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THE SUPERFICIAL PLEISTOCENE FORMATIONS IN THE RUZIZI PLAIN (Zaïre, Burundi, Rwanda). ANALYSIS OF HEAVY MINERALS

Les formations superficielles pléistocènes de la Plaine de la Ruzizi (Zaïre, Burundi, Rwanda). Analyse des minéraux denses.

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RESUME

L'étude exploratoire des assemblages de minéraux denses des formations superficielles de la Plaine de la Ruzizi est faite dans un but de caractérisation lithostratigraphique. Les associations minéralogiques sont principalement constituées par les amphiboles vertes, les paramétamorphiques (surtout la sillimanite et la staurotide), la tourmaline, l'épidote et les grenats. Ces minéraux trouvent leur origine dans le Précambrien constituant le soubassement de la région. Leurs différents types d'association font plus ressortir les particularités lithologiques des bassins versants qu'un ordre lithostratigraphique.

ABSTRACT

The assemblages of heavy minerals of the superficial formations in the Ruzizi Plain has been examined with regard to their lithostratigraphic characterization. The mineral associations consist mainly of green amphiboles, parametamorphics (mainly sillimanite and staurolite), tourmaline, epidote and garnets. These minerals originate from the Precambrien basement of the region. Their different types of associations emphasize the lithological particularities of the watersheds rather than a lithostratigraphic order.

INTRODUCTION

In an article awaiting publication, ILUNGA and PAEPE describe the Quaternary deposits in the Ruzizi Plain and put forward a lithostratigraphy based essentially on textural characterization and sedimentary structures, described in detail by ILUNGA (1984).

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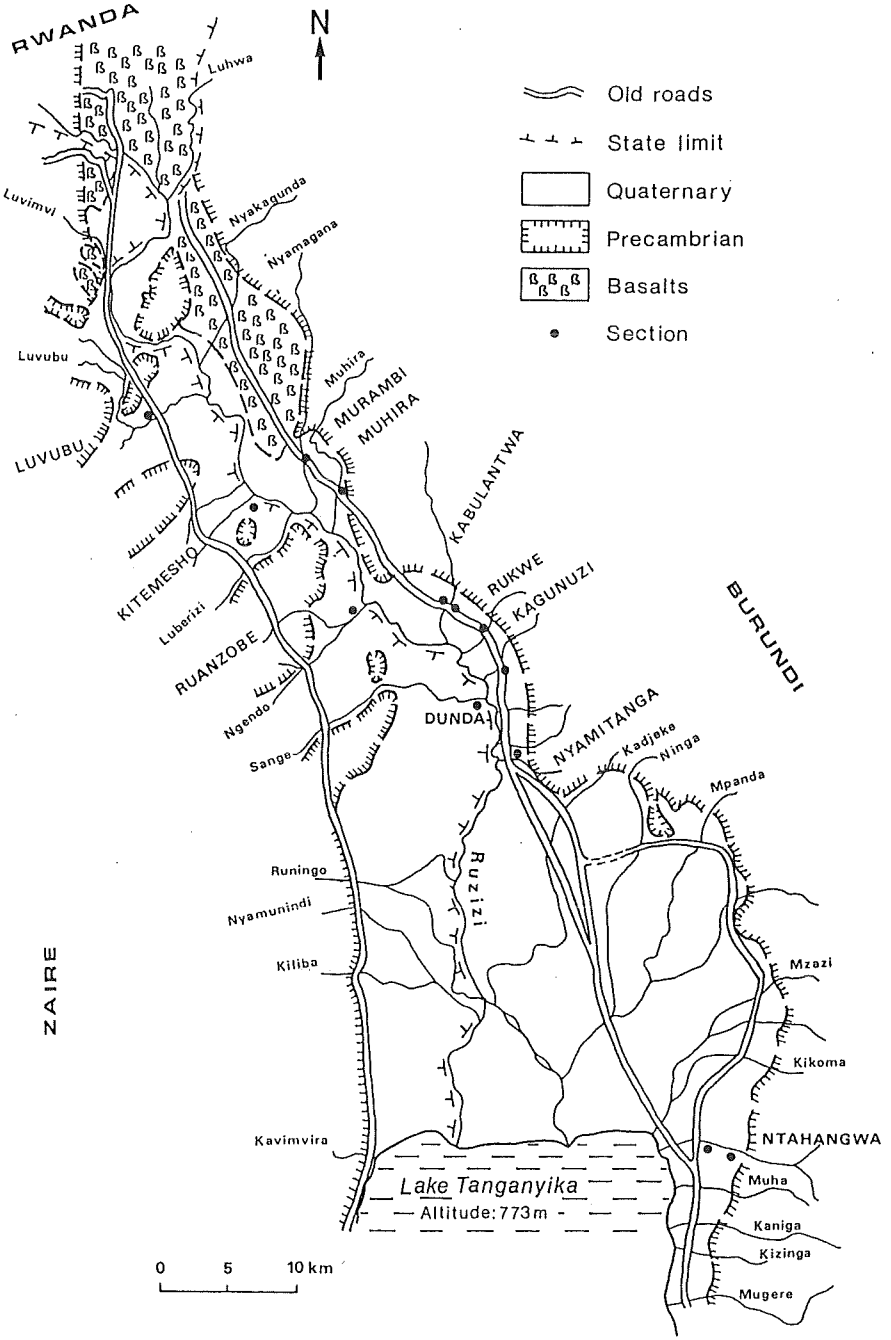

Fig. 1 : Situation map with geological outlines

The present paper reports the findings of an exploratory analysis of heavy minerals assemblages in these Formations to see if they constitute a lithostratigraphic criterion.

A non-systematic sampling was performed on all the Formations recognized but the lateral variability of mineralogical associations in the Bwegera Formation was tested on account of its geographic extension.

Our study covered the sand fractions comprised between 60 and 300 µm.

GEOMORPHOLOGICAL AND GEOLOGICAL CONTEXT

The Ruzizi Plain (fig. 1) is part of the Western Rift of Africa and is situated in the prolongation of lake Tanganyika (alt. 773 m) over a distance of 70 km. It is limited to the east and west by horsts in Precambrian formations and to the north by Neogene basaltic flows (PASTEELS, pers. com.).

Table I : Lithostratigraphie of the Ruzizi plain deposits

Probable age	Lithostratigraphy	
HOLOCENE	KADJEKE F. KAMANYOLA F.	RUKOKO F.
UPPER PLEISTOCENE	NAOMBE F. GIHUNGWE F.	TSHAMATE GROUP
LOWER TO MIDDLE PLEISTOCENE	LUVUNGI F. BWEGERA F.	
LOWER PLEISTOCENE	CIBITOKE F. MUHIRA F.	

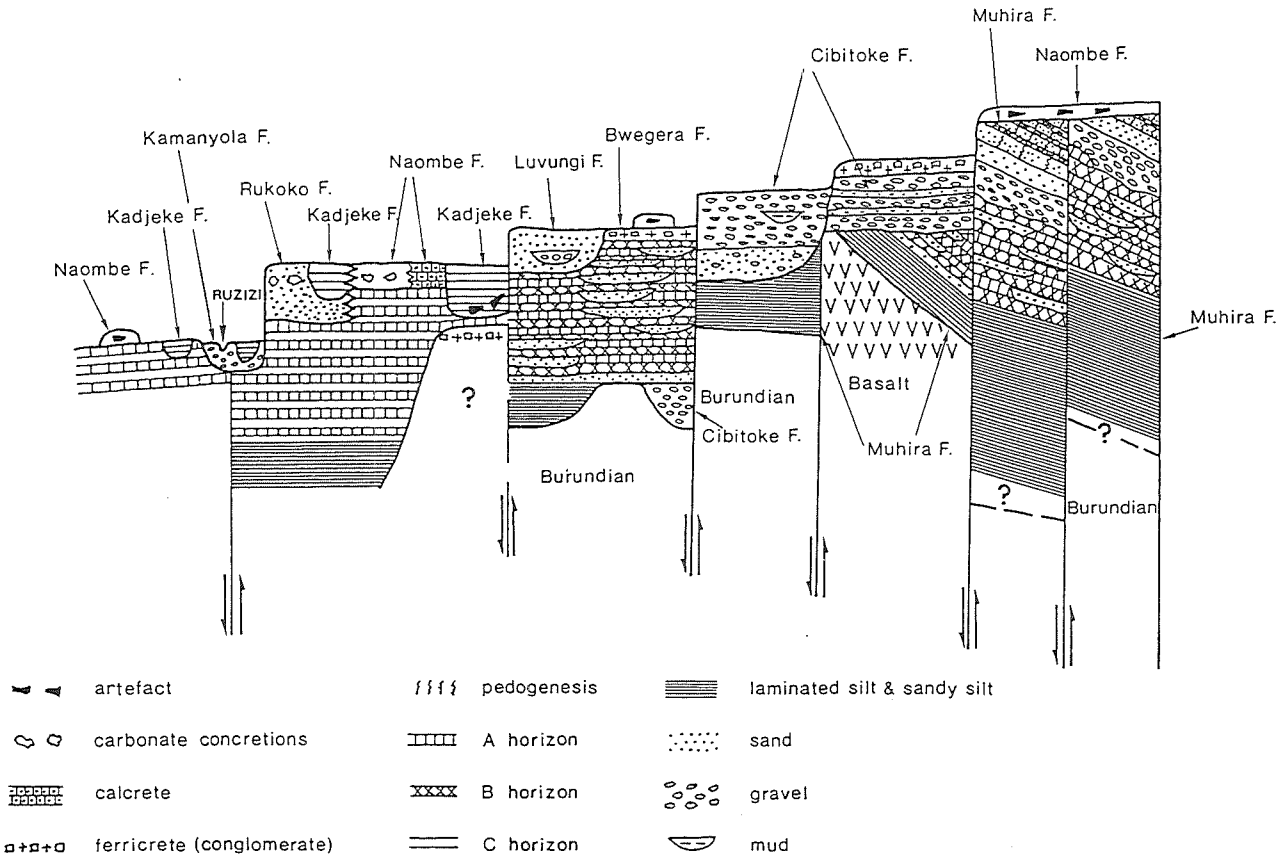

Fig. 2 : Lithostratigraphic schema.

In the region of Rugombo, these basaltic flows are interstratified in loose deposits of graben filling, indicating that the latter is at least 5.7 million years old in this region. Elsewhere BELLON and POUCLET (1980) dated a basalt of the island of Idjwi at 49 million years, implying that the Rift has existed since the beginning of the Tertiary and one can therefore consider that sedimentation in the Ruzizi Plain is as old. It is therefore hardly surprising that a gravimetric analysis reported the depth of the Cenozoic sediments to range from 1500 m to 2000 m in the lower plain (YZQUIERDO, 1960).

ILUNGA and PAEPE (op. cit.) identified a dozen lithostratigraphic Formations in the upper part of these sediments, wich are, from the oldest to the youngest, the Muhira and Cibitoke Formations, the Tshamate Group comprising the Bwegera, Luvungi, Gihungwe and Naombe Formations) the Rukoko, Kamanyola and Kadjeke Formations (Tab. I and fig. 2). Two additional Formations were reported in the coastal region of Bujumbura : the Ntahangwa and Bujumbura Formations whose facies suggest correlations with, respectively, the Muhira and Cibitoke Formations. The Kamanyola and Kadjeke Formations of Holocene age were not examined.

ORIGIN OF HEAVY MINERALS

The source of heavy minerals of the Ruzizi Plain sediments lies without a doubt in the Precambrian formations and in the Cenozoic basalts of the northern region; a brief petrographic description of these rocks is required.

The basalts in the Ruzizi Plain are generally vesicular and have a grey or green-grey colour. Petrographic studies have highlighted two main types : the first characterizes the region of Luhwa and the second the region of Cibitoke-Murambi. The Luhwa basalts have a vitreous mesostase, constituting more than 50 % of the mass, and contain microliths of plagioclases and phenocrysts of clinopyroxene and olivine, the latter greatly weathered. Idiomorphic biotite also occurs. Veins of iron oxides, calcite and zeolite run throught the rock. The second type of basalt is differentiated particularly by its smaller vitreous ground mass and the additional presence of plagioclase phenocrysts.

Intersertal or even poecillitic clinopyroxene occurs in variable amounts. Traces of olivine can be found in the form of weathered crystals. In certain slides there is a fibrous, pink mineral, probably a zeolite. The secondary calcite occurs in sparitic spots. These basalts form the southernmost extension of the volcanic field of South-

Kivu and probably correspond to alcaline basalts of type A-1 of TACK and DE PAEPE (1982). The only heavy minerals likely to come from these rocks are augite and very weathered olivine.

The Burundian is made up of thick (8000 to 10000 m overall), pelitic and arenaceous sedimentary formations with intrusions of acid and basic magmatics (calco-alcaline granites, dolerites, microgabbros and gabbros). It is subdivided into three series (RADULESCU, 1981) :

Upper (Bs) and middle (Bm) series : pelites, quartzites and quartzo-pelitic rocks.
Lower serie :
Bic-a : pelites locally arenaceous, phyllites, quartzo-pelitic rocks and quartzites with intercalations of metamafic rocks and acid metavolcanites. Conglomeratic beds in the lower part.
Bo : orthoquartzites occasionally brecciated, cataclastic micaceous quartzites and mylonites.

The Ruzizian (RADULESCU, op.cit.) has been subdivided into :

Rb : garnet or staurolite micaschists and paragneisses, kyanite micaschists, muscovite graphitic schists, metaquartzites, amphiboloschists, dolomitic limestones; retromorphosis and accentuated mylonitization.
Ra : granitic gneisses, granitoids, amphibole gneisses, migmatites, mylonites.

It must be noticed that the Ruzizian is considered as a part of the Burundi Super-Group by LAVREAU (1983). We must also point out that this stratigraphy is that of Burundi for we do not possess a geological map with sufficient detail for Zaire.

It is interesting to note that the affluents of the Ruzizi river that carry the alluvions to the plain, flow over the same rocks of the Burundian lower serie (Bia-b), the Ruzizian Ra-b and intrusive rocks such as granites, gabbros and dolerites.

From available documents and information obtained from geologists studying the Precambrian in Burundi, L. NAHIMANA, A. NTUNGICIMPAYE and K. THEUNISSEN, the heavy minerals likely to originate from the series constituting the geological basement of the Ruzizi Plain are the following :
- tourmaline, sillimanite, garnet, hornblende, zircon, kyanite (Ra-b),
- staurolite, hornblende, epidote, titanite, biotite (Bia-b),
- tourmaline, zircon, rutile, micas (granites),
- hornblende, rutile, zircon (amphibolites and dolerites).

RESULTS OF MINERALOGICAL ANALYSIS

The heavy minerals, immersed in clove oil (n = 1.535), were determined and counted by the "ribbon method". The numerical percentages were obtained by counting at least 225 nonopaque grains per sample, except in a few cases where low mineral content resulted in a smaller number of grains (between 150 and 210).

The mineralogical assemblages are composed of the following species or groups : anatase, zircon, tourmaline, rutile, titanite, staurolite, sillimanite, andalusite, kyanite, epidote, green amphiboles, garnets, apatite, micas and grains too weathered to be determined. Anatase is quite rare, but represents locally more than 10 % of the whole. Zircon and rutile are present in minor amounts and their variations are not significant. On the contrary, percentages of tourmaline (brown and blue varieties) show a great variability.

Among the parametamorphics, only staurolite and sillimanite are important, andalusite and kyanite being quite rare. Sillimanite occurs with prismatic and fibrous habitus, this latter characterizing fibrolite whose grains are in fact made up of a mixture of quartz and sillimanite as shown by the diffraction of X rays. Monoclinic green amphiboles comprise hornblende and actinolite. Brown hornblende is far less abundant and only gains importance locally. Epidote encompasses here epidote s.s. and clinozoisite. Garnets were not the object of specific determinations. Titanite, apatite, micas and weathered grains are grouped in the tables under the heading "misc.", on account of their small amount in the assemblages. The importance of this group lies in the greater number of weathered grains. Based on the foregoing findings, the heavy minerals have been distributed in 6 groups : tourmaline, epidote, garnet, amphibole, parametamorphics and the rest. Figure 3 outlines the quantitative variations according to lithostratigraphy and the geographic situation of the sections.

The Muhira Formation

This Formation represents the Lower Pleistocene and lies either on weathered basalt or on Precambrian. It is overlain discomformably by coarse deposits of Lower Pleistocene (Cibitoke Formation), or by red sands of the Upper Pleistocene (Naombe Formation). The thickness ranges from 25 m to more than 60 m in the type-section where the following facies can be seen, from bottom to top : silts and laminar sandy

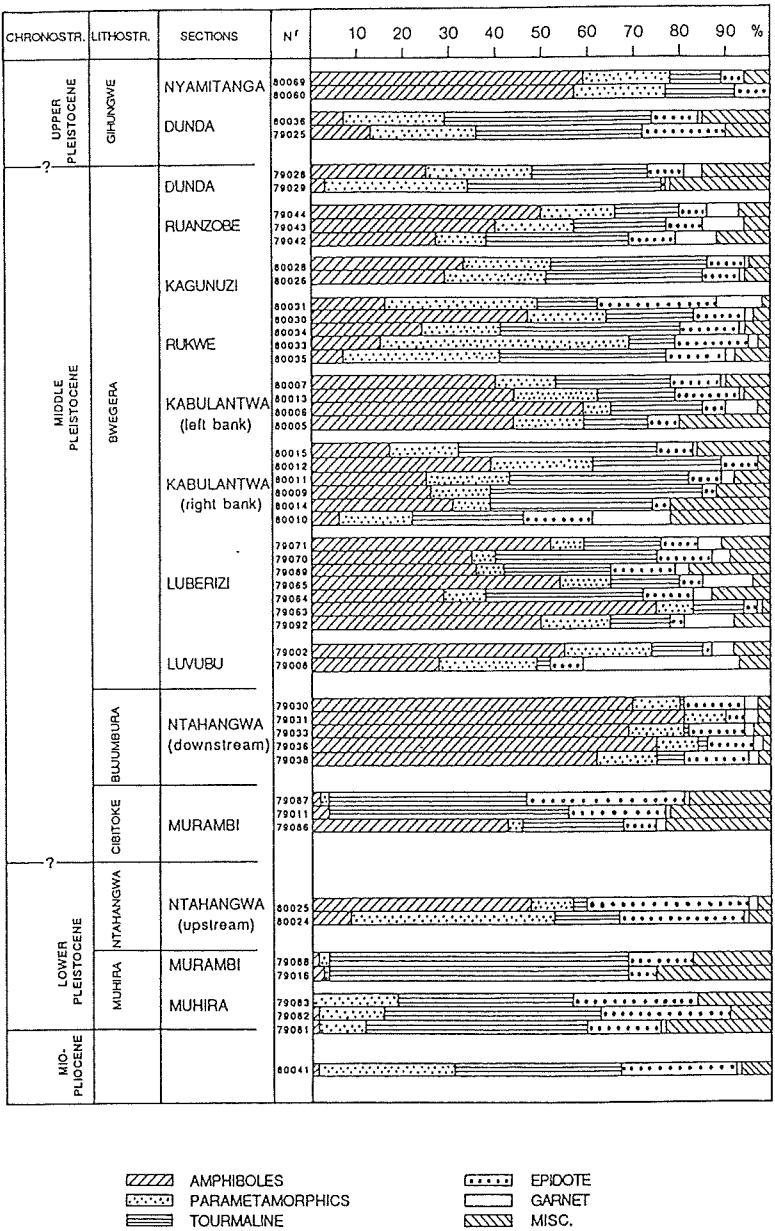

Fig. 3 : Stratigraphy and heavy minerals assemblages.

silts, yellow sands and green interstratified silts, gravel crowned by a palaeosol developed in sand, and finally red sand interstratified by beds of lateritic and quartzic granules.

Two samples taken from the Murambi section reveal a mineralogical content characterized by tourmaline, epidote and weathered grains.

The Ntahangwa Formation

The Ntahangwa Formation was observed along the river bearing the same name, towards the scarp. It shows a facies of laminar silts of flooding, locally climbing ripple lamination, with in certain places, a facies of lenticular ferruginous orthoconglomerate. The Pleistocene Formations lie on weathered and decayed rocks characterized by an association containing about the same proportions of tourmaline, parametamorphics and epidote. In the overlying sedimentary beds, amphiboles and garnets indicate allochtonous influences.

The Cibitoke Formation

In the type-section, the Cibitoke Formation is constituted of thick gravelly, red or yellow deposits, with decimetric interstratification of clay silts and sands. The sediment is cemented locally by ferric compounds.

Samples of this Formation were gathered in the Murambi section where the limit with the underlying Formation is marked by an increase of amphiboles and parametamorphics at the expense of tourmaline and epidote. The rest of the sequence indicates first of all an increase of tourmaline and reduction of parametamorphics, and then the very clear reduction of amphiboles and the increase of epidote.

The Bujumbura Formation

The Bujumbura Formation presents a sandy facies with horizontal planar stratification, and a few pebbly and carbonate beds. Along the watercourse, this changes to a gravelly facies with a large amount of sandy matrix. In the downstream section of Ntahangwa, amphiboles constitute the principal part of the association with

contents higher than 60 %; tourmaline subsists in traces and epidote completes the assemblage to the same extent as parametamorphics.

The Tshamate Group

This Group is made up of 5 Formations : Bwegera, Luvungi, Gihungwe and Naombe. These deposits lie conformably either on the Precambrian or on the Cibitoke Formation and are overlain by recent deposits of terraces.

The different Formations of the Group have in common :
- a younger age than the Cibitoke Formations;
- predominance of silty and sandy facies over gravelly facies;
- a grey-green colour, occasionally yellowish;
- occurrence of carbonate concretions.

The Bwegera Formation was sampled in several sections in order to assess its large geographic extension. It occurs in Luberizi, Kabulantwa, Rukwe, Kagunuzi, Ruanzobe and Dunda sections.

This Formation varies considerably in thickness, going from less than 30 m in the type-locality to more than 70 m in the region of Bwegera, south of Luvubu. In the type-locality one observes cyclothems of thick gravelly layers, coarse to fine sands and clayey palaeosols.

- The Luvubu section provided a remarkable sample at its base, very rich in garnets, but this must be considered an isolated case in the light of other results.

- The other sections offer great mineralogical variations, not simply from one section to another, but also within the same outcrop, making any attempt at synthesis rather difficult. It should be noted however, that the most important group is either that of tourmaline or that of amphiboles. Parametamorphics and epidote show a very rare predominence, as do garnets. The main trends are the following :
  - Luberizi section : association of amphiboles - tourmaline, completed by epidote;

- Kabulantwa section : association of tourmaline - amphiboles - parametamorphics, with predominence of tourmaline on the right bank and amphiboles on the left bank;
- Rukwe section : parametamorphics and epidote are more important and are associated either with amphiboles or tourmaline;
- Kagunuzi section : association of tourmaline - amphiboles - completed by parametamorphics;
- Ruanzobe section : amphiboles are unquestionably dominant, followed either by tourmaline or by parametamorphics;
- Dunda section : association of tourmaline - parametamorphics with variable amphiboles.

The Gihungwe Formation, in its type-section, is constituted of laminar silts at the base, changing towards the top to an alternance of sandy silts or silts with thin layers of fine sand. It is generally 25 m thick. The Gihungwe Formation was sampled in the sections of Dunda and Nyamitanga. At Dunda, the limit between the Bwegera and the Gihungwe Formations coincides with an important increase of epidote that completes the association tourmaline - parametamorphics. At Nyamitanga, amphiboles unquestionably dominate parametamorphics; tourmaline completes this assemblage. No mineralogical analyses were performed on the other Formations of the Tshamate Group.

GRANULOMETRIC VARIATIONS OF ASSEMBLAGES

As can be seen, mineralogical associations show little diversification, the differences involving, above all, relative quantitative variations between the different groups of minerals. In order to understand the reasons for this, we analysed the granulometric distribution of the principal minerals, for series of samples located vertically close together. This analysis was performed, as a trial, for the sections of Murambi, Luberizi and Ntahangwa.

The minerals were arranged in grain-size classes on the basis of their greatest width measured with an ocular micrometer. Indeed, KOMAR and CUI (1984) reported that there is a simple relation between this dimension and the equivalent diameter of the ellipsoid, enabling the calculation of the grain volume and hence its mass, which is important for the hydraulic behaviour of mineral grains.

The main textural characteristics of the heavy fraction are the following :

- there are three types of global heavy minerals grain-size distributions, the first one beeing by far the most frequent :

  - unimodal type with a modal class between 60 and 90 μm;
  - unimodal type with the modal class between 120 and 180 μm;
  - bimodal type.

- The global composition of the heavy fraction does not depend on the grain-size distribution of its mineralogical content.

- No mineral is restricted to a definite granulometric class, so that the mineralogical composition of a given class is not the same from sample to sample.

Therefore, only small differences between samples close to each other in the same section seem to be due to a sedimentary sorting processus, but the major differences in mineralogical composition cannot be explained by changes in the hydrodynamic conditions of the sedimentary environment. The mineralogical composition of the heavy fraction seems to be strongly dependent on the lithological characteristics of the source and drainage areas.

CONCLUSION

For the Formations that were sampled, and bearing in mind the exploratory nature of our analyses, the following conclusions can be drawn :

- The origin of the mineralogical assemblages is situated in the Precambrian formations. The absence of minerals characteristics of Neogene basalts can be explained by the weathering that occurred in their outcrops and which accounts for the disappearance of minerals that could have been found in our samples.

- The mineralogical assemblages can be distinguished above all by the relative proportions of various groups of minerals and far less by the diversity of species. These quantitative differences can be ascribed more to the lithological particularities of the watersheds than to phenomena of sorting, related to hydrodynamic characteristics of sedimentary environments.

- At this point, utilization of heavy minerals for stratigraphic aims holds little promise, at least for correlations. Nevertheless, we reckon that a closer sampling encompassing finer grain-size classes would make it possible to refine stratigraphy within the sections, and to gain better understanding of the sedimentary processes that are at the origin of Pleistocene deposits in the Ruzizi Plain.

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