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REPORTS on

LAKE TCHAD AND ZAIRE BASINS AND SURROUNDING AREAS

Regional-geographic and Geomorphic Analyses using

ERTS-Satellite Imagery (NASA User I.D. F085)

REPORT N° 3

THE ZAIRE - UELE-BOMU STRIPS

J. Sterckx

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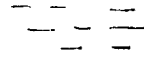
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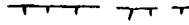
LEGEND

Clouds

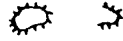


physical features

- scarp



- erosion



- river pattern - braided



- meandering



- lake



- forest



- savanna grassland



- marsh



human features

- settlements, roads, crop and fallow land



- burnt areas



regional-geographic division

- limit of subregions



- limit of regions



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Report N° 3

THE ZAIRE - UELE-BOMU STRIPS: ERTS 1093-08072,-08075,-08081,-08084
1094-08131,-08134,-08140,-08143

by Jozef STERCKX

INTRODUCTION

1) The situation of the region covered by the strips

The region encloses an area between the Zaire and the Bomu, characterized by the confluences Uele-Bomu, Itimbiri-Zaire and Aruwimi-Zaire; it also encloses adjacent areas south of the Zaire and north of the Bomu. Its geographic coordinates are: 6°25N/25°50E; 0°30N/24°25 E; 0°30N/21°10E; 6°25N/22°30E. The region thus limited forms a parallelogram of about 220.000 km², extending over part of the central basin of the Zaire and part of the northern plateau limiting this basin.

2) The aim of the research can be proposed as being threefold:

- To state the reconnaissance level of the ERTS-imagery in the humid tropics where the atmospheric humidity is very high and the tropical moist forest forms an almost continuous cover.
- To compare the ERTS-imagery with aerial photographs of the same region, with existing maps and with data from the literature in order to explain the observed features (perhaps some evolution over the last fifteen years can be recognized).
- To propose a geographical division of the given region, useful in preparing development projects in the different parts of the region.

In consequence this report will be divided into three headings:

- the examination of the ERTS-imagery
- the explanation of the observed features
- the geographical division of the region

PART I ANALYSIS OF THE ERTS-IMAGERY

For the analysis both contact-prints and positive transparencies have been used and enlarged to a 1/1 000 000 scale.

Unfortunately large parts of the area were covered by clouds, chiefly altostratus and altocumulus, which do not form an absolute handicap in analysis. Indeed, while altostratus form a compact cover (northeastern and southeastern parts of the area), altocumulus cover is relatively transparent, allowing us to recognize features characterized by strong contrast on the images. Cloud cover is more important on bands 4 and 5 than on bands 6 and 7, so that the latter are more useful for analysis.

I.1. Vegetation signatures.

On band 5 beneath cloud cover a continuous very dark tone characterizes the area south of the Uele; this has to be the tropical forest. Between the Uele and the Bili, affluent of the Bomu, the very dark tone is locally interrupted by gray spots, suggesting a discontinuity in the forest. North of the Bili very light gray tones predominate; they correspond to a savanna vegetation veined by the numerous dark toned windings of forest galleries. The forest-savanna limit lies about the Bili river; it appears relatively brusque but cloud cover hinders its exact delimitation. The limit is very irregular and savanna penetrates into the forest.

Compared with band 5, bands 6 and 7 show some differentiations in tone of the images:

- in general the area south of the Uele is less darker toned on bands 6 and 7, as is to be expected. But along the main rivers the tone is a little darker than elsewhere. This may indicate alluvial plains in the vallies either covered with the edaphic forest or being marshy. The clear toned areas correspond to human features as we will see further.
- North of the Bomu small differences in gray tones probably correspond to a difference between savanna studded with some trees and full grassland savanna or steppe.

I.2. Hydrographical and morphological signatures.

At first a particular feature has to be noted in the area of the Mogbo-Loko-Tshimb. where the altocumulus forms almost parallel bands. A comparison with the map allows us to state that clouds are grouping themselves above the divides and so they outline the vallies. Because the images are taken in the morning (at about 8.15) and the pattern is only characteristic of the area mentioned, it must indicate a differential heating between divides and vallies. This differential heating between divides and vallies may be due to the fact that the vallies are still in the shadow when the divides already receive solar radiations; it means the vallies are more or less incised in the plateau and the vegetation cover follows the relief surface. However it has been noted that this pattern is only typical for vallies oriented E-W and for cloud cover of altocumulus.

In general, the hydrological and morphological features allow us to distinguish different areas:

I.2.1. The area south of the Zaire valley

The relief appears as a flattening incised by vallies, which are almost sub-parallel to each other and to the Zaire. Comparison with the 1/1000000 scaled map of the AMS edition shows that these vallies, except the Lomako valley, are situated about 20 km nearer to the Zaire on the ERTS images. This difference is not due to the position of the satellite as is apparent from the coincidences of the Zaire and the Lomako on map and images; it must be a mistake on the map.

The Lopori and the Bolombo meander in large alluvial plains (about 5 km) which they have built up; these alluvial plains are hardly distinct in tone from the surroundings so that the vallies are probably shallow incised in the flattening area. These two rivers are pressed against their northern valley sides while the southern sides are mostly outlined by a very light gray toned line.

The Lomoko is characterized by several little pools.

On the ERTS images only few affluents of the main rivers can be recognized; the map shows a lot of short affluents mainly on the southern side of the rivers.

I.2.2. The Zaire valley

The Zaire is a braided river with few large islands and numerous small is-lands and sandbanks (it is still difficult to distinguish these two features on the images). On the largest island small differences in tone are visible on the enlarged image: the darker lines are presumed to be old branches of the Zaire filled up by the stream (as it is confirmed by the aerial photographs).

Downstream from the Itimbiri-Zaire confluence, the stream flows in a well outlined valley of about 25 km in width. The boundaries of this part of the

valley are emphasized by three features:

- light gray toned areas form nearly rectilinear limits of the valley north and south;
- numerous affluents are clearly recognizable in the light gray toned areas which suddenly disappear out of the rectilinear limits in the darker tone of the valley bottom of the Zaire;
- three of the northern affluents of the Zaire have built up alluvial fans just before their confluence with the Zaire.

The alluvial fans and the clearly outlined valleys of the affluents in the light gray toned areas indicate the deeply incised character of the Zaire valley. The rectilinear pattern of the valley sides and the constant width of the valley bottom suggest a graben, which has been followed by the Zaire.

At the confluence Itimbiri-Zaire, the latter appears to have been pushed to the south by the alluvium supplied by the Itimbiri; the deviation to the south of the Zaire is an interruption of the stream pattern up- and downstream.

I.2.3. The area between the Zaire and the Uele

A large part of this area is occupied by the Itimbiri basin. The Itimbiri itself describes well formed meanders interrupted by a sinuous segment of about 30 km upstream Aketi town. The Lower Itimbiri flows in a large alluvial plain (about 10 km in width), outlined by light gray toned bands on each side; the western boundary of the valley is nearly rectilinear, suggesting a scarp, while the eastern is rather sinuous. Upstream of Aketi, the northern affluents - the Likati and the Tinda - form with the Itimbiri a nearly rectangular pattern; there, neither the Itimbiri nor its affluents have alluvial plains on the ERTS-images.

The two affluents of the Lower Itimbiri, recognizable on the ERTS-images, namely the Tshimbi and the Mogboloko, have clear alluvial plains, marked by a somewhat darker tone; it is not quite certain if their valleys are deeply incised or not.

West of the Itimbiri, river density looks very high and shows a dendritic pattern. As stated before, the affluents have probably incised their valleys relatively deeply into the flattening area.

Farther northwards the valleys of the Dua, the Ebola and the Upper Likati are also recognizable by their slightly darker tone.

I.2.4. The Uele-Bomu area

This area also encloses part of the Central African Republic. In general river density looks very high except in the southwest between the Uele and Bomu; this part is drained by the Bili, an important affluent of the Bomu. The Uele and Bomu are braided rivers with islands and sandbanks and locally form bends with more or less geometric characteristics, that is the bends have angles with a more or less rectangular pattern. Another characteristic, especially of the Uele, is the fact of local splitting up in a main channel and multiple very small channels.

At their confluence, the Uele and Bomu form a single valley with two distinct channels, but interlacing with each other.

I.3. Cultural signatures.

In preceding analyses it has been stated that cultural features are best recognizable on MSS band 5. It is not the same for the region, analyzed in this paper; indeed the images of band 5 are of an almost continuous black

tone, which suddenly pass into a very light gray tone about the Bili (see vegetation). Only very small lines in the forest can be recognized as roads (compared with the map). But on the images of bands 6 and 7, on a relatively dark gray background light gray toned lines, bands and areas can be outlined and recognized as cultural areas, coinciding with the roads on band 5 images.

We accept the following general interpretation of these areas:

- distinct lines, interrupted by dots, are considered as small cultivated strips with villages; they are situated along roads;
- bands are important cultivated areas along roads;
- surfaces marked by geometrical limits and a homogeneous clear tone are plantations.

Important differences can be stated in the cultural landscape:

I.3.1. In the area, south of the Zaïre, cultivated areas are arranged to give linear patterns. In general they are situated on the southern limit of the alluvial plains and are connected with each other over the divides by a cultivated area which is also linear. On the southern side of the Zaïre valley signatures of human presence form a rather sinuous pattern, often interrupted by the valleys of the affluents of the Zaïre. A plantation area on the divide Zaïre-Lopori is easily recognizable.

I.3.2. In the Zaïre valley human presence appears sporadic; the only signatures recognizable as human facts are crop and fallow land on alluvial fans, and a succession of settlements along the Zaïre from the Itimbiri-Zaïre confluence to the Yenge-Zaïre confluence: Bumba is the most important being the river-port of the region.

I.3.3. In the region outlined by the Zaïre, the Itimbiri, the Tshimbi and the Dua bands of cultivated areas cover about 40 % of the surface and suggest a high population density. The cultivated areas avoid the valley bottoms as well as the tops of the divides and so they give a characteristic polygonal pattern, due to the dendritic river pattern. As mentioned before, cultivated areas emphasize the valley-sides of the Zaïre and the Itimbiri and they suggest that these sides are almost rectilinear. On the Itimbiri-Mogboloko divide a plantation is recognizable as a small white square (3 x 3 km).

I.3.4. The valley of the Lower Itimbiri is outlined on both sides by important cultivated areas, with short ramifications along affluents. From Aketi to Buta cultivated areas form small linelike patterns along the Itimbiri itself and along affluents on the Itimbiri-Uele divide. Some plantations can be recognized in the neighbourhood of Aketi.

I.3.5. The region about the Uele. The importance of cultivated areas rapidly decreases: along the Ebola (affluent of the Dua), and along the Upper-Likati (affluent of the Itimbiri) cultivated areas are still frequent, but north of the Uele they are limited to a few roads which connect crossing-places on the rivers.

I.3.6. The region about the Bomu and north of the Bomu. Except in the neighbourhood of Bangassou only a few small cultivated areas can be recognized on the images; the available map also shows a scarcely occupied area.

PART II EXPLANATION OF THE DESCRIBED FEATURES

This explanation is based on aerial photographs and on literature available.

II.1. Vegetation

II.1.1. From south to north L. Peeters (1964) describes the following succession of vegetation growth:

- On both sides of the Zaïre the tropical moist forest prevails; it is only interrupted by the edaphic forest in vallies characterized by large alluvial plains, namely the vallies of the Zaïre, the Lower-Itimbiri, the Lopori and the Bolombo. The tropical moist forest extends to about the Uele, but the climatic conditions become marginal or even remainder for the tropical moist forest; indeed the period of rainfall gradually decreases northwards so that the dry period covers at least two consecutive months in the neighbourhood of the Uele (F. Bultot 1972) and that is generally considered as a critical level for the evergreen forest in tropical areas.
- From the Uele to the Bili, the dense forest is characterized by L. Peeters as a subequatorial semi-deciduous forest. This forest still continues over some distance on the northside of the Bili, but there it is more or less deeply penetrated by a savanna with important forest galleries. Near to the Bomu the savanna becomes the predominant vegetation cover with dispersed islands of the semi-deciduous forest.

II.1.2. The forest-savanna limit drawn by L. Peeters (1964) is sharp and tortuous. The limit does not coincide with characteristic differences in soil. Then in our region the forest extends much farther to the north than in the east and west. Finally in the whole north Zaïre, the forest is penetrated by the savanna while itself continuing as islands in the savanna. These characteristics can be explained neither by geological nor by climatic differences, but they suggest a human intervention by clearing and cultivating the forest. Indeed on aerial photographs numerous clearing with crop and fallow land are recognized. Only the valley of the Mogboloko, affluent of the Itimbiri, has a clear marshy character on the aerial photographs.

II.2. Hydrological and morphological signatures.

II.2.1. On the northern side, the Zaïre valley is limited by a real scarp, incised by V-shaped vallies of the affluents. On the aerial photographs the scarp rises up near the stream at Lisala (western edge of the image) then it immediately retires from the stream about 10 km, turns again to the east and approaches the stream near Bumba. (We have seen this scarp at Yangambi - eastern edge of the area - dominating the valley bottom by about 20 to 30 meters). The southern valley side of the Zaïre is fully incised by the numerous short affluents, giving the valley side a very tortuous outlook so that the character of a scarp is less clear than on the northern side. In the valley bottom numerous old branches of the Zaïre can be recognized on the aerial photographs, some are filled up and the older ones are overgrown by the forest but the branches filled up recently are still marked by pools.

The problem of a possible graben structure can not be resolved and needs ground truth.

II.2.2. On aerial photographs an almost rectilinear scarp outlines the western side of the Lower Itimbiri valley; the only large amphitheatre was probably eroded by the river in the past. On the east of the Itimbiri it is difficult to recognize a real scarp: the differences in height do not appear very important and are softened by forest growth and clearing. Perhaps the eastern valley-side may be a monoclinical fold while the western scarp may be a fault.

II.2.3. The Uele is characterized by local splitting up into numerous branches, which regroup downstream. Neither aerial photographs nor

available geological maps give facts to explain this behaviour. We believe it is due to the presence of more resistant rocks crossing the river at these places; these rocks slow down erosion, and the river splits up allowing water transport by the easiest ways (The same phenomenon was observable on the Dikuluwe, an affluent of the Lufira (J. & S. Alexandre, 1961), and on the Lualaba upstream of the Kazembe marsh - east of Kolwezi - before the inundation of the valley by the artificial lake of Nzilo). This fact must be controlled by detailed geological prospecting.

II.2.4. The whole region appears to be a flattening.

II.3. Cultural landscape signatures

II.3.1. The ERTS images have been confronted with aerial photographs of the area and this confrontation confirms our hypotheses:

- The cultivated areas are crop land as well as fallow land, while the areas with geometrical forms are plantations of palms and coffee. The africans cultivate bananas, manioc, maize, peanuts; but for people living near the rivers fishing is more important than cultivation (J. Vansina, 1965). In the past, the fishermen were also the merchants for all areas along the Zaïre (J. Vansina, 1965).
- Crop and fallow land are generally situated on the valley sides and on the edges of the divides. In consequence crop and fallow land follow the relief of the valley sides and give a more or less sinuous pattern, which is particularly clear on the southern valley side of the Zaïre.

It can be easily understood that people avoid the very humid and densely forested valley bottoms. But why they also avoid the divides is not so clear; it can be a question of soils, which are generalized on maps as ferrallitic (Soils Map of Africa; Oxford Atlas); besides, the soils on the divides are probably old, while the soils on the valley sides are relatively young. Probably, the forest prevents erosion of the plateau. About the Uele the soils are probably lithosols on ferruginous crusts.

II.3.2. The differences in density of cultivated areas and also of population are more difficult to explain. A certain coincidence can be stated with the distribution of tribes, described by J. Vansina (1965). The highest density with the polygonal pattern corresponds to the home of the Mbuja, a tribe of the Binza group. The Binja another tribe of the Binza, occupy the region of Aketi. These tribes appear to be the most important of the Binza and they would have developed more efficient agricultural technics namely continuous cultivation of the same soil and a repair of soil fertility by manuring (J. Vansina, 1965).

In particular this high density of people and cultivated area in the tropical moist forest has to be noted in contrast with the very low density in the savanna north of the Uele, which is much easier to reclaim. The Zande, who live in this savanna are chiefly hunters and so agriculture is of little interest to them. Secondly as the Zande are dispersed over a very large area, population density normally decreases. Besides, J. Vansina asserts that settlements of the Zande are hamlets rather than villages, and, in consequence, the cultivated areas are very limited so that they can not be recognized on the ERTS images.

But one question remains: why do the Binza live in the forest and reclaim it? It is an historical fact that the Binza people were dislodged by the war-minded Zande in the XIX century and migrated from the savanna into the forest (J. Vansina, 1965)

PART III PROPOSAL OF A GEOGRAPHIC DIVISION

III.1. Principles of the proposed division

- (1) The level of a geographic division depends on the extent of the area and on the scale of the images and map deduced from the imagery; in our proposed case only a macro-division is possible.
- (2) An authentic geographic division has to be founded upon both physical and human features and on their relationships, as far as they can be recognized or inferred from the ERTS images, controlled by aerial photographs and data of the literature. The relationships considered are the coherence and consistency of various features revealed by their factual coincidence, giving various homogeneous landscape units, which differ one from another. Landscape units, homogeneous for all features considered, are the smallest and most concrete units in a geographic division; they are called "facets". Facets are then grouped into units of a higher order in the hierarchy of geographic division. The higher order units are less concrete because not all features are considered.
- (3) A geographic division is not an aim in itself. It must be helpful in making development plans for the area and has to point more detailed investigations. In this option the main criteria are the actual occupation density and pattern, the vegetation cover, and the hydro-graphic pattern.

III.2. Application of the principles on the area studied.

It is clear that the heavily cloud covered areas are not considered because on these areas nothing can be stated on earth surface features. So we have to exclude large parts in the eastern section; elsewhere cloud cover does not fundamentally disturb a macro-division.

III.2.1. The smallest landscape units or facets recognizable on the ERTS imagery (these facets are not outlined on the map, since they are too small):

- a braided river with islands and sandbanks: the Zaire
- a large alluvial plain along the Zaire, covered by edaphic forest;
- small alluvial plains - along other rivers - incised by a meandering river and covered by edaphic forest;
- small alluvial, marshy plains;
- valley sides with crop and fallow land in clearings;
- plantation areas on divides;
- incised vallies, covered by tropical forest;
- divides with tropical forest;
- savanna on divides
- forest galleries;
- scarps;
- alluvial fans, with human occupation;

III.2.2. These facets can be grouped into larger classes on the basis of the repetition or alternation of facets giving a characteristic homogeneous pattern over larger areas:

- the Zaire valley with stream, alluvial plain, valley sides;
- south of the Zaire we have an alternation of divides with tropical moist forest, cultivated valley sides and alluvial plains with edaphic forest, forming more or less parallel bands;
- north of the Zaire crop and fallow land on valley sides of a dendritic river system, form a polygonal pattern, enclosing the tropical moist forest on divides as well as the forest in valley bottoms;

- along the Itimbiri, rivers with crop and fallow land on the valley sides, and tropical moist forest on the divides form a more or less rectangular landscape pattern;
- the forested plateau with very sparse human occupation between the Aruwimi, the Zaire and the Itimbiri;
- the forested plateau with crop and fallow land along the few roads crossing the Itimbiri-Uele and Uele-Bili divides;
- the plateau is covered with savanna interrupted by very incised crop and fallow land on both sides of the Bomu;
- the savanna region north of the Bomu with forest galleries;
- in the northeast numerous small scarps mark the area as erosional features of the savanna covered plateau; very sparse human occupation features can be recognized.

These higher order units characterized by a particular pattern of grouped facets, are called subregions: Zaire, South Zaire, North Zaire, Zaire-Aruwimi-Itimbiri, Uele-Bili, Bomu, Mbari and Ouara.

III.2.3. Finally the subregions are grouped into geographical regions on the basis of the principal vegetation cover and the recognition of more or less continuity of crop and fallow land:

- (1) Zaire-Uele region characterized:
 - in general a dense forested area
 - crop and fallow land form lines and bands marked by a certain continuity giving a scattered cultural landscape.
- (2) Bomu region:
 - a savanna covered area
 - sparse and discontinuous crop and fallow land;

The limit between these two large regions is relatively simple when we consider only two main vegetation groups. But as has been stated before, this limit is probably merely artificial and is determined by clearing and cultivating.

CONCLUSION

What impact can the analysis and geographical division have on development plans? That is what significant indications can be deduced?

It is clear that two complete different regions have to be considered, their natural environment and human features being completely different. The Zaire-Uele is rather difficult to clear, but actual population density, the moist tropical climate, and the presence of navigable waterways destin this region to develop a plantation economy of crops and timber. In the neighbourhood of the large incised rivers the danger of erosion is real and there the tropical moist forest has to be protected.

The Bomu region is a savanna region and is more vulnerable to erosion, because of the alternating dry and rainy seasons. Irrational clearing has probably caused the erosional features in the Ouara-subregion. Besides population density appears very low. We believe density has to keep low and people grouped in most favorable sites, while the remaining area should be forested.

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