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Petrological Characterization of Pelites from the Mintom Basin and Their Weathering Mantle

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Abstract The aim of the present study is to characterize a weathering mantle developed on pelitic rock in the tropical forest region precisely in Mintom (South East Cameroun). This characterization include morphology, physico-chemical and mineralogic analyses. The region is characterize by a hot and wet climate consisting of four seasons of inequal length and intensity. The average temperature is about 24°C and the mean rainfall is about 1633mm/years. The rocks in the area consist of limestone, dolomites and pelites. Fieldwork consist of landscape analysis, geologic prospection and soil profile description. Mineralogical and physico-chemical was carried out on various samples in the laboratory. Morphological results show that the studied profile has a general brownish yellow aspect, with a thickness of about 6m and a silty-clayey texture. Five horizons can be distinguished from top to bottom : a humiferous horizon, a loose yellow set, a yellow horizon bearing quartz fragments and large indurated blocks, a saprolite consisting of a fine and coarse saprolite possessing some pelite relics of variable sizes and a deep red colour just like that of the parent rock. The parent rock is a massive pelite with a reddish colour when wet and a violet colour when dry. It has a powdery feel. Analytically, the soils have an acidic pH (4,0 to 4,2), a high organic matter content (4,8%), a C/N ratio of about 6,76, a cationic exchange capacity of 7,64meq/100g with a saturation rate S/T of about 7. Particle size distribution shows that the silty fraction is dominant (59%), followed by the clayey fraction (30%). The main minerals are kaolinite, quartz, smectites, calcites, dolomites, goethite and hematite.

Keywords: *pelitic rocks, weathering mantle, petrology, Zoebefam, Mintom, South East Cameroon*

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1. Introduction

The formation and developpment of soils depend on two importants surfaces processes which are: the wheathering and the pedogenesis. these processes are essentially interactions between water and rocks; and they depend on climate and station factors [1,2]. Several works have been done on the bahavior of chemical elements in the weathering materials developped under various parent rocks [3,4,5]. Many studies associating the geochemistry of major trace and Rare Earth elements were carried on ultrabasic, intermediate and metamorphic rocks in Cameroon [6,7,8,9,10]. The morphology and petrology of lateritic weathered materials have been discussed and published in several journals and Books [11,12,13]. much research into rock weathering has concentrated on the geochemical and mineralogical changes undergone by the rocks and their weathering product [7].

The study area is situated in the Mintom Sedimentary Basin, South Cameroon. many work have been carried out in the Mintom Basin. The studies were focus on geologic and geophysic prospection of calcareous [14]; palaeoenvironmental and sedimentological studies on carbonated and pelitic rocks [15]; physico-mecanic and petrologic characterization of carbonates rocks for their industrial valoralization [16]. But, none study has now been made on a weathering profile developped on a pelite. The aim of this study is to make a physico-chemical and a mineralogical characterization of a weathering profile developped on pelitic rock in the Mintom Sedimentary Basin.

2. Geographical and Geological Setting

the study area is situated in the Dja wathershed of the Mintom area, withing the coordinates 2°30' and 3°00' latitude North, and 13°00' and 13°30' longitude east

(Figure 1). The Dja wathershed is characterized by a Humid and heat continental equatorial climate, with four seasons [17]; and by a guinaea-congolese green humid forest [18]. it belong to the Mintom formations which is part of the Central african Fold Belt. the Central African Fold Belt in Cameroon is subdivided onto four main geotectonic domains which are from the North to the South (Figure 2): the Northern Domain (Poli and Mayo Kebbi Volcano-Sedimentary series) [19,20,21,22]; the Adamawa-Yadé Domain edged to the North by the Tcholliré-Banyo Fault [23,24,25,26]; the Southern nappes corresponding to stacked metasedimentary units thrust unto the Congo Craton, which ares: the Bafia Group, the Yaoundé Group, the Yokadouma and Nola Series, the Mintom formations [27,28,29]. The Mintom formations consist of carbonates and pelites [15,16] (Figure 3).

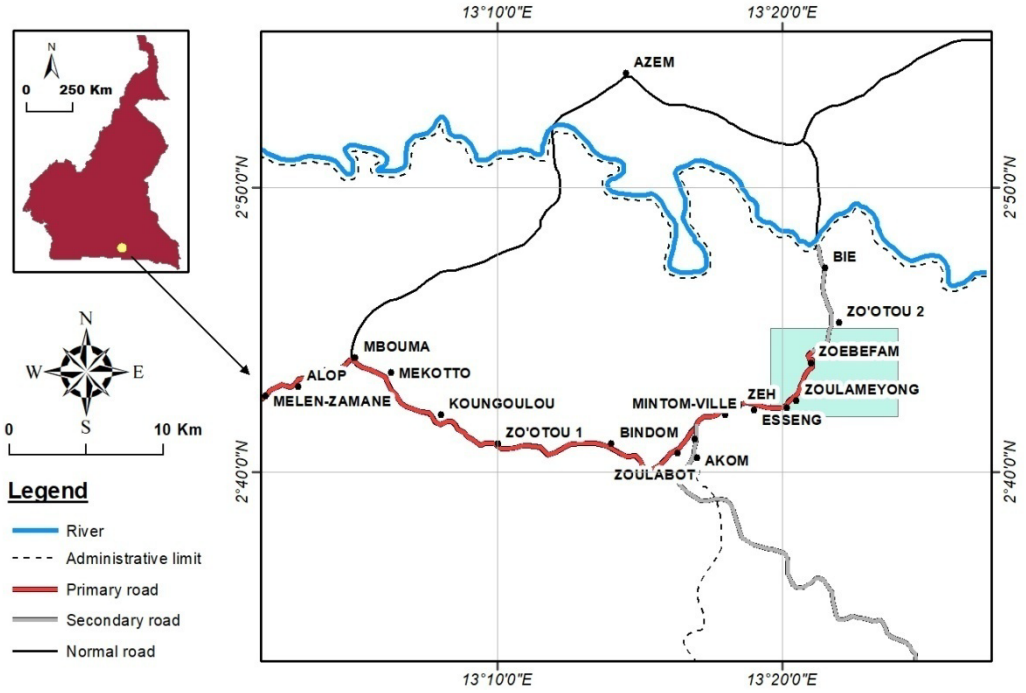

Figure 1. localisation of the study area.

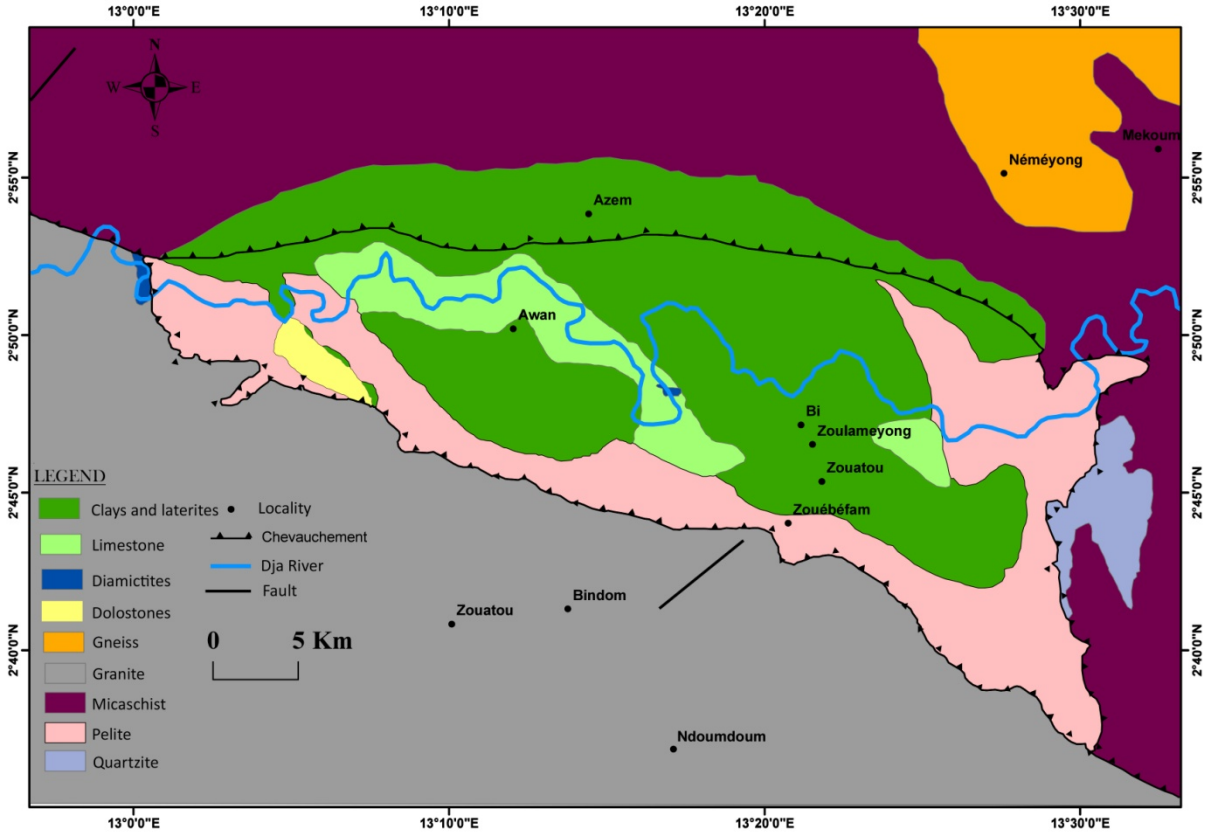

Figure 2. Simplified geological map of the study zone [35]

3. Material and Method

The field work consisted on the openning of a 6m pit under a pelitic rock, at the coordinate system 02°43'96'' latitude North, and 13°20'89'' longitude East. After that, the description of different levels of the weathering profile was made. four samples of soils were collected (01 on each horizon) for physical, chemico-physical and mineralogical analysis.

The mineralogical analysis were carried out at the "Mission de Promotion des Matériaux Locaux" in Yaoundé Cameroon, by XRD of the whole powder sample using the "Eslinger and Peaver (1988)" method.

physico-chemical and physical analysis were carried out at the "laboratoire d'analyses, plantes, engrais et eaux" at the "IRAD" Nkolbisson (Yaoundé Cameroon), and to the "Laboratoire des Sciences du Sol" of the Yaoundé I University. The pH was mesured whith a ph-meter, the granulometry was obtained by the Robison pipette Method on a airdry soil sample. exchangeables basis and the "cationic exchange capacity (CEC)" were determinated by a ammonium acetate solution at pH 7. The azote was determinated by the "kjedhal" Method, while the organic carbone was determinated by the "Walkey and Black" method.

4. Results

4.1. Morphology of the Weathering Profil

The weathering profile present five differents levels which are from the Bottom to the top (Figure 3):

-the coarse saprolite with 300cm thick;
-the fine saprolite with 100cm thick;
-the loose horizon with quartz fragments (100cm thick);
-the yellow loose horizon (80cm thick)
-the humiferous horizon.

The entire description is given in Figure 3.

4.2. Mineralogy

The mineralogic evolution was determinated on samples collected in three levels of the weathering profile: the coarse saprolite, the yellow loose horizon and the humiferous horizon (Figure 4). At the bottom of the profile, the mineralogy is made up of primary minerals like quatz, calcite, dolomite, geothite and hematite, smectite and kaolinite as clay (Figure 4a); the loose horizon is characterize by the presence of quartz, smectites, calcite, the disappearance of hematite, and the increase of geothite (Figure 4b); the humiferous horizon is made up of primary minerals as quartz, smectites, calcites, dolomite, kaolinite, goethite, hematite (Figure 4c).

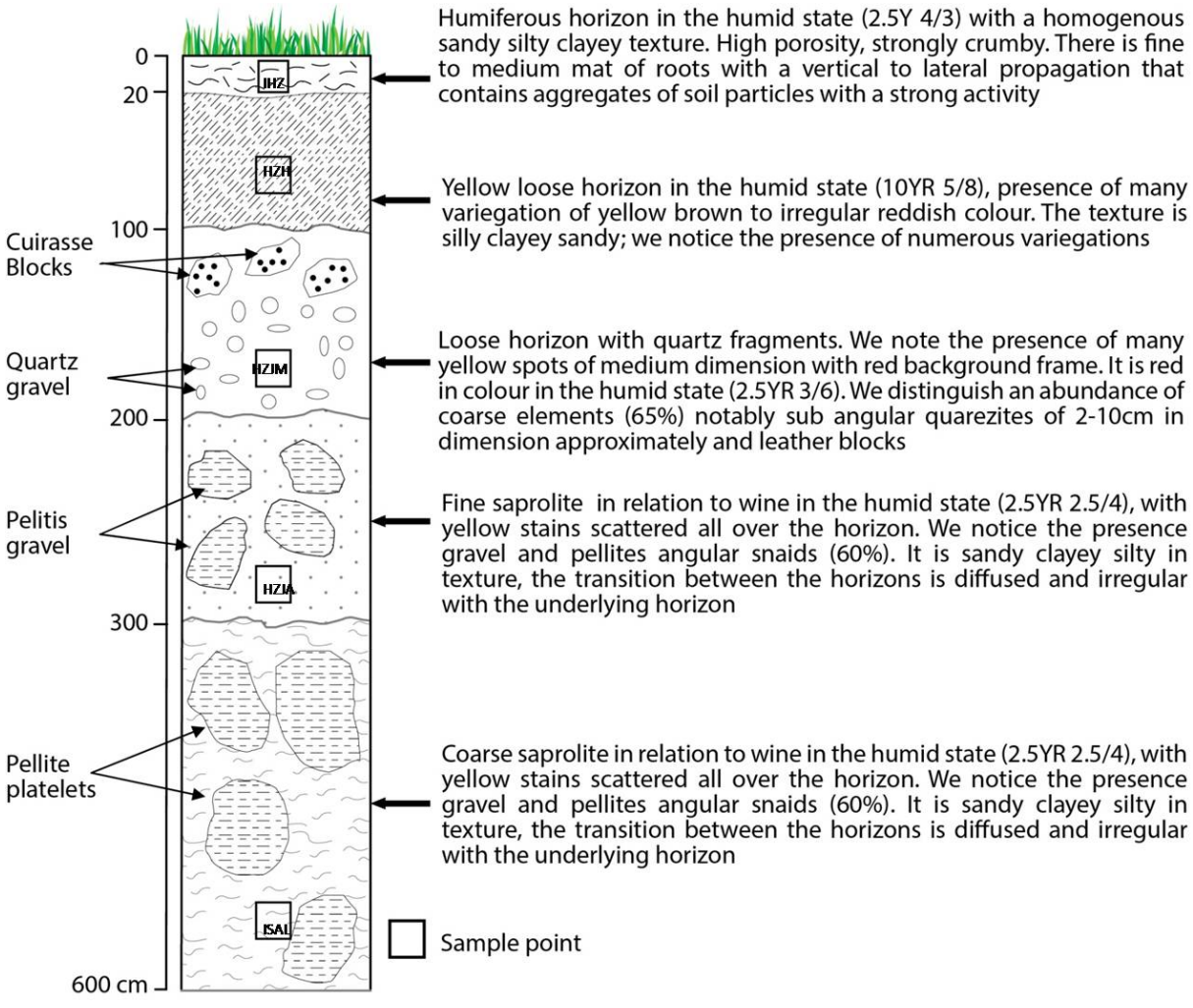

Figure 3. Description of the weathering profile

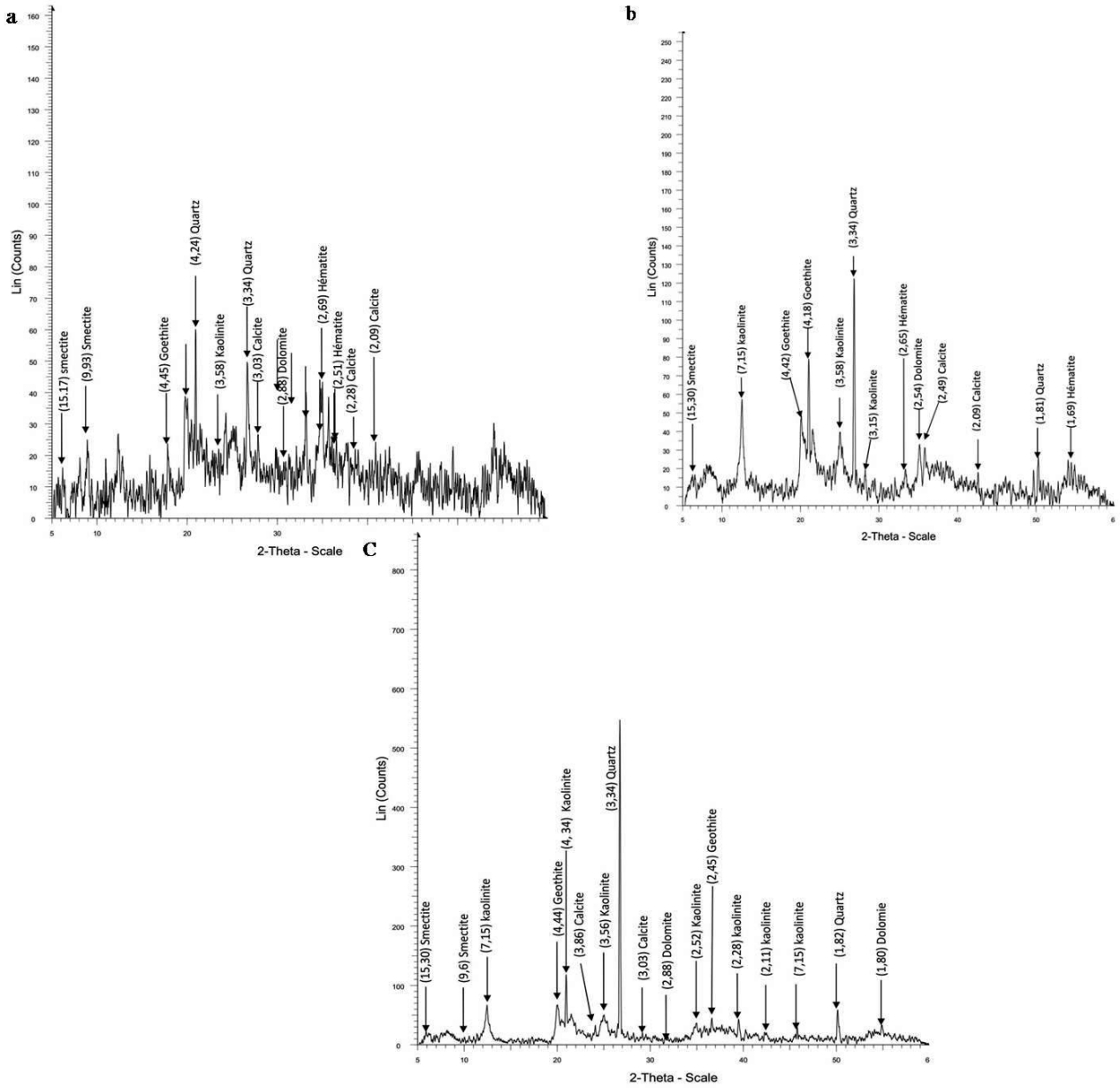

Figure 4. X-ray diffraction spectra for: a) the coarse saprolite; b) the loose horizon; c) the humiferous horizon of the Zoebefam area

4.3. Physical Analysis

- Granulometry

Granulometric analysis results are given in Table 1, Figure 5 and Figure 6, showing that: clay ratio is about 25.23% in the coarse saprolite, increase in the fine saprolite (30.29%), and decrease in the loose horizon and the humiferous horizon (28.68% and 17.6%) respectively (Table 1; Figure 5). the limstones content have the same evolution than clay. it is about 53.3% in the coarse saprolite, 58.75% in the fine saprolite, 54.36% in the loose horizon, and 31.91% in the humiferous horizon (Table 1; Figure 5). the Figure 6 show that the weathering profil mostly present a sandy-clayed silt and a clayed silt texture, the humiferous horizon present a claycy sand silt texture.

Table 1. Physical analysis

Samples	Depth(cm)	Granulometry(%)			
		Clay	Limestones	Sand	Total
HZH	0 - 20	17,6	31,9	50,47	99,97
HZJM	20 - 100	28,68	54,36	16,97	100,01
HZJA	100 - 300	30,29	58,74	10,97	100
ISAL	500 - 600	25,23	53,3	21,38	99,91

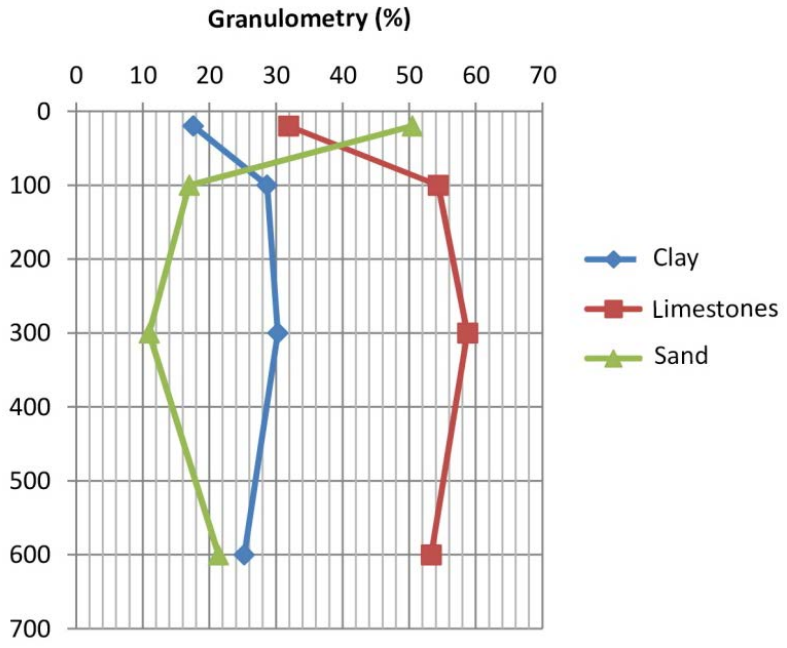

Figure 5. Evolution of the clay, silt and sand percentages along the profile

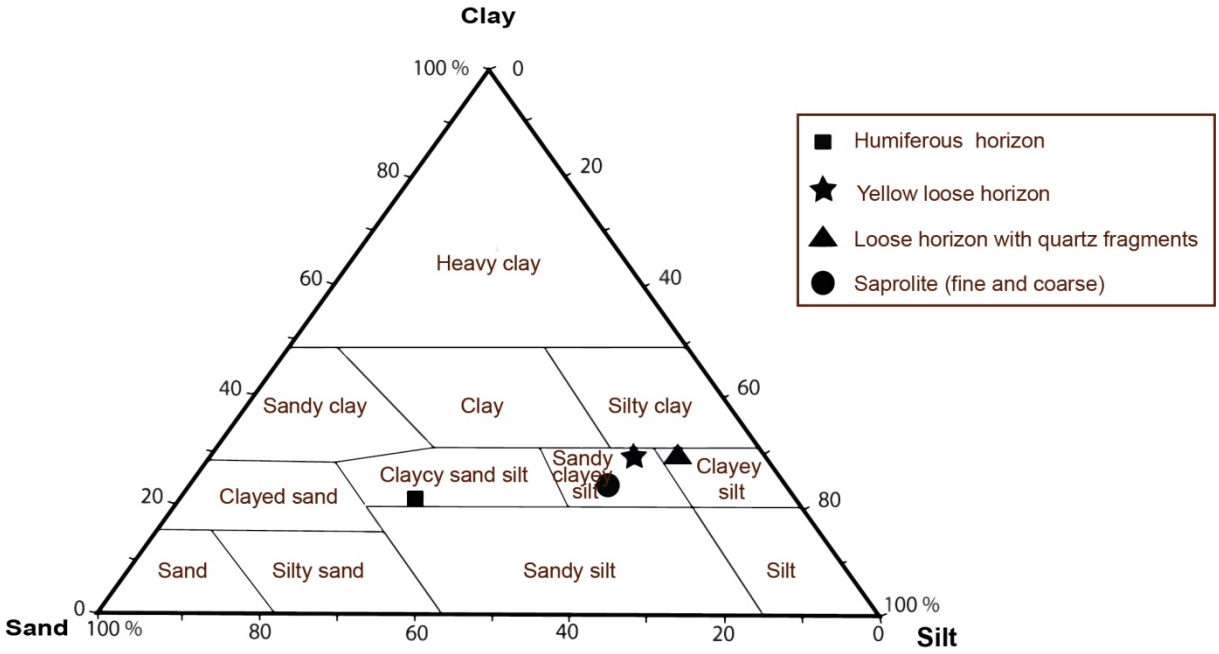

Figure 6. Distribution of the different soils samples in the textural diagram of Jamagne [36]

- porosity

Porosity ratio increase from the bottom to the top of weathering profile (Table 1); it is about 28.46% in the coarse saprolite, increase at 47.27% in the loose horizon, and rich 60% in the humiferous horizon.

4.4. Physico-chemical Analysis

physico-chemical analysis results are presented in Table 2, Figure 7 and Figure 8.

Water pH ratio is high in the coarse saprolite and in the humiferous horizon (4% and 4.2%), while it is about 3.7% in the loose horizon (Table 2). the pH KCL increase from the bottom to the top of the profile (Table 2). the exchangeables cations sum is made up of Mg^{2+}, Ca^{2+}, Na^{+}, K+; this sum presented his highest ratio value is in the humiferous horizon (0.25 méq/100g) (Table 2). the cationic exchange capacity (T) ratio vary whiting the profil; it present his highest value in the loose horizon (13.17%) (Table 2). The saturation ratio (S/T%) vary between 0.09% and 0.01% (Table 2). nitrogen ratio vary between 3.01% and 4.44 whiting the profile (Table 2; Figure 8). organic carbon ratio increase from the bottom to the top of the weathering profile, and rich a value of 2.84% in the humiferous horizon (Table 2). the C/N ratio is high in the humiferous horizon (6.76%) (Table 2).

Table 2. Physico-chemical analysis

Physico-chemical analysis														
Samples	Depth (cm)	pH			Exchangeable bases					CEC or T meq/100g	S/T (%)	Organiccarbon (%)	Total nitrogen (%)	C/N
		pH water	pH KCl	ΔpH	Ca2+ meq/100g	Mg2+ meq/100g	K+ meq/100g	Na+ meq/100g	S meq/100g					
HZH	0 - 20	4,2	4,1	0,1	0,01	0,02	0,06	0,01	0,12	2,75	0,04	2,84	0,42	6,76
HZJM	20 - 100	3,6	3,7	–0,1	0,13	0,02	0,02	0,01	0,18	13,17	0,01	1,65	0,44	3,75
HZJA	100 - 300	3,7	3,6	0,1	0,00	0,02	0,08	0,01	0,11	8,21	0,01	1,55	0,31	5,00
ISAL	500 - 600	4,0	3,9	0,1	0,02	0,04	0,07	0,01	0,14	6,43	0,02	0,69	0,34	2,02

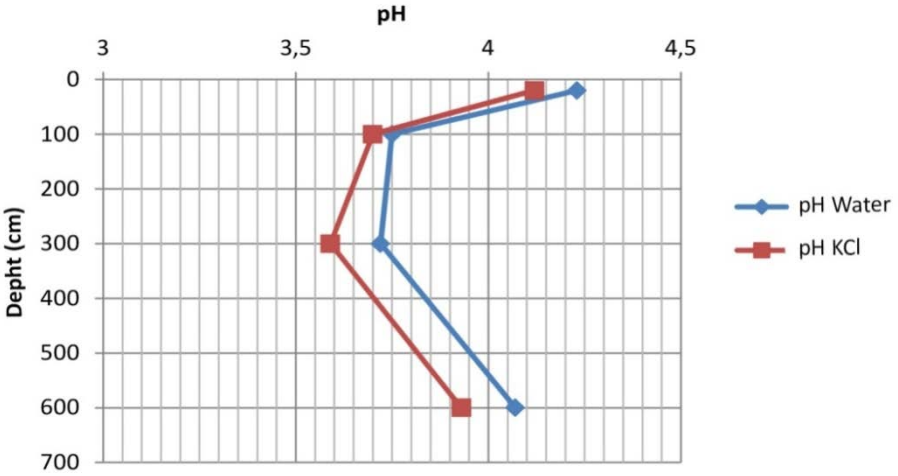

Figure 7. Water pH variation curves and pH kcl with depth

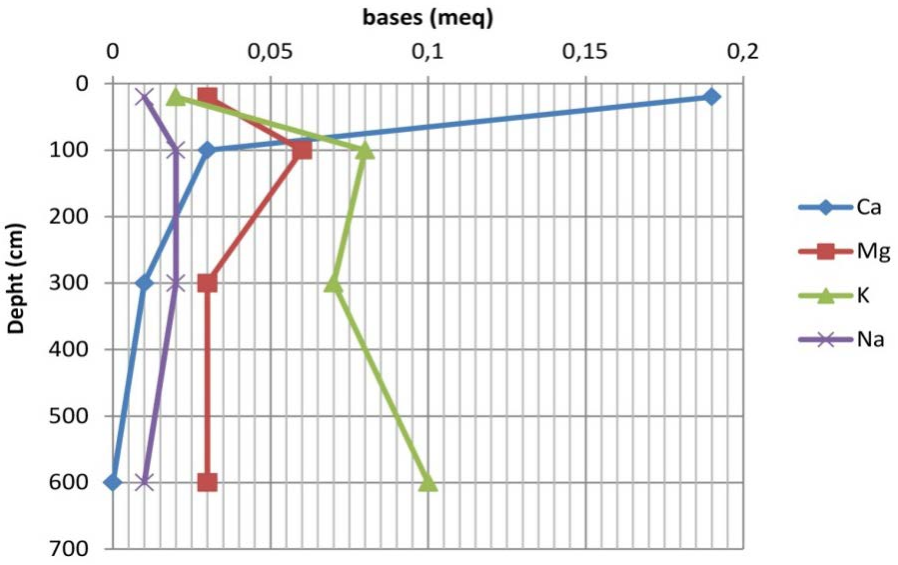

Figure 8. Evolution of exchangeable bases in the profile

5. Discussion

The Zoebefam weathering profil is 6m thick. This thikness can be explain by convex form of the topography, with a more quick water circulation. The consequence is the transport of fine particles, and a strong lixiviation [31]. The mineralogy is in majority made up of quartz, calcite, dolomite, goethite, hematite, smectite and kaolinite. Kaolinite, goethite and hematite neoformation is favoured by the morphoclimatic and hydrologic environment of South Cameroon. in this context, rains are abondant, the hydrographic system is dense, favorising a good drainage resulting from a strong slope and a good permeability [32]. Solutions are diluted and renewed regularly, winning a total dissolution of bases and partial of silicium, leading to the formation of kaolinite [12]. The high proportion of quartz is due to its low dissolution during weathering. Goethite might the related to the high porosity that seemingly facilities the stagnation of water in cavities [33]. Hematite results from the dehydratation of goethite [14].

The weathering profile texture vary from sandy-clayed silt, clayed silt and claycy sand silt form. physico-chemical

analysis revels that the pH is acid (4 to 4.2%); this can be explained by the fact that there is a lot quartz in the profile. the weathering profile on a pelitic rock in the Peissonel watershed described by reference [34] presented a alkalin pH, due to the presence of calcareous blocks in the area. organic carbone is very low in the humiferous horizon (2.84%) of the Zoebefam weathering profile; while it is about 10% in the first centimeters of the Peissonel watershed weathering profile. this difference to the fact that the Zoebefam watershed in the tropical forest, while the Peissonel area is in temperate climate with a good vegetation conservation and a slow degradation.

6. Conclusion

The study permited to highlight the morphological, mineralogical, physical and the physico-chemical characters of the Zoebefam watershed:

- the weathering profile is divided into five differents levels: the coarse saprolite, the fine saprolite, the loose horizon with quartz fragments, the yellow loose horizon, the humiferous horizon.
- the mineralogy is made up of quartz, calcite dolomite, goethite, hematite, smectite and kaolinite.
- granulometric results shows that clay and silt ratio ares more abondant in the fine saprolite; soil texture vary from sandy-clayed silt, clayed silt and claycy sand silt form. porosity ratio grow from the bottom to the top of the weathering profile and rich 60% in the humiferous horizon.
- exchangeables bases presents ares Mg^{2+}, Ca^{2+}, Na^{+}, K+ ; the pH is acid, and the organic carbon is very low.

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