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A REVIEW OF GEOMORPHOLOGICAL RESEARCH IN SHABA (ZAIRE) FROM 1961

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RESUME

Au Shaba, les recherches géomorphologiques ont principalement eu pour objet, outre la géomorphologie régionale : a) les phénomènes actuels : action des rivières et du ruissellement aidé par l'intervention des termites et de l'homme (feux de brousse et pâturages)
b) l'étagement des terrasses et des surfaces d'aplanissement, interprété dans le cadre des variations climatiques survenues au Quaternaire et au Tertiaire.

ABSTRACT

Geomorphological research in the Shaba region have been mainly dealing with two kinds of phenomena (in addition to regional geomorphology) :
a) present-day erosion and deposition made by rivers and overland flow helped by termites and by man (grass burning and cattle tracks)
b) stepped terraces and erosion levels explained by Quaternary and Tertiary climatic oscillations.

In spite of the often difficult circumstances, much geomorphological research has been carried out in Shaba (the former Katanga Province) over the last sixteen years. At least 15 papers, more or less directly related to geomorphology, have been published between 1961 and 1977.

This research is principally by J. ALEXANDRE and S. ALEXANDRE-PYRE, who, individually or in collaboration produced the vast majority of the works (11 out of 15) which will briefly be analysed in

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the following in a chronological order of publication.

Following a thesis (1960, unpublished) on the Geomorphology of the Dipompa Mountains (Fig. 1), MAMMERICKX published in 1961 a photo-geological map and description of this appalachian-type region. Peripherally, the ranges have been subjected to differential pedimentation which has bevelled the softer rocks, leaving the harder ones as inselbergs.

ALEXANDRE and ALEXANDRE-PYRE (1961), in a study of the entrenched meanders of the fluvial basin of the Middle and Upper Lufira, demonstrated the adjustment of the stream to structure. Though the Shaba schists seldom contain more than a small proportion of non-schistose rocks, the schistosity is sufficiently well developed to develope selectively an entrenched meander extension in a direction perpendicular to that of schistosity. Moreover, numerous rectilinear sections and angular bends reflect the influence of joints and sometimes of bedding planes in determining the position of these tropical streams.

In several cases a suction effect of the main stream by tributaries is observed. This phenomenon occurs, firstly, when the competency of the tributary is markedly inferior to that of the main stream and, secondly, when the tributary has sufficient power to adapt its longitudinal profile to that of the main stream.

Some meanders have appeared during the incision (ingrown meanders) while, in other cases, they have progressively entrenched the substratum. Because of the disparity of dimension and form of valley and river plain meanders, it is improbable that in Southern Shaba the first type is derived from the second.

In a later study of the Lufira and the Upper Lualaba, ALEXANDRE (1962) again describes the various factors of river development.

With regard to the valley meanders, progressive entrenchment into less and less weathered rocks has involved a weak oblique erosion in the softer rocks, lateral erosion in rocks of medium hardness and a negligible action in hard rocks.

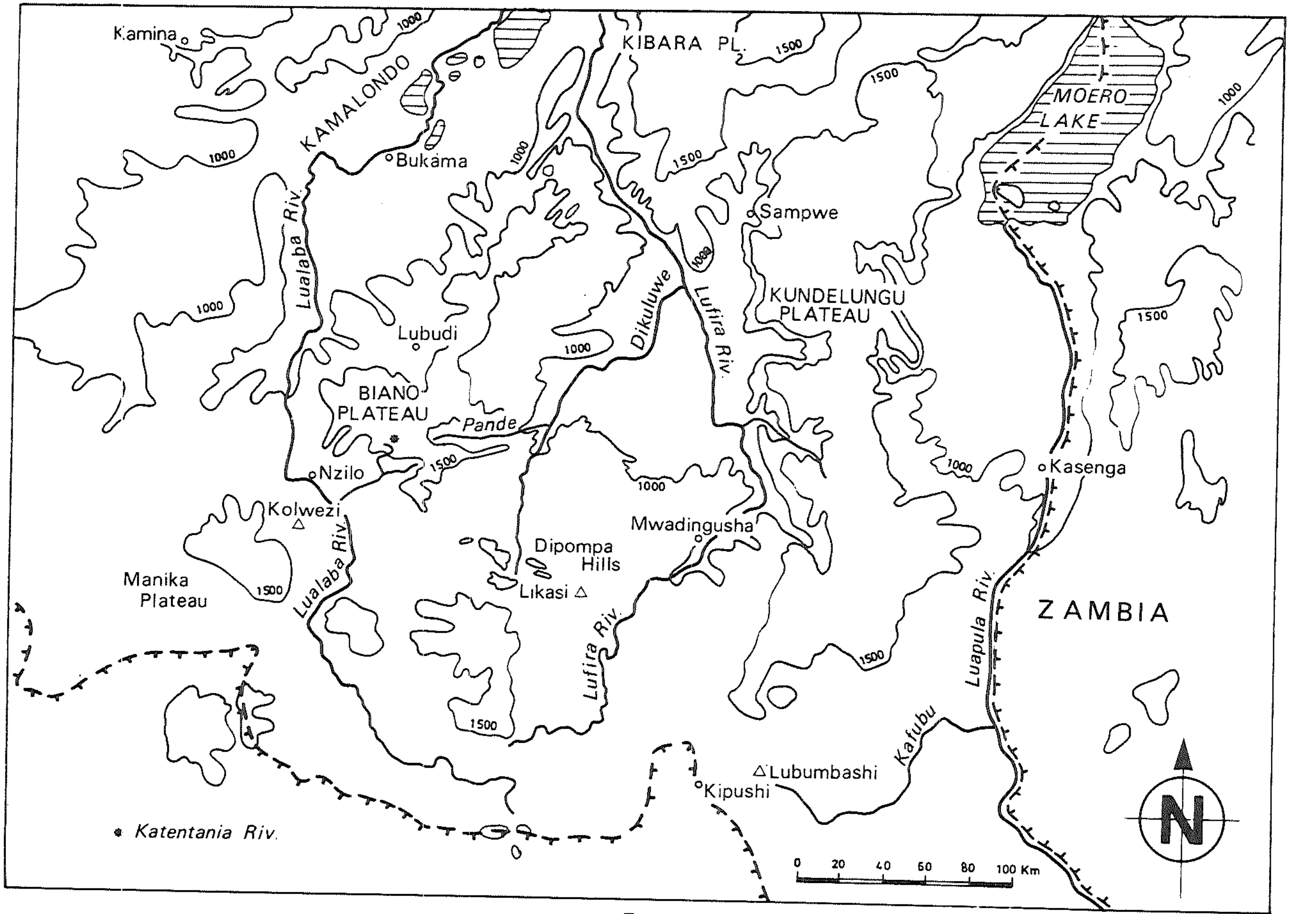
Kamina
KAMALONDO
Bukama
KIBARA PL.
MOERO
LAKE
Sampwe
KUNDELUNGU
PLATEAU
Lualaba Riv.
Lubudi
BIANO
PLATEAU
Pande
Dikuluwe
Lufira Riv.
Nzilo
Kolwezi
Kasenga
Mwadingusha
Dipompa
Hills
Likasi
Manika
Plateau
ZAMBIA
Luapula Riv.
Kafubu
Lubumbashi
Kipushi
Katentania Riv.
1000
1500
0 20 40 60 80 100 Km
N

Fig. 1

With regard to the free meanders, these become established in the bedrock once they have swept away the more or less altered cover. They gradually adapt themselves to the structure, specially by extension normal to schistosity or in angular patterns determined by joint sets. These meanders are frequently of complex development. For instance in the Kando river, three generations of meanders can be observed, which may be related to progressive stages of decrease in discharge. At each stage, adjustment to the new discharge is thought to have taken place along an inherited form which has been partly maintained due to the anchoring of old bends.

It seems that under the present climate, vertical erosion is practically non-existent (except in the particularly soft-rock areas); similarly, lateral erosion is strongly inhibited. Fluvial landform development in the modern humid phase seems to have been concentrated at its inception.

In general, the meander trains of the Lufira and the High Lualaba possess a wave-length which is proportional to the area of the drained surface. However, though the Lualaba has meanders which have the shape of basket handles, and which migrate slowly downstream, the Lufira has long transverse meanders, which migrate rather quickly. As the average discharge of the two streams is similar, it is the load which seems more particularly to influence the meander behaviour: the Lufira has an extremely low solid discharge, but the Lualaba has a significant traction load.

Moreover, the horizontal bends of the streams seem well adjusted to vertical oscillations of stream flow and an appreciable vertical amplitude corresponds to a wide meander zone. In fact, these conclusions agree with established theory on the helical discharge of streams. This type of discharge seems particularly well developed in narrow, deep channels (as in the case of the Lufira) while an aborted form appears in broad shallow streams (as in the High Lualaba).

In a phytosociological study of the alluvial plain of Middle Lufira, STREEL (1963) has discussed the relationship of vegetation, soil and relief. As in the work of STREEL-POTELLE (1959) and of MAMMERICKX (1960), the wide surfaces bordering the Lufira are interpreted as pediplains. These impinge against scarps or inselbergs which have been shaped by fluvial systems. Below the high ground, main streams fragment into multiple rill systems and eventually degenerate into what is effectively no more than a sheet-wash system which removes from the surface any fine rocky fragments, so progressively smoothing and levelling the surfaces. In this way the slope of the pediment gradually decreases from 6 to 0,7%

In 1964, ALEXANDRE and ALEXANDRE-PYRE summarized their observations on rain-wash phenomena in Southern Shaba.

In woodland conditions, the soil is protected by a triple screen : 1) trees with their typically rather thin discontinuous foliage; 2) grass, which is seldom more than 1 m high; the whole of this cover represents less than 25% of the ground surface though there is increased protection when the stems are bent; 3) mosses, algae, some vascular plants or, locally, a thin bed of dead leaves also protect the ground.

In these conditions, only on slopes of at least 15° do the first indications of incision appear. But in farming areas, rills can appear on 3° slopes. Grazing by livestock reduces the protective effect of vegetation especially along cattle trails and destroys the soil structure. Erosion increases especially when the discharge is fast enough to transport the sand and fine gravel which operate as erosional agents. On the other hand, if a valley slope decreases, coarse elements settle and make a pavement which inhibits vertical cutting.

It has also been observed that incision is retarded by the colonisation of vegetation in the rills. Certainly the growth is favoured by an additional moisture in the dry season.

The persistent sheet flooding in rainforest conditions which leads to a concentrated system of rills does not produce a similar effect in savanna conditions, because the competency of the stream flow is much diminished by the grass. The mean maximum speeds measured are about 0,50 m/sec on a slope of 3°. It seems, following experimental hydrological studies, that a minimum speed of 0,70 m/sec is necessary to start vertical erosion.

ALEXANDRE and ALEXANDRE-PYRE concludes that, from a geomorphological point of view, (owing to the almost complete lack of vertical cutting due to rain wash) savanna is radically different from rain forest and steppe.

The Biano Plateau has been studied in depth by ALEXANDRE-PYRE in doctoral work (1965). The part dealing with the peripheral areas was published in 1967 and the study of the plateau itself in 1971 (vide infra).

With a view to the study of the erosive power of rain wash on low woodland slopes (max. 2 to 3°), observations have been made by ALEXANDRE (1966).

When early fires (i.e. less than 2 months after the last rain has fallen), the soil protection by unburned grass, fresh vegetation and dead leaves is very efficient. The few traces of erosion observed are localised where forest litter is easily removed by running water.

In places burned by late fires, clear evidence of erosion is observed, for example the pitting in areas of relatively soft soil or the exposure of roots.

No erosive marks can be observed on unburned spots, except where soil have been brought to the surface by burrowing animals, principally by the termites.

It is extremely difficult to make a precise estimate of the soil volume excavated by the termites, especially as each kind of termite seems to use selectively a specific size of soil particle. For example, Cubiterm mounds are more than usually rich in coarse sands. On the other hand, according to SYS (1961), *Macrotermes falciger* enriches the soils in clay minerals in a proportion from 7 to 50%.

Part of this clay fraction is later removed when diffuse rain wash preferentially transports from the surface all grades below 20 microns.

The results of ALEXANDRE-PYRE's researches into the geomorphology of the peripheral areas of Biano Plateau were published in 1967.

The Pande Depression is formed from 2 flats : an upper, 13 km long with an average slope of 1% and a lower, about 30 km long with an average slope of 0,5%. The hypothesis of a graben-like origin of this area, as suggested by LEFEVRE (1953) and RAUCQ (1954), is rejected for several reasons : 1) other slopes as steep and as high as those bounding the depressed area are observed elsewhere in the region in many other tectonic directions; 2) at the foot of the scarps, the forms interpreted as alluvial fans by LEFEVRE are, in fact, fan-shaped bedrock outcrops covered by a thin bed of sediments; 3) the geological succession and the thickness of the beds are the same as in other parts of the plateau.

The slopes of Pande Depression are compounded of 3 elements :
a) an approximately 30 m-high scarp whose slope is always steeper than 60°. This scarp is an outcrop of arkosic sandstones of the Upper Kundelungu formation (Ks_3) and it retreats by undercutting of the underlying schistose rocks.
b) a dissected zone which has an alternation of furrows and ridges (each about 100 m wide). The mean longitudinal slope of the dissected zone is approximatively 30°. The furrows and ridges are formed in the shales of the median formation of the Upper Kundelungu formation (Ks_{22}).
c) a glacis of generally concave shape inclined at between 18° to 2°, also cuts across the Ks_{22} and is covered by deposits the thickness of which rarely exceeds 3 m.

The upper part of the glacis has a mean slope of 12°. Big termite mounds are present on this slope, usually at a density of 4-5 per hectare. A silty cover related to termite activity overlies a thick stone-line made of sandstones, quartz pebbles and shales fragments, which is about 50 cm thick.

The gullies of the dissected zone extend into the higher part of the glacis but they extend laterally in a U shaped form and are not usually deeper than 2 m.

The median part of the glacis has a mean slope of 5°, and has a cover about 2 m thick mostly made of shaly wastes, whose fragments are not usually larger than a few cm in diameter. These fragments are usually sub-rounded and relatively well-sorted. Channels on which branch tributary gullies are rather more deeply incised (about 5 m). The bottoms of these channels are filled by grey or black clayey silts, which are related to a very wet climatic period. This latter deposit is locally incised by modern fluvial activity.

The lower part of the glacis has a 2° slope. Present day deposits are very thin. The deep channels from above continue into this part and widen out.

To summarize, there is evidence of four climatic periods in the glacis gullies : 1) a steppe climate, probably rather cool and responsible for the deposition of the shaly materials, some of them possibly even resulting from congelifraction; 2) a transition climate characterised by the appearance or the deepening of the channels; 3) a wet climate which has caused the erosion of the higher deposits and the infilling of the gullies below by fine sediment rich in organic matter; 4) a modern transitional climate characterized by renewed river incision.

In addition to rectilinear slopes, some hollows due to spring action and structurally controlled flats are locally observed.

The lowest part of the Pande Depression has been shaped by 2 types of planation process. First, a preliminary weathering phase in a wet climate, then a steppic phase, during which thin wastes are carried away by diffused rain-wash or sheet-wash. Thus planation surfaces are formed both by weathering and ablation.

In the Lubudi region there are multiple planation surfaces and also 3 cuestas formed by the Kiubo (Ks_{21}), the Kanianga (Ks_{122}) and Lower Kundelungu (Ki_2) sandstones respectively.

Erosion surfaces are also present in the western part of the Biano Plateau, but there is also an appalachian-type topography, the ridges of which are made of quartzites or quartzophyllites.

According to ALEXANDRE-PYRE, the conditions to the development of piedmont planation surfaces are : an area with a bedrock which is not very hard, located below a fairly steep slope with quite numerous and more or less parallel gullies. The gullies provide coarse waste which produces a pavement which inhibits vertical down cutting. It is then that the main erosional process of the glacis formation, i.e. lateral planation, is at the most efficient. The slopes of the gullies as well as those of the glacis are essentially controlled by the dimension of the transported products.

The supply of coarse waste implies a climate when there is only limited chemical weathering and important flash flooding, i.e. a steppic-like climate. A wetter climate causes a new vertical incision. However, a very wet climate produces a sedimentation of gully bottoms and a quick return to significant chemical weathering.

The piedmont surfaces extend from the spring zone downwards and the planation surfaces by weathering and ablation upwards from the main streams.

Planar surfaces produced by ablation can be formed on any bedrock, even the hardest, inasmuch as all rocks are affected by strong weathering here.

The slopes of planar surfaces produced by weathering and ablation are always quite smooth (maximum 2°). On the other hand, the slopes of the glacis are generally steeper, from 2 to 18°.

In another study on the origin and conservation of piedmont glacis in tropical regions, ALEXANDRE-PYRE (1969) points out that the physical development of the glacis is often only a rejuvenation of similar older forms. In all regions studied by this author, the glacis are found beneath planation surfaces formed by weathering and ablation. Glacis continue to grow larger because the slope underneath a planation surface becomes steep enough and high enough to provide the coarse elements for the pavement.

A comparative study of the alluvial deposits belonging to the river-systems of the Upper Lualaba (Zaïre), the Kafue (Zambia) and the Sabi (Rhodesia) has been published in 1969 by ALEXANDRE-PYRE and SERET.

Two types of alluvial covers are present there :

1) deposits of a steppic-like phase representing a climate which is much drier than the present. The sorting of river deposits is moderate. Deposits contain less than 1% of pebbles among which are friable materials such as shales. Colours are generally pale and acquired before transport as they impregnate the grains of thin deposits. The bedding, inconspicuous except in some lenses of coarse sediments is, however, sufficient for the deposits to be recognized as being of fluvial origin.

2) deposits of a climate wetter than that of today. These sediments are better sorted, generally finer (usually clay to fine sands) and dark coloured whether yellowish-brown (owing to ferruginous compounds) or grey or black owing to the presence of organic matter.

River flood plains have been formed by sedimentation either during a dry climate when the discharge has been low, or during a wet climate when vegetation has trapped the sediment. The modern climate is considered to be an intermediate type without sedimentation but with vertical down-cutting by the rivers.

ALEXANDRE-PYRE and SERET found in all 3 river-systems evidence of climates both drier and wetter than that of the present. However, in southern regions, wet phase deposits are less important. In Zambia and Rhodesia, hillside-wastes are more important than river deposits reflecting the greater aridity of these areas when compared to Shaba region.

ALEXANDRE and ALEXANDRE-PYRE (1970) distinguished 2 types of planation surfaces in Upper Shaba.

1) Erosion glacis or piedmont glacis, located at the foot of the high plateau slopes. This type of glacis has been described in depth by ALEXANDRE-PYRE (1965, 1967) in the areas around the Biano plateau.

It has been noted that the glacis slope is controlled by the flow competency. In the upper part, a 18° slope corresponds to 40 cm-long cobbles while the 2° slope of the lower part corresponds to a maximum of 3 cm-long pebbles.

The glacis appears to be made of coalescing fanshaped rock outcrop with a thin cover formed during the extension of gullies.

Dispersion of coarse sediments could only take place in areas which have a sparse cover of vegetation. The presence of friable shale pebbles in the deposits implies a moderate chemical weathering. Thus the erosion glacis appears to be inherited from drier steppic-like climatic phases.

According to COTTON (1955) the term pediplanation can be given to the whole range of processes which lead to the formation of these piedmont glacisses.

2) Summit planation surfaces, which are generally less well graded than the piedmont glacis and are locally dominated by residual hills. These have steep slopes from 20° to the vertical in crystalline rocks and up to 50° in strongly-dipping sedimentary rocks. However, true cornices are absent. At the foot of residual hills, the slope is about 4° but the planation surfaces themselves have slopes which are nearly everywhere lower than 1%.

Coarse sediments have not been observed on the surface, but, beneath a silty cover about 1 m thick, there is a stone-line composed of fragments from about a few mm to a few cm in diameter.

This stone-line, which is about 30 cm thick, represents the residue of the progressive accumulation of numerous layers of weathering products, the lower grades of which were subsequently eliminated. Coarse fragments which could not be carried by rain-wash have simply been left in situ, thus making a pavement. Termites and other burrowing animals have brought to the surface fine soil particles which are partly dispersed by splash and rain-wash and partly exported to streams. As ALEXANDRE (1966) had already noted, after the consolidation of the materials consequent upon the desertion of the termites galleries, soil is finally at a lower absolute altitude in spite of the local accumulation.

The planation surfaces are shaped by the combined action of an earlier weathering and the removal of weathered products by different processes. On the very smooth slopes, of about 1°, erosion is mainly accomplished by diffuse rain-wash. This is only very efficient when a sparse vegetation is present, i.e. with a steppe-like climate.

After W.M. DAVIS and COTTON, the term of peneplanation can be given to the whole of the processes which eventually lead to the formation of these summit planation surfaces.

A climate drier than that of the present is favourable as much to pediplanation due to lateral planation on glacis than to peneplanation due to diffuse rain-wash on already flattened summit surfaces. On the other hand, a wetter climate favours the weathering which inhibits the process of pediplanation but which promotes the waste decay which results in the most perfect type of peneplanation.

The Biano Plateau studied by ALEXANDRE-PYRE (1965, 1971) is made of 3 main planation levels (1575-1595 m, 1605-1625 m and 1640-1650 m). These represent together more than 90% of the plateau surface. The plateau is generally covered by a sand layer, which is usually less than 15 m thick. If we disregard the valley-sides, slopes on the plateau never exceed 4%. Granular laterite concretions, residual pebbles and boulders of sandstones ("grès polymorphes") are sometimes seen with the sand cover, both at the surface and in the sand mass.

Its sedimentological properties suggest that the sand cover has been deposited by rivers similar to the modern Tchad or Ngami. The regional trend of the coarsest sand grains, 420 microns at both Biano and on Kamina Plateau (BEUGNIES, 1950) but only 300 microns at Kwango (L. CAHEN, 1954) seems to indicate that the accumulation extended progressively northwards.

The undulating sand deposits on the high surfaces are interpreted as the result of a redevelopment of the form of transverse dunes shaped by a NNE or SSW prevailing wind.

In conclusion the sedimentological details of the Biano sands show that a final reworking due to rain-wash (or even probably to sheet-wash) affected the superficial sandy deposits.

The term "ochre sands" is only justified in the Biano Plateau when referring to a peculiar pedological development which has no particular stratigraphical significance. According to ALEXANDRE, the ochre colour is probably due to the "pectisation" or even the crystallisation of ferrous solutions when the evapotranspiration of grass eliminates more or less completely the capillary soil water.

The pisolitic laterites would be formed in sands at the limit of an upper dried ochre horizon and of a lower wet red horizon. These conditions are realized under a savanna climate when there is a high enough ground watertable. The ferricrete seems to develop under a slightly wetter climate or in less well drained locations.

It seems that the "Polymorphic" Sandstones of the Biano Plateau are of multiple origins. Some are silicified limestones, which have fossils belonging to the Polymorphic Sandstones series, whose outcrop is now much dissected by erosion. Others are chalcedonic sandstones formed in cover sands.

On the highest surfaces, the presence in some cases of granular laterites and ferricretes and in others of ferruginous skins gives some evidence of a succession of climates, at some time much like the modern one with grass vegetation and at others of arid type. Since the ferricretes are only covered by a pale suture free coating, the 1575-1595 m surface was presumably formed in only one dry phase. In contrast, as ferricretes with a sutured inner dark coating, a few mm thick, and superficial pale-coloured outer coating are present, the higher surfaces must have experienced at least two arid phases.

The fact that these coatings, which are typical of desert origins are not found below the 1575 m surface seems to prove that a major climatic change occured. By analogy with the climatic evolution of non-tropical regions, this can be referred broadly to the change from the Tertiary to the Quaternary.

ALEXANDRE-PYRE thinks that the highest surface (1675-1700 m) is probably mid-Tertiary, whereas the 3 main surfaces (1575 to 1650 m) are probably late-Tertiary. The actual shaping of the surfaces would mainly be due to the action of surface rain-wash induced by heavy rain in a steppe-like environment.

The landform study in the valleys of the Biano Plateau and their deposits permits a distinction to be made in the climatic evolution of the Quaternary of the region into following successive phases :
1) an accumulative phase under a steppe-like climate; this being substantiated by plant fossils, granular laterite concretions, braided streams, bright-coloured sediments and a lack of true soil-humus.
2) a phase of vertical down cutting (and, locally lateral erosion if there has been a pavement) under a transition climate similar to that of the present day.
3) further accumulation under a climate wetter than that of the present with fine grained deposits, much humus and an abondance of valley-side wastes. During that phase, all the valleys were probably covered by rain forest from which are derived the present day riparian forest. In contrast, the plateau which is covered by sand was occupied by a grassland wetter than the modern one.
4) a new phase of vertical downcutting under a transition climate which begins in a new geomorphic cycle.

From a chronological point of view, at least four distinct Quaternary stages can be established in the Katentania valley. The first stage is related to the Tertiary/Quaternary climatic change, but human artefacts have not yet been found. The second stage is dated as the end of the Earlier Stone Age, i.e. a few hundreds of thousands of years. The fourth stage corresponds to the Middle Stone Age (about 30.000 B.P.).

RAUCQ (1969) in his report to the Académie des Sciences d'Outre-Mer (Bruxelles) on the study of the Biano Plateau emphasizes the tentative character of some statements by ALEXANDRE-PYRE, such as the climatic change at the Tertiary-Quaternary boundary and the southerly derivation of the sandy river deposits covering the plateau. Moreover, according to RAUCQ, the coating of the sandstones and the eolian reworking of the cover-sands could already have taken place under a climate characterized by an alternation of long dry seasons and short wet seasons.

Otherwise, RAUCQ again offers some evidence in favour of a tectonic origin for the Pande depression. He emphasized the fact that the presence of gypsum beds implies an upwelling of deep mineralising waters along faults that bound the depressed area.

MORTELMANS' (1969) analysis of ALEXANDRE-PYRE's thesis examines whether the fragments of the uppermost surfaces of the Biano Plateau (1675-1700 m) are a truly discrete surface or, rather, remnants of the 1635-1650 m surface, uplifted to the east of a NS fault, as suggested by an aerial photographic interpretation. Consequently, he doubts the supposed mid-Tertiary age of the highest planation surface.

Moreover, MORTELMANS points out that between the surfaces considered as end-Tertiary by ALEXANDRE-PYRE and the river terrace dated as Acheulean (about 60.000 years B.P.) in the Katentania valley, is inserted only the highest river terrace, that refered to as representing the change between the Tertiary and the Quaternary. MORTELMANS thinks that the main event in the geomorphological evolution during the Quaternary has been the separation of the Shaba High-plateaux due to the carving of Lofoi and Kamalondo depressions. Thus the present river system of the Biano Plateau probably did not originate until the Middle Pleistocene following the headwards erosion of the streams flowing into the large depressed areas.

In spite of all the geomorphological research already carried out, much remains to be done, especially in the scope of quantitative geomorphology. ALEXANDRE and ALONI (1972) have analysed the methodology for slope study in a tropical environment.

The main subject of the project is to be a study of areal surface wash including diffuse rain-wash to sheet-wash. Apart from static observations on topographical forms and superficial deposits, a study of the dynamic aspects of the phenomena is also necessary. In particular, the part of various factors (vegetation, soil surface, soil sequence, action of burrowing animals etc.) having an influence on the wash must be quantified.

The action of the rain-wash itself must be measured during rainfall conditions with guide marks and gauges.

In 1974, STERCKX published a geographical study of the Ruwe-Kolwezi region, based principally on an analysis of aerial photographs. With regard to the geomorphology, a 1 : 100.000 map shows the main structural units and the major landforms. This map is only descriptive but it leads to a subdivision of the area studied into 3 zones :

a) sand covered plateaux occupied by "dilungu" (herbaceous steppe-like vegetation);
b) undulating surfaces covered by "miombo" (woodland);
c) stronger relief covered by discontinuous miombo.

ALEXANDRE (1974), on the basis of observations along the Lufira river at Mwadingusha, and the Lualaba river at Nzilo and at many other places, describes the various erosion processes acting on rapids under different tropical climatic conditions :

a) limited corrosion and block removal in a hot and humid climate in a rainforest or a dry deciduous forest environment;
b) abrasion and polishing by pebbles and possibly also sands become the main processes in a drier climate in a savanna environment;
c) erosion is completely reduced under dry climatic conditions with a steppe environment, but if the rapids are buried by sands, some corrosion of the bedrock takes place.

The processes occur on rapids situated downstream from a quiet reach, but other conditions which bring more pebbles will favour abrasion and polishing action.

ALONI (1975) has studied the morphological evolution of big termite mounds in Upper Shaba. The erosion of the *Macrotermes falciger* mounds, could bring a layer 6 to 25 cm thick of fine material to cover the stone-line generally found in the soils of the region. During a first stage, the parts of mounds not yet covered by vegetation are dried up and then attacked by splash and are partially destroyed by collapse. In a second stage, the termitaries, while entirely covered by vegetation are eroded by sliding which occurs mainly on steep flanks. Finally, mounds which are completely abandoned by termites are progressively reduced by diffuse rain-wash and splash.

As is obvious from the observations on mounds built on 4 different types of soil, the *Macrotermes falciger* termitaries have forms which depend mainly on the mechanical properties of the external layer.

At the end of this short review of the recent geomorphological research in Shaba, it appears that substantial progress has been realized in the study of planation surfaces (glacis, pediplain, pediment, peneplain), stream pattern, evolution of rapids and falls, evidence for Tertiary and Quaternary paleoclimates and on the role of the termites and other burrowing animals. Promising studies have also been initiated on processes of rain-wash as well as interrelations between relief, vegetation and soil. Finally, preliminary geomorphological mapping surveys have been carried out.

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