement are inexhaustible sources of materials.

The various volcanic eruptions of effusive, explosive and extrusive dynamisms (Kamga, 1986; Wandji, 1995; Moundi, 1996) have favoured the installation of basalts (alkaline, transitional), basanites, ankaramites, hawaii, mugearites, trachytes, rhyolites, pyroclastics; all these volcanic products constitute exploitable materials for construction, servicing and ornamental purposes.

The phenomena of erosion, alteration, bauxitization due to external geodynamics are marked by the presence of bauxite, clays and many other minerals yet to be explored.

5.3.2. Potential Mineral Resources of the Soil and Subsoil

The soil and subsoil of the West Region have rich geological, hydrogeological and mining potential for certain mineral substances. Indeed, the data from the general reconnaissance geological and photo-geological maps produced as part of the mining inventory highlight targets of mineral indexes, surface mineral expression and even deposits.

The map in Figure 16 shows the spatial distribution of six (06) aluminium (Al) mineralization showing targets and one (01) tin (Sn) target.

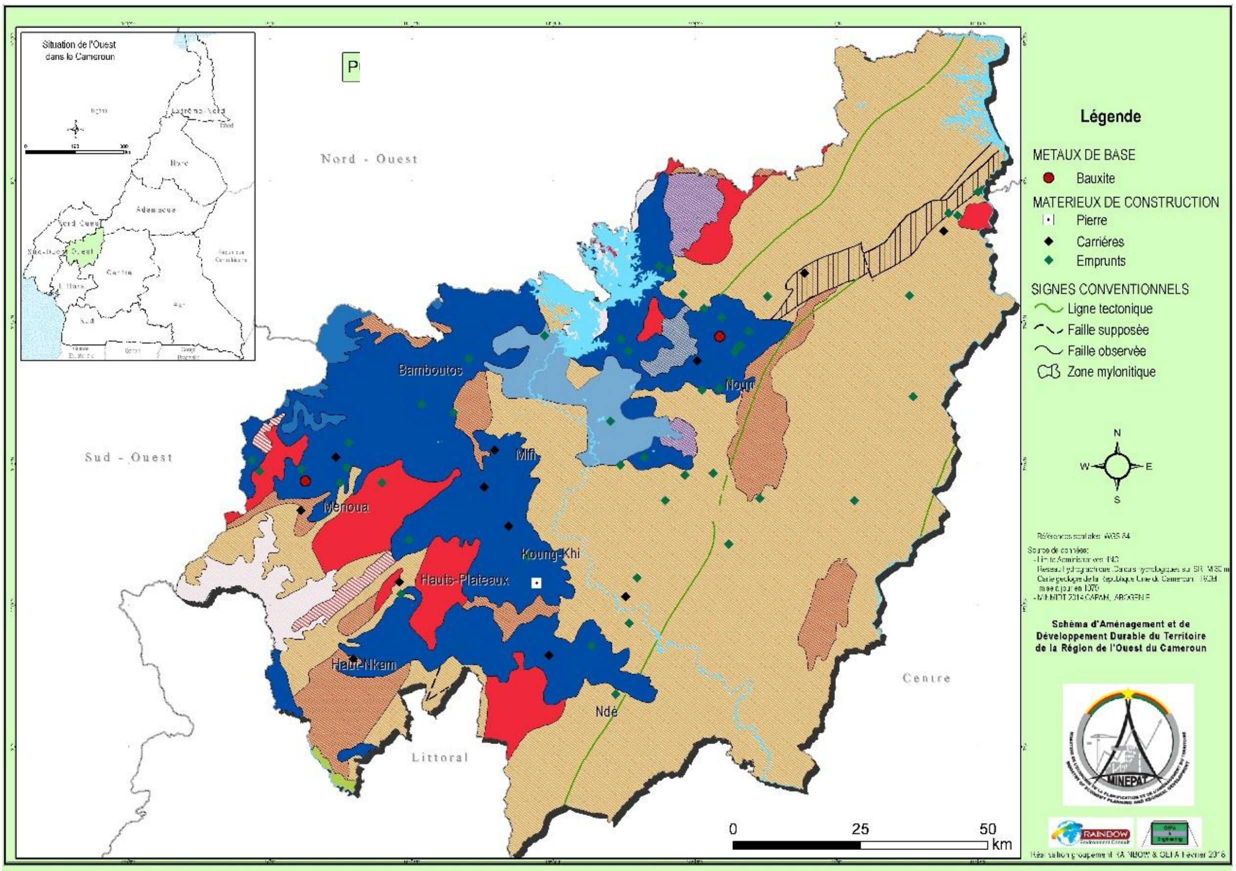
The mineralization index of tin (Sn) in granitic gneiss is reported in the Haut Nkam Division.

5.3.3. Bauxite

As for aluminium (Al), its indices are expressed in the field in the form of bauxite developed at high altitudes (altimeter amplitude from 1200 m to 1700 m):

- or on tray basalts for:
  - ✓ the target of the Noun Division stands at an altitude of about 1200 m;
  - ✓ the target of the Bamboutos Division stands between 1300 m and 1400 m altitude;

Map 17: *The distribution of the mineralization index showing 6 targets in Al and one (01) target in Sn in the West Region*



- ✓ one of the 3 targets identified in the Menoua Division is above 1600 m altitude;
- or on the migmatitic base (granitic gneiss) for:
  - ✓ two of the 3 targets of the Menoua Division between 1400 m and 1600 m;

✓ a target in the Haut Nkam Division above 1600 m altitude.

The formation of bauxites from laterites here dependents on two core factors: the lithological nature of the bedrock and the high altitude of the genesis site.

In fact, there are bauxite deposits in most of the West Region, including the famous and important Fongo Tongo deposit.

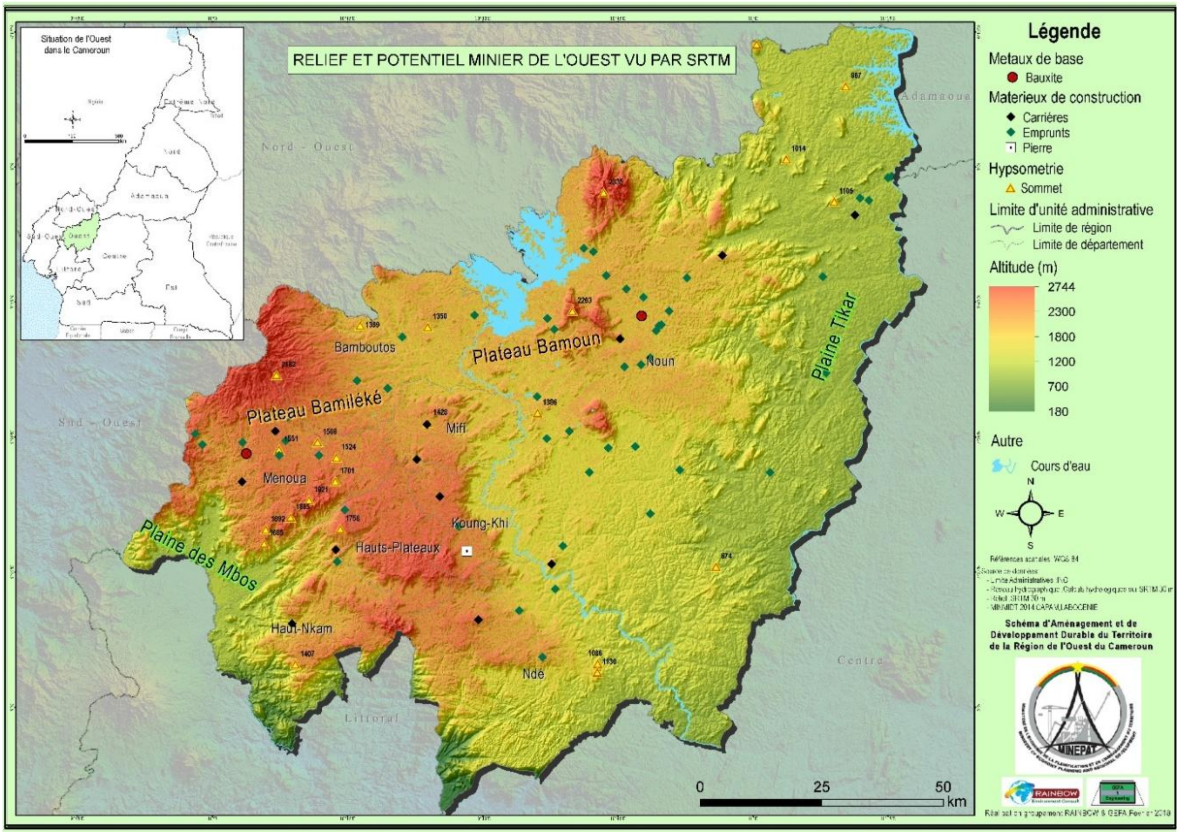
The Fongo-Tongo bauxite deposit near Dschang (Menoua) was discovered in 1957 by Bumifom prospectors (Weecksteen, 1957). It results from lateritic alteration of basalts, but also trachytes (HIERONYMUS, 1971). Its reserve is estimated at 46 million tonnes at an average alumina content of 47%.

Various other small deposits have been formed to the detriment of basalts and trachytes in particular:

- on the low slopes of Bamboutos;
- the colluvial bauxitic laterite from Bangam further east;
- some armoured plateaus formed at the expense of the "basalt plateaus";
- the bauxite occurrences reported in Fontem, Bafoussam and Bafang;
- the four million tonne bauxite reserve in Foumban.

Bauxite indexes are also reported in Bamendjou in the Highlands Division.

Map 18: *Impact of morphology on mineralization in the West Region.*



5.3.4. Materials

There are huge deposits of rocks such as the Baham foliated granites, granitic gneiss representing more than 90% of the crystalline basement of the West, huge deposits of sand in Batié and clay in Marom, all used for construction, decoration, ceramics and cosmetics.

In addition, there are huge pozzolana deposits in the Noun; they contain crystals of Labrador, Anorthite, Olivine, Augite, Ilmenite and Nepheline with interesting mechanical properties and proven pozzolanic power; they are exploitable, on an industrial scale, for cement manufacture.

5.3.5. Water Resources

It is also worth noting the presence of many mineralized water sources, such as:

- the Nsansié bicarbonated water source in the Noun Division, with a natural flavour similar to that of tonic;
- the source of the Fossette near Foumbot (T° 29°C) with gas release of HCO3-;
- the source of Koutaba with a high content of dissolved CO2;
- mineralized water springs in the Bamboutos mountains in the Bamiléké area.

Table 3 presents the distribution of mineralization indexes and shows that the mineral substances identified are distributed throughout the West Region while affecting all its divisions.

Table 3: *Distribution of the various mineral substances over all the divisions of the West Region*

Divisions	Mineral families				
	Valuable substances	Base metals	Energy substances	Building materials	Water resources
MIFI		Bauxite		Basalt, Sand	
KOUNG-KHI				Basalt, Granite	
HIGHLANDS				Pegmatitic granite, Sand	
HAUT-NKAM		Bauxite and related substances		Basalt, Granite Sand	
BAMBOUTOS		Bauxite	Lignite	Prismatic basalt	Mineralised water
MENOUA		Bauxite		Basalt, Rhyolite	
NDE	Gold Gems	Copper, Iron, Silver, Molybdenum, Lead, Zinc	Uranium, Platinum Group Metals (PGM) Rare earths	Basalt, Granite	
NOUN	Gold	Copper, Bauxite and related substances		Ignimbrite, Basalt, Pozzolanas, Black earth, Clay, Sand	Bicarbonate mineral water

From this table, it can be seen that at the current state of the mining inventory in the West Region:

- five of the six major mineral resource families listed in Cameroon are represented, as the substances of the Industrial Minerals family have not yet been identified in the region;
- construction, servicing and ornamentation materials are abundantly present in all its divisions;

- bauxite appearances and deposits are found in divisions where volcanic formations (basalts and trachytes) are well developed and at high altitudes;
- the Ndé and Noun Divisions have a wide range of mineral substances from the 5 families listed, compared to the other divisions;
- the Koung-Khi and Highlands Divisions, probably for non-exhaustive exploration, contain only building materials as potential mineral resources.

5.4. Current Mine Production in the West Region

Presently, there is no effective exploitation of mineral substances in the West Region. The core of mining activities is limited to the exploitation of material quarries. This exploitation, 70% of which is carried out in an artisanal way, mainly concerns:

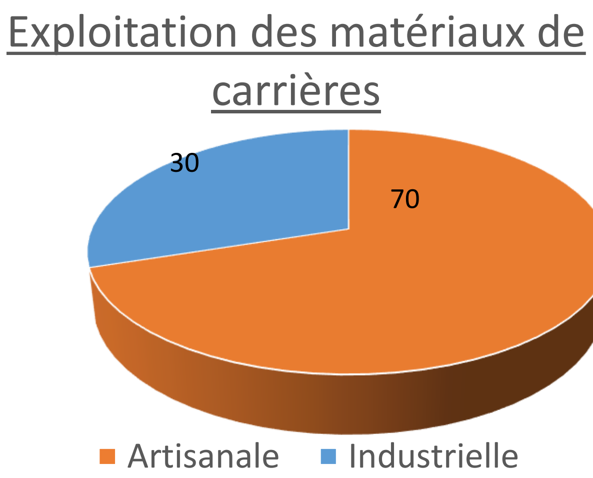
- stones (basalt and granite);
- sand along the main rivers of the region;
- laterite and
- pouzzolana.

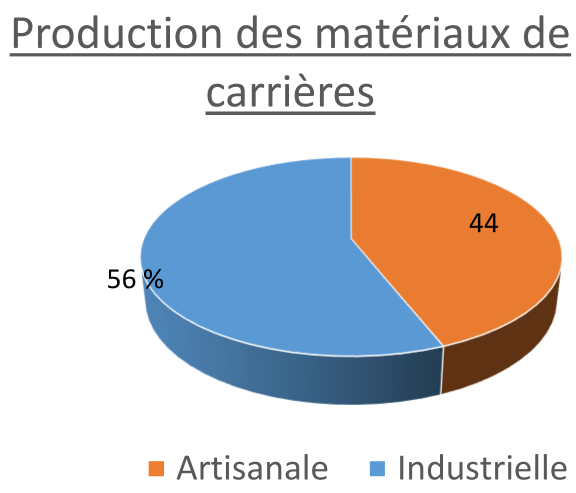
One hundred and eighty-one (181) artisanal quarrying permits have been granted by MINMIDT and many other quarries are operated illegally.

Nine (09) industrial quarry permits, including five (05) of public interest (including aggregates for ongoing road projects in the area) and four (04) of a commercial nature have been awarded.

The production of industrial quarries in 2017 is estimated at 73,996.79 m3 of stone and that of artisanal quarries at 57,957.56 m3. Figure 19 shows the relative importance of these two types of production, with industrial production accounting for 56% and craftsmanship for 44% of total quarry materials production.

Figure 1: *Distribution of types of exploitation (artisan.=70%, indust.=30%) at the top and production (indust.=56% and artisan.=44%) at the bottom, quarry materials in the West Region*





Tables 4 and 5 present, respectively, the main characteristics of the industrial and artisanal quarries currently operating in the West Region.

Industrial quarries producing only aggregates from massive rocks are only exploited in 3 of the 8 divisions of the region, namely:

- Noun: 3 public interest quarries and 1 commercial quarry;
- Bamboutos: 2 quarries of public interest and 1 commercial quarry, all developed in the Mbouda municipality
- Mifi: 2 commercial quarries exploited in the Bafoussam III Subdivision

Map 19: *Mining potential of the West Region*

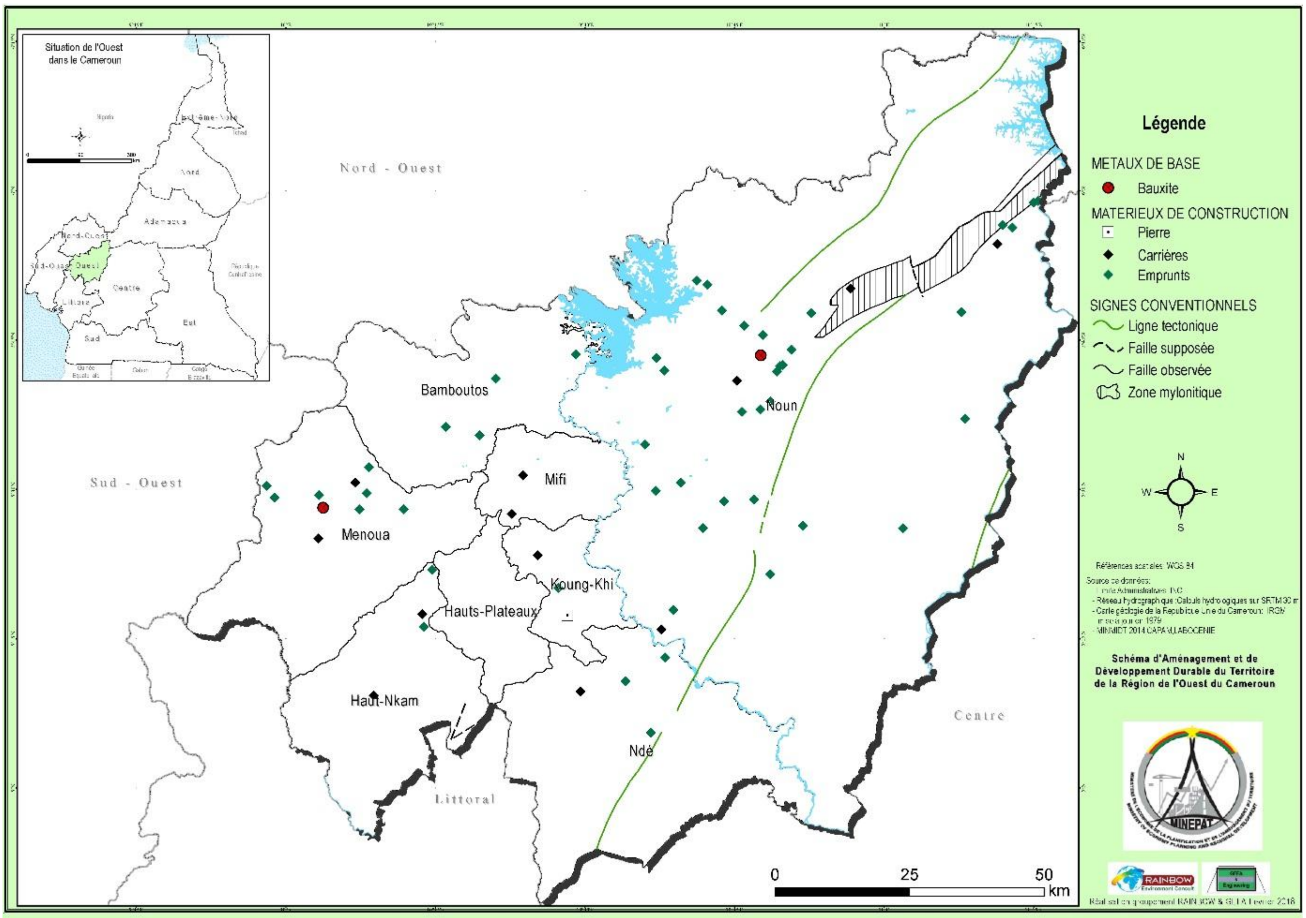


Table 4: *List and main characteristics of industrial quarries in the West Region*

Division	Municipality	Operators	Exploited materials	Types of quarries
Noun	Magba	ESER Contracting and Industry	Stones	Public interest
	Magba	BUNS	Stones	Public interest
	Koutaba	GRAVEXO et M	Stones	Commercial
	Foumbot	RAZEL Cameroon	Stones	Public interest
Bamboutos	Mbouda	ESER Contracting and Industry	Stones	Public interest
	Mbouda	SATOM	Stones	Public interest
	Mbouda	CAPITSA	Stones	Commercial
Mifi	Bafoussam III	China Longteng Sarl	Stones	Commercial
	Bafoussam III	KETCH	Stones	Commercial

Artisanal quarries are exploited to produce aggregates manually from river rocks and sand. Table V shows that this activity is widely practiced in all 8 divisions of the West Region.

In addition to sand and gravel, the following are exploited in an artisanal way in the Noun (Foumbot town, Baïgom, Mbantou, etc.) and Menoua (Nden-Matok/Santchou Subdivision) Divisions:

- laterite and
- pozzolana and volcanic ash with a pozzolanic effect. Pozzolana is increasingly used as a building material in the region;
- the clay that is exploited in the Bazou Subdivision, in Beudou and the kaolin in Balengou.

Table 5: *List and main characteristics of artisanal quarries in the West Region*

Divisions	Municipalities	Stone quarries	Quarries of sand
BAMBOUTOS	MBOUDA	Balatchi, Bamengou, Batchela, Bamaka Bagadene, Bamékémé, Louh, Bafacoldjini, Bahélé, Nenenou, Bahoboing	Nantsap, Nzemmegueme , Bamenieun
	GALIM	Bamenyam, Galim, Bagam	Bamenyam, Galim, Bagam, Mevobo, Tata, Ngossong
	BATCHAM	Bameguéa, Nzintia, Tsépou, Nzié, Tchuelekont, Gwa'a-gwa'a, Bametin	
	BABADJOU	Ntoungha, Bamelo, Bamendjingha	Tchou, Douou Doji
HAUT-NKAM	BANA	Bapouh, Kwak, Bakam	
	BAKOU	« Liag » Rocky mountain	
	BANDJA	Toukon, Song, Tsekouo, Fangam, Tchipa, Bakeu	Batcham, Balako, Tchala, Bameudjo, Dakvet, Guieu, Tsake, Batoula, Lapoa
	BANWA	Fambélé, Fomessa II	Moumée marché, Cene Makongo, Bameleck
HIGH LANDS	BAHAM	Kaffo, Baho, Chengne	
	BANGOU	Baloumgou, Demlouh	
	BATIE	Bachepan, Guiè, Nkula	
KOUNG-KHI	PETE-BANDJOUN	Pété, Pété II, Yom	
	BAYANGAM		Bandrefam
MENOUA	SANTCHOU	Foungo	Fongwang, Nganzom
	FOKOUE	Communal quarries	Bamegwou, Fompéa, Fokoué, Fotomena
MIFI	BAFOUSSAM I	Banefo, Kovou, Noun Bridge	
	BAFOUSSAM III	Nepenet, Nepaha	
	CUB	Baleng, Bamougoum	

Divisions	Municipalities	Stone quarries	Quarries of sand
NDE	BANGANGTE	Logefar, Bangoua, Metcha, Pendou, Tswaliassau, Pettchouet, Velounbeng, Bantoum III, Maham	BantoumI, Bangangté, Bangang-Fokam, Bangoua, Sokouak, Maham, Fodjou
	BAZOU	Tountse, Tergal, Coteau, Toungo, Bagnoun, Bamaha, Saha, Bassoumdjang	Toungo, Bagnoun, Bamaha, Ngombe, Bassoumdjang Behebeu, Menozi, Ntanga-fetba
	TONGA	Samtse, Kouandjim	Saliki, Nkamjim, Maham
NOUN	MASSANGAM	Mansonem, Mamoguam, Matoufa, Malanden, Mancha, Massangam, Machatoum, Matam	
	FOUMBOT	Baïgom, Fosset, koupka, Njimbot Fongue, Njincha, Fossang	Mount Mbapit, Baïgom, Kouffen, Mahouon, Maka, koupka, Njimbot Fongue and Tenjouonoun, Fosset

5.4.1. Socio-economic impact of quarrying

In the West Region, the socio-economic impact of quarrying is not negligible. Indeed, in addition to the fixed duties and taxes paid by quarry operators, multiple jobs are generated through operational industrial quarries, while artisanal mining is the main source of income for many young men and women in the region.

5.4.2. Environmental impacts

Apart from child labour in artisanal quarries, the other negative effects of quarrying in the West Region include:

- degradation of surface water, air and soil quality;
- silting of watercourses;
- destruction of vegetation and wildlife;
- modification of the landscape;
- noise pollution caused by dynamite firing;
- tremors that crack the houses of the local populations (in the case of industrial exploitation);
- non-compliance with safety and hygiene measures which is a real problem in artisanal quarries.

5.5. Prospects for Mining Production: Ongoing Programmes and Projects in the Mining and Quarrying Sector

A reading of the mineral index map in Figure 16, table III showing the current status of the mining inventory and current mining production earmarked for construction materials, shows that:

- the West Region remains under-explored in terms of mining resources;
- the few mineral indexes and deposits inventoried there have a spatial distribution with a very low network;

- the indices thus identified are located mostly near the main roads.

The projects mentioned above could provide some solutions to this exploratory gap in the West Region.

- The Mining Sector Capacity Building Project (PRECASEM) began in 2012 with funding from the World Bank and the Government of Cameroon. A major recent effort has been made by this project to carry out a 160 km² airborne geophysical survey campaign in certain geographical areas of Cameroon, including the West Region. This project will considerably increase the area covered by the mining inventory.
- The ACP-EU Development Minerals Programme aims at improving the profile and management of Neglected Development Minerals (industrial minerals; building materials; cut and semi-precious stones, low value metals). It intervenes through in-depth capacity building with activities including training, small grants, production of maps and databases, development of environmental and safety regulations, organization of community dialogues, technology fairs and networking events, etc.

5.6. Analysis of Mining Development Issues in the Region: Strengths, Weaknesses, Threats and Opportunities

To better understand the possible problems that may arise from the development of mining, it is important to highlight the assets and strengths, weaknesses and threats as well as opportunities inherent in the geological and mining context of the West Region.

5.6.1. Mines

5.6.1.1. Assets and strengths

Although not effective till date, the exploitation of mineral substances, listed according to the available knowledge and which only concern a small portion of the region and those still to be highlighted, will stand as assets and strengths:

- of considerable mining potential;
- a geological context very favourable to the presence of significant mineralization;
- a known and identified deposit of a significant size and with a good tonnage - content pair;
- good accessibility to mineralization sites....

5.6.1.2. Weaknesses

As for weaknesses, they manifest themselves through:

- the total absence of mineral exploitation as of now.
- insufficient photo-geological coverage for exploring, prospecting and developing the mineral resource potential of the region;
- partial geological and mining exploration and prospecting of the regional territory;
- insufficient knowledge of mining potential, as the mineral inventory (incomplete) only affects a portion of the region with very loose information links;
- the lack of resources and awareness raising frameworks for the promotion of the mineral resource potential of the region's subsoil: the absence of marketing on mining potential in order to attract investors;
- the lack of transversal coordination of the decentralized services of the ministries in charge of mines and infrastructure at the regional level;
- insufficient vertical coordination of the decentralised services of the Ministry of Mines in the region;

- insufficient road infrastructure for comprehensive geological and mining exploration and efficient mining....

5.6.2. Quarries

5.6.2.1. Assets and strengths

Materials quarrying, the main and only current mining activity in the West Region, has the following assets and strengths:

- a favourable geological context with a crystalline basement and volcanic cover made of massive rocks decomposed into laterite, exploited responsibly or altered as materials, and a very dense hydrographic network responsible for alluvial deposits rich in sand and gravel;
- a significant potential in building materials, servicing and ornamentation;
- the availability of an abundant workforce for the crafts sector;
- a leading and rapidly expanding mining activity, contributing to the diversification of the region's economy and thus to sustainable development.

5.6.2.2. Weaknesses

In terms of weaknesses, the extraction of quarry materials is marred by:

- lack of mapping of deposits, identification of materials while precising the characteristics of potential quarries (lithological nature, tonnage, spatial delimitation, summary geotechnical properties, accessibility, environmental constraints, etc.);
- a structural or organisational imbalance with 70% of artisanal exploitation for an annual production of 44% and 30% of industrial exploitation for a production of 56%;
- lack of survey traceability of the operating permits granted, leading to illegal exploitation of the quarries, among other things;
- artisanal production generally carried out in an informal setting;
- rudimentary equipment and operating methods;
- lack of funding and supervision of the activity;
- poor condition, on several sections, of the existing road network and access roads to the operating sites;
- lack of structure and organization of artisanal quarries;
- the employment of children in the artisanal quarrying activity;
- failure to comply with safety, hygiene and environmental protection rules and measures at the operating sites.

5.6.2.3. Challenges and threats

In trying to achieve its full potential and contribute effectively and efficiently to the diversification of the West Region's economy and its sustainable development, the mining sector faces many challenges and threats, including the following:

- optimizing partnerships between the mining sector and other sectors of the economy in order to finally promote the development of this important part of the mining industry, the exploitation of mineral substances, which has not been carried out till date in the West Region. In other words, the creation of favourable conditions (exploration/prospecting and inventory of mining resources, setting up structures to promote the mining potential, administrative services with sufficient human

and financial resources, etc.) for the mining industry in the region through the effective exploitation of its minerals is important;
- the lack or poor supervision and insufficient monitoring of the mining sector, which can lead to its development in isolation from the rest of the economy with little impact on the working population and local communities;
- the control and monitoring of negative impacts on populations (destruction of houses, etc.), which are essential for better quarrying;
- a good preparation and optimization of the contribution of the mining sector to the diversification of the regional economy through an effort of good governance in the fields of infrastructure, employment, revenue management, transparency...;
- increased pressure on the environment at quarry sites;
- control and monitoring of negative impacts on ecosystems such as the destruction of natural habitats, pollution of surface water, groundwater, soil degradation and loss of biodiversity;
- sources of conflict such as:
  - ✓ the import of a qualified workforce;
  - ✓ the exploitation of quarries confronted with customs and habits, such as deposits established on sacred sites for local populations;
  - ✓ disagreements between craftsmen themselves;
  - ✓ overlaps between mining areas and protected areas.

5.6.2.4. Opportunities

In the West Region, the mining sector offers current and future opportunities:

- the availability of good quality quarry materials in the presence of a large market;
- the existence of numerous deposits of construction materials that are easily exploited and accessible;
- an industrial and artisanal activity that creates wealth for all stakeholders: citizens, governments and mining companies;
- a mining sector:
  - ✓ with tax revenues adding value to the regional economy;
  - ✓ with significant employment potential in the formal sector of the region;
  - ✓ catalyst for infrastructural development;
  - ✓ the positive impact on employment, the supply of products and services;
  - ✓ contributing to the development of local communities by improving their level of education and vocational training;
  - ✓ likely to create a regional dynamic by promoting building materials on site (brickworks, glassware, pottery, tiles and earthenware...).

CONCLUSION

The following conclusions can be drawn based on observations made in the field both along the access routes to the two selected sites located on the right bank of the Nyong River and on the same sectors of the landmarks of the said sites:

- bedrock outcrops are rare on the routes used and absent in the reference areas of the proposed sites on the right bank;

- it is the orthogneiss that sporadically outcrops through the access roads followed using the existing geological map, in accordance with the lithological prescriptions indicated, for the area hosting sites 2 and 3;
- these orthogneiss, foliated differently, are affected by folds and fractures;
- the orthogneissistic nature of the bedrock is a priori favourable for anchoring the foundations of a dam on the 2 sites;
- the loose covering soils of the two sites are represented on the one hand by fine sands from the alluvial terraces, and on the other hand by the clayey-sandy and gravelly-clay products of the bedrock's lateritic alteration cover; all these loose materials can be used for the construction of a dam;
- the bedrock at Site 2 appears to be lined with orthopyroxenite (which can be seen through the boulders on the alluvial terrace of the reference area) whose usual deposit pattern is in the form of veins or enclaves in a massif;
- the substratum at site 3 is probably orthogneissistic in nature, which can be seen through the screes and boulders encountered at the foot of the drainage basin's slope on the left bank;
- the course of the Nyong at the latitude of the two sites is tectonically guided: at site 2, its straight line follows the configuration of a NW - SE fracture, while at site 3, it draws a bend which, upstream, begins through an E - W fracture relayed downstream by directions of foliation and/or ENE - WSW fractures, then NE - SW.

In addition, at the end of this first surface geological survey, one can say that the two sites have similar geological conditions, because of the absence of outcrops. These poor observation conditions leave many geological unknowns and do not allow the quality of the sites to be specified and separated on the basis of geological criteria at this preliminary diagnostic stage, hence the need and relevance of the proposed reconnaissance work programme.

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