Bull. Soc. belge Géologie	T. 85	fasc. 4	pp. 163-172	3 fig.	Bruxelles	1976
Bull. Belg. Ver. Geologie	V. 85	deel 4	blz.163-172	3 fig.	Brussel	1976

QUATERNARY STRATIGRAPHICAL PROBLEMS IN THE NORTHERN PIEDMONT PLAINS OF THE SHEBSHI MOUNTAINS [NORTH - EASTERN NIGERIA]

by J. MOEYERSONS (*)

SUMMARY. - An important escarpment divides the northern piedmont plains of the Shebshi Moutains (NE Nigeria). The Western part of the plains forms part of the Benue Plain and is essentially etched out by erosion processes, as indicated by the omnipresence of a typical stone-line profile. The eastern part, the Zing Plateau, consists mainly of accumulated plains. Following this stratigraphical boundery over some distance, it appears to delineate the south-western corner of an ancient Tchad Basin. The reason why accumulation took place on the remnants of this basin, while erosion was predominant elsewhere, could not be explained in a satisfactory way. The stratigraphical study led to the conclusion that the actual phase of relative stability and humid climate was preceded in former times by a dry period of marked slope evolution.

1. INTRODUCTION.

The southern affluents of the Benue River, between Yola and Jalingo (NE Nigeria), drain two important surfaces, separated by an escarpment, more than 100 m high. This so-called Lankaviri Escarpment (fig. 1), forms the western limit of the Zing Plateau, lying between 400 and 300 m above sea level and dominates the Plain of Jalingo, situated at about 200 m. Dispersed residual masses prolongate the level of the Zing Plateau to some kilometres into the Jalingo plain. More to the south, the Lankaviri Escarpment coincides with the western flanc of the Shebshi Mountains, rising more than 600 m above the Zing Plateau and the Belwa River basin. The existence, west of the Shebshi Mountains, of residual masses, reaching 300 to 400 m in altitude, suggests that the northern outliers of the Shebshi Mountains were entirely surrounded in former times by the Zing Plateau. According to general topography, descending to the east, a drainage pattern with an eastern component of this ancient Zing Plateau is very probable. In more recent times, the Jalingo Plain could have been formed by regressive erosion from the lower Benue Plain. These data corroborate the opinion to C. VOUTE (1962) that during former times the upper and middle Benue drained their waters of the east,firstly to the Zaîre Basin and later to the Tchad Basin. Therefore, the Zing Plateau is to be considered as a dissected remnant of the African surface from end-Tertiary times.

The greater part of the area, under study here, is underlain by precambrien cristalline rocks, composed of granites and gneisses. Along the Benue, Cretaceous marine sediments occur. According to R. MURAT (1969), parts of the Shebshi Mountains are covered by basalts and sandstones, dating from Cretaceous and Tertiary times.

On the base of records, mentioned by M.G. BAWDEN and P. TULEY (1966), it seems that the Jalingo Plain and the western edge of the Shebshi Mountains receive an annual mean of about 1270 mm of precipitation, while the Zing plateau has about 1015 mm precipitation" year.

(*) Koninklijk Museum voor Midden-Afrika, B-1980. Tervuren, België.

FIG. 1: TOPOGRAPHICAL MAP OF THE STUDY AREA

Location of the study area with indication of accumulation plains.

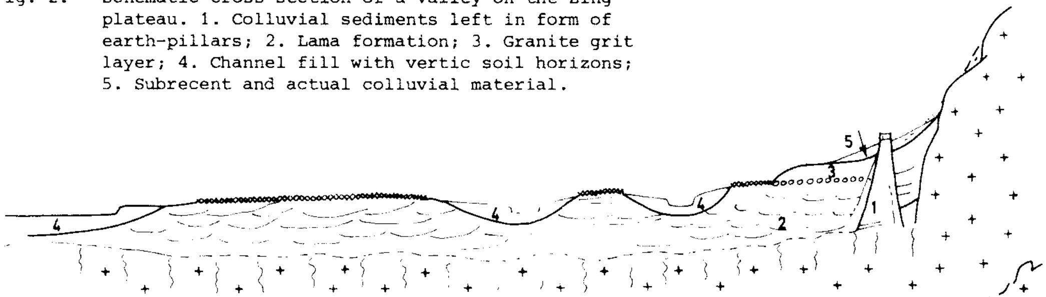


Fig. 2. - Schematic cross-section of a valley on the Zing plateau. 1. Colluvial sediments left in form of earth-pillars; 2. Lama formation; 3. Granite grit layer; 4. Channel fill with vertic soil horizons; 5. Subrecent and actual colluvial material.

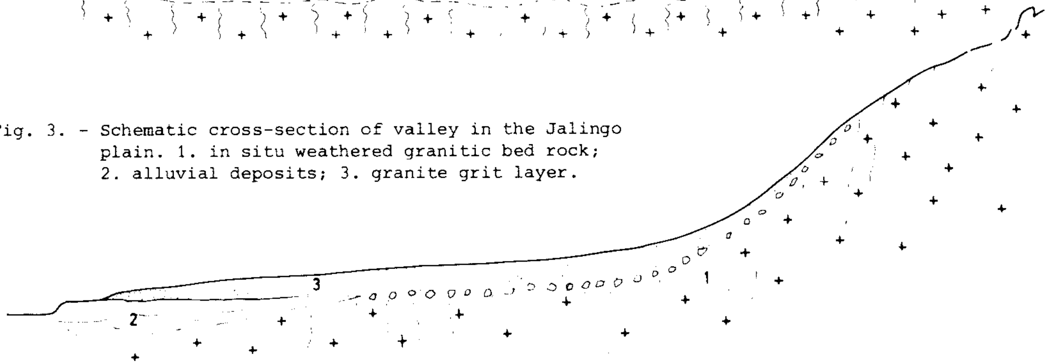


Fig. 3. - Schematic cross-section of valley in the Jalingo plain. 1. in situ weathered granitic bed rock; 2. alluvial deposits; 3. granite grit layer.

A geomorphological and Quaternary stratigraphical survey on the Zing Plateau and the Jalingo Plain revealed a marked difference between the two areas.

2. THE ZING PLATEAU AND THE BELWA RIVER BASIN.

2.1. SOME MORPHOLOGICAL ASPECTS.

The piedmont plains on the Zing Plateau and especially in the Belwa River Basin are usually characterised by slightly concave or rectilinear slopes, the slope angles varying between 0° and 5°, depending on the width of the "Flachmuldentäler". More detailed observation revealed that the piedmont plains are cut by two types of rivers : a first type consisting of shallow and wide valleys, filled up by clayey sediments in which occur a number of superposed vertic soil horizons; a second type consisting of ravines of the Arroyo type, incising actually the older valleys, but also attacking not yet dissected parts of the piedmonts. Furthermore, pedimentation steppes of the type described by H. RHODENBURG (1969) and H. FOLSTER (1969) in other parts of Nigeria can be observed.

The "inselbergs", rising up above the Zing Plateau are characterised by their high degree of denudation, giving rise to many sound rock outcrops, and by the structural control of their form (J. MOEYERSONS, 1977). The transition between bare hillslopes and the piedmont plains is generally made by a strongly marked break of slope, or by a concave slope section when a thin mantle is present on the hillslopes.

2.2. STRATIGRAPHY.

Observations in the field revealed that the piedmont plains on the Zing Plateau are in fact accumulated plains. An idealised valley cross-section is given on fig. 2. The stratigraphical succession is described in detail in annex 1 and can be summarised as follows :

5. recent colluvial material, often with an upper homogeneous and a lower laminated facies.
4. badly calibrated colluvial material, generally bearing three or four vertic soil horizons, and filling up the channels of a former drainage system, developed in the plains.
3. a colluvial layer of granite grit : the upper part shows almost a homogeneous structure, while the lower part often displays small channel structures, often containing granite pebbles.
2. an important proluvial layer, covering the entire valley. This layer is called the Lama formation.
1. granite grit of colluvial origin, partly silicified and occuring only in small earth-pillar remnants.

These stratigraphical entities can be subdivided into two groups : a first group consisting of material derived from the hillslopes and containing the numbers 1, 2 and 3; the numbers 4 and 5 can be considered as reworked material derived for the major part from the lower group. This subdivision suggests the existence of an important morpho-dynamic phase, probably composite, followed by a more stable period.

It seems that the stratigraphical succession, as described above, is not merely the result of a continuous deposition. The accumulation was interrupted by periods during which the former deposits were partly evacuated or during which the landscape was rather stable.

A first interruption of the accumulation in the piedmont plains must be situated between the deposition of the so-called earth-pillar colluvium and the Lama formation. The fact that layer 1 is only preserved in a few pillar-like remnants indicates the development of an important ravination system, with formation of badlands. During this stage, there was not only intense erosion of layer 1, but it is clear that material, eventually derived from the hillslopes, was directly evacuated out of the study area, as no remnants are to be found.

A secund interruption took probably place after the deposition of the Lama formation before the granite grit mantle of layer 3 was spread out over the plains. This hypothesis is based on the fact that the Lama formation is very strongly kaolinised over its entire thickness, sometimes exeeding 10 m. It is difficult to consider such a thick horizon as the B- horizon of the ferruginous tropical soil, whose oxidised A-horizon, developed in the overlying granite grit mantle, often is reduced to a thickness of less than 50 cm. The important enrichment of the Lama formation with kaolin should therefore, be considered as an indication of the existence of a long and or intense phase of chemical weathering preceding the deposition of the granite grit.Probably the A-horizon of this palaesol was eroded during, or just prior to, the first arrival of the granite grit. Anyway, it has been observed near sugu, situated at the eastern edge of the Schebshi Mountains, south of the area under study, that a very thick red-brown A-horizon is stil present on top of the Lama formation there. The red colour of the overlying granite grit is due to a later, less intense, phase of pedogeneiss.

Concerning the lower group of layers, placed in what was called a "morphodynamic" period, it is clear that the active phases of this period were not necessarilly of a catastrofic nature. When it is true that the channel structures of the Lama formation suggest a rather quicely changing breaded system of runoff channels, characterised by temporary inondations, it is clear that the arrival of the overlying granite grit mantle in the plains, especially of the upper part of that mantle, took place during, a rather stable period of a certain duration. Indeed, experimental research(J. MOEYERSONS, 1975) showed that the mechanism of splash-creep was of major importance for the transport of the gravels. Taking into account that this process is rather slow and that it needs a substrate, partly free from vegetation, it can be accepted that the deposition of the upper part of the granite grit layer took a long time in a landscape charactérised by an open savannah vegetation.

The reworking of the above described lower group of sediments was realised during three stages. First, slope pedimentation did start from the central drainage lines, smal scarps consuming by regressive erosion the granite grit layer 3, leaving behind a thin veneer of the coarsest particles. At some places, these steps did attain the foot of the hillslopes, at others the piedmont plain was partly protected by the occurrence of lateritic duricrusts preventing the scarps from further withdrawal. At a certain moment, drainage channels developed upslope as well as downslope from the steps. These channels were connected with the central drainage lines and were fed by sources as indicated by the presence of small source heads. However, the drainage became progressively worse, the bed walls becoming unstable and the beds filled by colluvial material. Three or four vertic soil horizons are generally developed within these sediments. Finally, the actuel stage is characterised by the formation of ravine cuttings of the Arroyo type, almost entirely fed by runoff water during and shortly after rainstorms, which gives rise to important stream floods in the lower courses of this drainage system. Arroyo cuttings are not only restricted to the older channels but also intact parts of the plains are actually affected.

The evolution as indicated above is given in table 1.

3. THE JALINGO PLAIN.

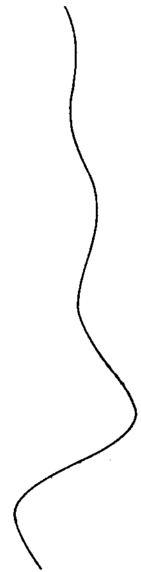
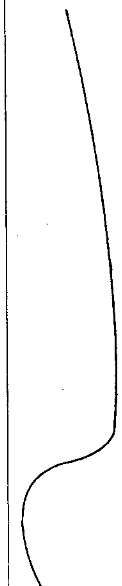
3.1. MORPHOLOGY.

The Jalingo Plain is characterised by a fewer number of residual massifs than the Zing Plateau. Moreover most of these hills are covered by a very thick sapprolitic mantle which in turn are covered by a colluvial layer, which can be followed far into the plains. The transition between hill slopes and piedmont plains is always made by a mooth, concave slope section.

3.2. STRATIGRAPHY.

In opposition to the piedmont plains on the Zing Plateau, the Plain of Jalingo can meanly considered as an erosional surface. An idealised profile is given in fig. 3. Essential stratigraphical elements are the stone-line floor with the overlying mantle and a formation, usually of alluvial origin, filling up an ancient channel in the central part of the valley. Vertic soil horizons can be present. An important number of observations in the field has shown that, going from the Zing Plateau in a westerly direction, the lateral extension of the Lama formation becomes gradually more restricted, occupying only the very central part of the plains west of the Lankaviri escarpment. The alluvial formation on fig. 3 is the equivalent of the Lama deposits on the Zing Plateau. The stone-line, which is the lateral prolongation of this meanly alluvial formation is therefore of the same age. The piedmont plains around Jalingo ressemble the pediment-peripediment complexes described by W.V.G. BALCHIN and N.PYE (1956). In spite of the rather complex evolution which could be traced on the Zing Plateau (table 1), the stratigraphy in the Jalingi plain renders only the possibility of establishing a rather simplified evolution sketch, consisting of the formation of a pediment-peripediment complex, followed by a phase of chemical weathering, contemporaneous

TABLE 1. - THE STRATIGRAPHICAL SUCCESSION ON THE ZING PLATEAU, ITS INTERPRETATION AND TENTATIVE CORRELATION WITH CAMEROUN

Stratigraphical succession	Erosion phenomena in the piedmont plains	Pedogenesis	Morphodynamics active - stable	Climat sec - humide	Tentative correlation with J.HERVIEU (1970)
Colluvial material in channels	- arroyo formation - development of vertic soil horizons vertical incision slope pedimentation				
Granite grit : homogeneous structure		pedogenesis : ferruginous tropical soil			
Granite grit : channel structures or granite pebbles					
	denudation of top of Lama formation : slope pedimentation ?				BOSSOUMIEN
		intense chemical weathering			PESKEBORIEN
Lama formation					DOUROUMIEN
	formation of badlands				PRE-
"earth-pillar" colluvium					DOUROUMIEN

with or preceding the formation of the granite grit mantle, overlying the stone-line.

4. POSSIBLE REASONS FOR THE QUATERNARY STRATIGRAPHICAL DISCONTINUITY IN THE STUDY AREA.

A certain relation exists between the morphology of the "inselbergs" and the lateral extension of the Lama formation : on the Zing Plateau, the latter has its maximal extension whereas the hill slopes are strongly denudated, fringes of a truncated sapprolite covered by a thin veneer of colluvia, only left on places protected by boulders and sound rock outcrops. To the contrary, in the Jalingo Plain, where the Lama formation is greatly restricted in extension, the hill slopes are still covered by a thick sapprolitic mantle. This indicates that the denudation of hill slopes, correllative to the deposition of the Lama formation in the plains, was much more pronounced on the Zing Plateau than in the Jalingo Plain.

An explanation of this phenomenon might be found in the fact that the Zing Plateau, protected by the Shebshi Mountains from the monsoon winds, receives markedly less precipitation than the Jalingo Plain. With H. RHODENBURG (1970), it can be accepted that morphodynamic phases must be identified with relatively drier periods, while slopes become more stable during wetter conditions. Accepting the possibility that a relative difference in humidity between the Jalingo Plain and the Zing Plateau was maintained during drier climatic pulsations, one could explain the stratigraphical difference between the two areas by a drier pulsation during the past, whereby rainfall on the Zing Plateau fell deeper below the supposed threshold value, delimiting the initiation of the degradation of the landscape. However, such explanation remains hypothetical.

The stratigraphical discontinuity, as found in the study area, can be followed farther to the south. Indeed, accumulation plains of the type found on the Zing Plateau can be observed at least as far south as Sugu. There, as previously mentioned, the top of the Lama formation seems to be intact in several places. Accumulation pläins, the Lama formation being the so called "Douroumien" sediments, were also found by J. HERVIEU (1970) in the territory of cameroun, east of the Atlantika and Mandara Hills. On the other side, plains characterised by the typical stone-line soil occur around Jalingo and can be followed to the south and the west, at least as far as Wukari. The Quaternary stratigraphical limit can be traced along the Lankaviri escarpment, along the eastern edge of the Shebshi Mountains and the plateaus in the south. At the foot of the Mambilla Plateau, this limit turns to the east, the Mambillas being covered by stone-line profiles, identical to these of the Jalingo plain, as shown by observations of A.W.S. MOULD (1960). There is also the fact that the accumulation plains are situated at a certain distance above the Benue River. In fact, these plains descend very slowly near to the Logone Basin. It is thought that the accumulation plains of the study area and its surroundings form part of the south-western corner of an old "Chad Basin", to which belonged the Upper and Middle Benue during Lower Pleistocene times, period during which the Lake Chad was in expansion (C. VOUTE, 1962).

5. STRATIGRAPHICAL CORRELATION WITH NORTHERN CAMEROUN AND OTHER AREAS.

The stratigraphy on the Zing Plateau can be compared with that of Northern Cameroun described bu J. HERVIEU (1970). Table 1 gives the correlations as can be deduced from the description. The author, mentioned here, identifies the morphodynamic periods with drier climatic pulsations. This is very often done by many workers. It should, however, be mentioned that climatic fluctuations are probably not always the factor which activate erosion. An example of the study area can be taken into account : here, two periods of erosion are situated after a phase of pedogenesis; the oldest period is the equivalent of the Bossoumien in Cameroun, the secund period occurs after the granite grit layer was spread out over the piedmont plains. In both cases, the erosion was preceded by the formation of a ferruginuous tropical soil. One of the characteristics of this type of soil is the development of a very porous poorly cohesive, oxidised A-horizon and an impermeable, illuvial B-horizon, which becomes in time very clayey (J. D'HOORE, 1964). The nature of this type of soil is such, that its A-horizon becomes gradually more susceptible to erosion. Therefore, erosion of the A-horizon after installation of this type of soil must not necessary be considered as the result of a climatic variation. Erosion of the A-horizon could be considered as a climax phenomenon following the formation of a ferruginous tropical soil and initiated by local factors. Therefore this type of erosion could make part of an always itself repeating cycle pedogenesis-erosion during one climatic cycle, favourable for this type of pedogenesis. For this reason, the palaeoclimatic evolution, given in table 1 is not strictly parallel to the oscillations of the morphodynamic graph. Only the important morphodynamic periods are considered as significant. By this method, the palaeoclimatic interpretation, based on the complex stratigraphy on the Zing Plateau becomes of the same type as that, which was deduced from the stratigraphy in the Jalingo Plateau.

None of the layers described in the study area are dated. This is a supplementary difficulty in making correlations with other areas. However, it was already stated by K. BURKE and B. DUROTOYE (1970) that the whole West-african sub-continent suffered under a dry climat during the period of the Würm glaciation in Europe. It seems probable that the Lama formation and the stone-line are from this period.

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ANNEX : DESCRIPTION OF LAYERS AS FOUND ON THE ZING PLATEAU.

1. This formation lies probably directly on the weathered bedrock. Its earth-pill r like remnants perche through more recent sediments. The upper part displays an accentuated lamination; laminae of coarse, rounded quartz sands and gravels alternate with fine bands (1-3 cm thick) of finer material. Below the laminated facies, often silicified on tops, the earth pillars are made of silty-clayey material. Micas or feldspars are note present. Earth pillars occur only within a very narrow belt along the activity at the foot of the hill slopes. Their morphological position and the sedimentation structures indicate a colluvial origin.

2. This formation fills up the entire plain. It can be followed from the foot of the hills to the centre of the plains. It consists of greyey and whitish material, varying in texture and structure. The colour is due to the presence of a kaolin clay matrix, englobing sands, gravels and pebbles, generally made up by angular quartz grains, subrounded granite pebbles and some feldspar gravels. Micas are not present. Dissecation cracks, displaying polygonal and columnar structures, are very common during the dry season. The sedimentation structures consist generally of shallow (1 to 2 m) and wide (10 to 20 m) channels, with well rounded pebbles having a diameter going from 1 to 20 cm at the base. These channels are filled up with the above mentioned very badly calibrated material, settlet in layers, 10 to 50 cm thick, parallel to the channel bottoms. The channels cut each other and they can often be recognised by a slight difference in colour, ranging from white to dark grey. However, many of these structures are nearly invisible due to the important kaolin enrichment, probably caused by the alteration of the feldspar gravels, still present locally, but being heavily weathered.

   The channels are generally directed to the centre of the valley. They are relicts of a breaded runoff system, connecting the hill slope with the central drainage line in the plain.

   This alluvial-colluvial formation achieves its highest-extent around Lama and is therefore called Lama formation.

3. A so-called granite grit layer, or its reworked remnants, can be found on some interfluvia in the plain, but especially near to the foot of the hills. This layer is composed of quartz, feldspar and mica sands and gravels, being the weathering product of the granitic rock outcrops on the hill slopes, and transported into the plains. An upper and a lower facies can be distinguished : the lower facies displays gully structures, forming a layer of 1 or 2 m thick. However, in many places this gully member is reduced to a stoney pavement of rolled pebbles, separating the underlying Lama formation from the overlying upper facies. The latter displays a homogeneous structure, only interrupted by sparse discontinuous quartz gravel lines.

   This granite grit layer, and especially its upper part, can sometimes be followed over the basal concavity to the hill slope, where it is interrupted by solid rock outcrops, and where it can not always be distinguished from thin sapprolitic soils. Where it occurs on hill slope sections, it contains, or lies at the base of, granite boulders. The granite grit layer also occurs on the interfluvia in the plain, but its thickness is most times reduced to a thin veneer of some centimeters. Its presence there prooves that the plains were once smooth graded surfaces, entirely covered by the stratigraphical unit described here and incised afterwards.

   The granite grit layer can easily be distinguished from the Lama formation by its typical red-brown colour, caused by chemical destruction of the silicates.

4. Arroyo cuttings, incising older valleys, show that the latter are filled by sediments, consisting of quartz and feldspar gravels and sands, mica blades, the whole being englobed by a clay matrix. Parallel to the channel bottoms occur horizons, 5 to 20 cm thick, alternating in colour (black and dark brown grey), and displaying polyedric dissecation cracs. The black horizons are considered as topomorphic vertic soils and occur mostly in a superposed sequence of three or four. Every horizon is separated from the other by a layer of brown or grey, less fissured material. The bad calibration of these channel deposits and the angularity of the gravels indicate that the layers in which these vertic soils are developed, have a colluvial,rather than an alluvial origin. The filling up of the channels is probably a rather recent feature, resulting from colluviation processes at the moment that the channels in question become gradually more badly drained.

5. Subactual granite grit accumulation occurs at the foot of the hill slopes as well as in the above described channels. This layer can attain a thickness of some decimetres and can generally be subdivided into two syblayers. The lower one displays undulating or subhorizontal lamination indicating transport by a diffuse sheet of water runoff. The upper sublayer consists mainly of homogeneous granite grit and its thickness generally does not exceed 50 cm.

Communication présentée à la séance du 20 janvier 1976