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REPORT ON THE ACCOMPLISHMENTS OF ERTS ZAIRE IN NORTH SHABA, 1980-1981

Jointly Sponsored by:

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(Under Contract No. AID/afr-C-1483 with Spectral Data Corporation)

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June 1981

PART V

EVALUATION OF THE GEOLOGIC AND MINEROLOGIC POTENTIAL OF NORTH SHABA BY MEANS OF LANDSAT IMAGERY AND OTHER AVAILABLE DATA

Conducted at ERTS ZAIRE
with the assistance of
United States Agency for International Development
(Contract No. AID/afr-C-1483 with Spectral Data Corp.)

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SECTION 1

DESCRIPTION OF THE METHODOLOGY

1. Introduction

As part of a multidisciplinary effort to evaluate the resources of North Shaba, the ERTS Zaire Geological Division was given the job to establish the usefulness of Landsat imagery in mineral exploration.

Objectives

The goal of this project was to demonstrate that Landsat imagery is a useful adjunct in mineral exploration.

The basis for this demonstration was the supposition that Landsat imagery would offer a great advantage in mapping a large area because of the synoptic view it offers, namely, coverage of about 32,225 square km in each image. Secondly, it was believed that such images could provide the interpreter with a significant amount of new information useful to the geologist. Such a combination would be a less expensive first order exploration tool which could be used as a base map for airborne geophysics, acquisition and interpretation of aerial photos and for ground truth surveys.

Location of Study area

The area of study was in North Shaba, of approximately 110,000 square km. This corresponds to four Landsat scenes. The corner coordinates of this area are more or less as follows:

E 29° 00', S 5° 00,; E 28°00 S 8° 00'

E 26° 00', S 5° 00,; E 25°00'S 8° 00'

In order to facilitate interpretation of the four chosen Landsat scenes, an additional two scenes from the eastern sector were added. These also extend from 5°00 south to 8°00 south latitude.

Field work was confined to the scenes entitled Kongolo and Mannono (see planche 5) on the remaining two scenes, Mwanza and Lubunda, only overflights were conducted.

From the hydrographic point of view the zone can be divided in two parts: an eastern and western separated by the Lualaba River. The project area lies within the Lualaba drainage basin as well as the western portion of the Lomami River.

To the west of the river, the region is characterized by a regular relief sloping gently to the north. The rivers which drain this region have a northerly flow parallel to that of the Lualaba. This regularity of topography is due to the lack of tectonic movement in this area since Kibaran and Kundelungian time. The orogenesis during mid Tertiary time only affected the area by upraising the southern portion, reversing the drainage and providing a new direction for the streams along a gentle slope to the north .

Quaternary activity hardly affected this area and the quaternary is marked by the entrenchment of the cycle described above and the development of the hydrographic region evident in the streams of the area today.

East of the river one finds a region belonging to the high plateau of the East African Rift system and one recognizes the ancient peneplained region which has been deserted slowly since mid-Tertiary time. This erosion is due to the mid tertiary and more recent rejuvenation caused by the uplift of the rift area.

The project area is drained almost entirely by the Lualaba River and its tributaries except for the western most region vhich is draned by the upper Lomami River. The Lomami River is almost entirely a mature river whereas the Lualaba shows a variety of profiles. Depending on the amount of rejuvenation the Tertiary peneplain has undergone due to orogeny and rifting.

2. Characteristics of the Landsat Imagery

The Landsat system consists of a multispectral scanner (MSS) and a return beam vidicon camera (RBV) as well as two magnetic tape recorders.

The images used by ERTS Zaire was produced by the MSS system, a radiometer with four channels which scan the earth's surface and measures the intensity of the reflected energy of a particular object or area. This system works simultaneously in the following 4 portions of the electromagnetic spectrum.

- Band 4 - from 0.5 to 0.6 micrometers in the visible portion of the sepctrum
- Band 5 - from 0.6 to 0.7 micrometers in the "upper" visible portion of the spectrum
- Band 6 - from 0.7 to 0.8 micrometers which is the near infrared part of the spectrum adjacent to the visible
- Band 7 - from 0.8 to 1.1 micrometers which is the near infrared

For this study the team used black and white imagery of bands 4, 5 and 7 as well as colour composites of bands 4, 5 and 7 developed on Cibachrome paper at scale of 1:200,000.

For the Manono scene, imagery from 9 June 1978 in black-and-white and false colour was used. The imagery from 14 September 1972 was exclusively black-and-white.

For the areas of Mwanza and Lubunda the only imagery available was for 4 June 1978. Both black-and-white and colour composites were used.

For the Nyunza area, three images were available: 29 June 1978, 9 July 1973 and 22 February 1975,in both false color and black and white.

All the imagery was of good quality with cloud cover of less than 10%. Some line noise obstructed certain scan lines but with little overall negative effect on the interpretability of the imagery.

3. Methodology Used to Prepare a Geologic Map Using Landsat Imagery as a Base

Bibliographic Research

Before the interpretation work began, as much basic data as possible was collected. In this regard the following documents were consulted:

La Geologic du Zaire, L. Cohen, 1964

L'etain au Congo, P. L. Roy

L'or au Congo, P. L. Roy

La Carte Geologique du Zaire de J. Lepersonne at a scale of 1:2,000,000, 1974

Mineral index map of Zaire of the B.R.G.M. Paris 1976

The Tectonic map of the Belgian Congo and of Rivanda Burundi, L.Cohen, 1:3000,000, 1957

Geologic map of the Belgian Congo, P.Fourmaries, at a scale of 1:2,000,000, 1930

Concession map of Sogetain, 1:500,000 based on C.S.K. maps of 1931.

Aerial photos of North Shaba from C.S.K, 1952-1960

All the above maps being of small scale, the information available is of dubious precision and cannot be depended upon. Nevertheless, all of these documents serve as exellent guides for interpretation. All of these maps notwithstanding scale, precision or even location were extremely valuable in guiding the scientific research.

Method of Analysis of the Imagery

The analysis was conducted on imagery at scales of 1:1,000,000 to 1:200,000.

Structural analysis was conducted at a scale of 1:1,000,000 initially and then at 1:200,000.

The lineament analysis was conducted by three independent interpreters and the results were then consolidated. Data which had been identified by two interpreters was inmediately considered valid. Data or linears identified by only one interpreter were either discarded or sometimes accepted if a valid explanation was given by the author.

At the large scale all the small scale data was transferred while making certain necessary corrections. In addition, whatever linears were visible on this larger scale imagery which had been missed on the smaller scale interpretation was added to the larger scale data base. Again, this redefinition was done by three interpreters. After this stage, the definition of the folds and other structural features such as thrust faults as well as other faults and their direction of movement was undertaken.

After this stage, the lithographic interpretation was performed. The available geologic maps were used as guides. This mapping effort included taking into account and noting outcrops, dips, strikes, drainage patterns, faults as well as vegetational texture and vigor. Taking all these parameters into account, as well as using the geologic map, it was possible to delimit and identify certain units. Where such identification was difficult, or disagreement was found with existing maps, the information was noted with a question mark or a dotted line. Every point of contention or disagreement required a field check and we will show firther what resulted.

4. Ground Truth

Ground truth was condusted by aerial overflights, interpretation of available aerial photographic coverage and field checks. (See planches 12 A-D)

The flight plan was made on the basis of the following criteria:

- The accessibility of the area under consideration by road, etc.
- Logistical support available in an area.
- The need to have a general understanding of the area
- The need to have detailed information on certain poorly interpreted areas or areas which posed a problem.

The road plan was made to correspond to and supplement the above whenever possible. Often no road existed where previously one had been noted and so certain ground truthing had to be eliminated from the plan.

5. Methodology Used in Final Interpretation

The following steps were followed in the final interpretation.

The structural interpretation was conducted by two geologists who had been in the field; this geologists corrected the initial interpretation,located new lineas and folds based on the field work and determined the direction and amount of displacement along faults. Additional work is done on aerial photos (see appendix) to verify lithology and structures.

The best imagery for the interpretation of faults was found to be channel 7. The best Landsat images for lithologic work is usually channel 5.

6. Conclusions

Analysis of the four Landsat scenes of North Shaba showed the following:

Effective structural maps can be produced by using the morphologic characteristics of the terrain. The analysis and description of the structures in this section shows that this area has undergone a very complex geologic history.

Lithologic interpretation is difficult because of vegetation cover and by the small area of certain formations.

Intrusions are relatively easy to interpret due to their geomorphic surface characteristics.

The combination of the Landsat interpretation and the known geologic facts available from the literature increased knowledge of the area and permitted one to arrive at certain useful conclusions related to the formation and genesis of mineral deposits in this sector. This study will certainly lead to the discovery of new mineral deposits in this region. A description if this phenomena can be found in the following section of the report.

SECTION 2

INTERPRETATION, FIELD WORK AND RECOMMENDATIONS

7. Introduction

This section deals with four main topics related to the four Landsat scene areas studied:

1. The known geologic characteristics

2. The Landsat interpretation conducted by the ERTS Zaire and Consultant team.

3. The relationship and conclusions drawn from the integration of the data.

4. The economic potential of this region as perceived by the ERTS Zaire and Consultant team.

Finally, certain conclusions will be drawn and recommendations made regarding the efficiency of the Landsat approach for mineral exploration in Zaire and its usefulness in the context specified by the project agreement between the government of Zaire and the United States of America.

8. Preparation for Field Work and Final Analysis of the Landsat Imagery

Prior to going into the field the ERTS team conducted a preliminary interpretation of this region with a view to constructing drainage maps, defining linear features,and defining gross lithologic features. This information integrated with data drawn from known sources allowed us to reach two conclusions, the first was that we were badly in need of basic field data in certain areas where interpretation of the Landsat data was difficult. This allowed the team to choose certain areas to visit on the ground. The second conclusion was related to the formulation of an hypothesis regarding the genesis of the known mineral deposits and the possible location of such deposits. Thus on arriving in the field the team knew where it had to go to verify the interpretation and the hypothesis.

The hypotheses were two. The first proposed that gold deposits were related to saddle reef vein systems in the folds of Kibaran rocks in the region north and east of

Nyunzu. Thus the mission was to check on the existence of and the production of gold in the anticlinal folds of this region. The second proposed that all the tin deposits of the Manono district (North Shaba area) were palingenic in origin rather than igneous and that structural controls must be established to explain their existence. Thus a structural model for the genesis of these deposits was created before leaving for the field. This model may be described as follows:

1. Folded metamorphic rocks control the emplacement of pegmatites

2. The cores of overturned or tightly folded synclines are the main locci for pegmatization, i.e. where deep burial took place and where the mobility of volatile fluids was restricted.

3. The pegmatites of this region are often related to dolerite bodies which in some cases act as hanging wall barriers.

4. The pegmatites are not necessarily all tin rich and neither are they necessarily related to granite intrusives.

5. These pegmatites are not igneous per se but polingenic.

6. The source of tin and colombo-tantalite can be found in the metamorphosed host rocks.

7. Reverse faults along axial trends and thrust faults are common in this region and are also expected to be controlling factors in the location of tin deposits and the emplacement of pegmatites

Based on these hypotheses, the background which was drawn from the literature and discussions among the geologists concerned, a field plan was developed. Had proper funding been available (and time permitted) this field plan could have been carried out. As it was only 25 percent of the field sites chosen were visited and field verification was not as systematic as it could have been.

A great deal of work has been done in this area before independence by the Belgians but unfortunatly this work is unavailable in Zaire except in the files of Belgian companies. We are aware of 1:50,000 scale reconnaissance mapping of much of the area studied by the ERTS team which is in the files of Geomines/Zairetain but this information was not available to us. In addition the consultant perused much literature in the file of the U.S.G.S. library in Washington which would have been extremely useful as background information. Other than the foregoing, the previous work used by the ERTS/Consultant team is noted in the bibliography. However, the main texts used are as follows:

- Carte des gites Mineraux du Zaire et Notice Explicatif. Service Geologique du Zaire 1974.
- Carte Geologique du Zaire et Notice Explicatif. Departement des Mines du Zaire 1974
- Geologie et Geographie du Katanga, Robert 1956
- Morphology of the Earth- King 1967
- African Magmatism and Tectonics,-Gass, Clifford 1970
- Biogeography of the Southern End of the World- Darlington. 1965
- La Geologie du Zaire, - L.Cahen 1964
- Les Cartes de Consession du Shaba- Dept. des Mines 1980

Altough some material is available it is extremely hard to find and when available as at the Department of Geology the working hours are so short and the research material so disorganized that it is quasi-impossible get any work done.

9. Geomorphology (See planche 13)

The geomorphology of this region is extremely heterogenous and is due to the highly complex Tertiary and Quaternary tectonics which have affected it.

Robert (1956) describes in detail some of the geomorphic features and their historical development but unfortunately he does not provide a comprehensive review of the region since the late Mesozoic.

The same author believes that three main geomorphic cycles can be recognized in Shaba as follows:

a. Ancient Peneplanation-Jurassic to Mid-Miocene

b. Second peneplanation which began some time in the Mid-Miocene after changes in elevation took place in East Africa, due to rifting,and block faulting of the region to establish isostatic equilibrium.

c. A final phase of peneplanation which began in mid-Quaternary times after the elevation of plateaus around the Rift and the completion of the sinking of grabens such as that of Tanganika and Upemba

Robert (ibid) also points out some interesting facts concerning geomorphic developments in the Shaba region but does not tie them together. Some of these bear noting here.

1. The Zambezi-Lualaba drainage has definitly shifted since late Tertiary time so that it can be said that the Zambezi drainage is progressively being captured by that of the Lualaba.

2. The plateau areas of Shaba have been elevated as much as 800 meters since Miocene times.

3. The Lualaba north of Kougolo has probably flowed northward toward Kisangani since Jurassic time. This cannot be said of the Lualaba to the south which has a different fauna. North of Kongolo the fauna is Nilotic whereas south of Kongolo

it is Zambesean (see also Lepersonne 1974).

4. There has been much stream capture in Shaba and some reversals of streams.

5. A large lake existed at the confluence of the Lukuga and Lualaba as late as 1891

6. Lake Tanganika had no effluent (in modern times) until 1878.

The geomorphic provinces of this region have probably been described elsewhere but this literature was unavailable to us. We have therefor attempted to identify these zones based on Landsat imagery. Many of the zones chosen can be further subdivided but for the purpose of this report we shall limit the taxonomy to six features. These include:(See map planche 13)

A. La province elevee du Rift

B. La province des hauteurs Kibaro-Ruziziene

C.. La province des hauteurs Permo-Carboniferes

D. La province des hauteurs Bushmaienne-Mesozoic

E. Le plateau Lubao/Manono ou l'ancienne Vallee de la Lomami-Luvinza

F. Province du Graben de l'Upemba

Three of these provinces are Post Miocene (A,B,F) the rest are vestiges of the pre-Miocene erosion cycle.

F. <u>The province of the graben of the Upemba</u> is a very recent phenomenon and is related to the development of the rift valleys. In fact it is an incipient rift. This feature holds little or no economic interest to us but is important only in that it probably represents an area of crustal thining (a Kibaran anticline) which has collapsed into the mantle.

A. The province of the Rift consists of a high plateau which slopes steeply into Lake Tanganika from about 20-40 km. to the west of the lake. Westward of that, the plateau slopes more gently toward the Lualaba River and is occasionally broken by NNE/SSW trending en echelon faults. These faults are parallel to Lake Moero Lake, the Upemba graben and Kibaran age folds.

In two cases these highlands have been breached by rivers (by the Luvua and the Lukuga). In the case of the Lukuga, this breach has been intermittent. Robert (1956) reports that before 1878, Lake Tanganika had no effluent and that it was in that year that the Lake began to flow out through the Lukuga gorge. By 1895 the lake level had fallen 9 meters to approximately its present level. The effect of this was to innundate the Kabalo plain where a large lake (Landei) formed whose vestiges which can still be observed in the swamp land between the confluence of the Lualaba and Lukuga.

The Luvua flows from lake Moero and may well represent a series of captured stream channels which flowed south eastward before the elevation of the Rift highlands.

It is an important thesis of this report that all pre-Tertiary drainage was from NW to SE. Map 13 shows the drainage directions as interpreted from Landsat features and based on various sources in the published and unpublished literature (Pollinard, Veatch, Lepersonne, Robert, Stancioff). The proposal that a "pre-Tertiary" (Jurassic to Miocene) land surface was first transgressed by shallow seas from the east and later drained toward the east was important implications for the discovery of economic deposits in this region. To support this thesis we need only point to the many sources of alluvial diamonds south of Bujimayi in ancient Triassic channels (Veatch, Pollinard). In Angola, similar channels were found between the Luembe and Luana Rivers (Beetz and Farnham). In addition a review of the major alluvial gold deposits of southern and eastern Zaire clearly shows that these deposits are presently found upstream of their source rocks.

These facts suggest a number of targets for alluvial mineral exploration; eg. the course of the Lukushi/Luvinza south of Manono for tin. The course of the Lusindoi/Balaie south of Kiambi for tin. The upper course of the Luizi for tin and it's lower course for vein and pegmatite deposits. The course of the Lomami/Lukashi/Mulafia for diamonds.

In conclusion, the importance of the elevation of the rift region is that it produced a reversal of drainage

after the impounding of large number of streams and lakes. The erosional effects on much of the region west of the rift have not been great since Triassic times and therefor it can be expected that mineral deposits should be easy to locate once their alluvial detritus has been found and vice versa. The model proposed above is new and could prove of assistance to exploration teams.

B. La province des Hauteurs Kibaro/Ruziziene

This region consists of folded mountains in the area to the north of Nyunzu and to the east of Kongolo as well as the Rift elevated equivalents of these rocks to the west of the Rift mountains per se. Because of block faulting along the east caused by Tertiary to Recent rifting much of the Kibaran folded sequence has been removed and it is supposed that the few linear ridges visible on Landsat represent the quartzitic erosion resistant basal sandstones of Kibaran rocks. The remainder of this area is underlain by Ruzizian rocks. It is also plausible to suggest that most of the Kibaran rocks in the eastern segment might have been removed by the erosion of the postulated eastward flowing streams before the elevation of the Rift.

This area has been very poorly explored because of its rugged topography and inacessibility. Its potential is unknown though from our interpretation there seems to be no reason to believe that significant tin deposits could not be found in the extension of the Manono, Kiambi and Mitwaba geomorphic/structural trends.

The northern portion of this area from west of Kongolo (Lubunda) to Niemba has undergone far less Tertiary to Holocene diastrophism and probably appears much as it did in mid-Tertiary time when it acted as a divide between the Kivu and North Shaba areas. The streams north of this area flowed north and east while south of the Makutano/Zongwe "Massif" the streams flow east and south.

C. La Province des Hauteurs Permo-Carbonifers

This region is characterized by high ground separating the Lomami and Lualaba drainage systems, the area between Kasongo in the Kivu and Lubao. This area is underlain by a large NW-SE trending auticline of Permo-Carboniferous sedimentary rocks which are flanked

by Triassic sedimentary rocks. The highest bluffs of this area are in Permo-Carboniferous rocks while the lower slopes are covered by Pliocene and Pleistocene sediments. This would suggest a broad valley or plain from Kabinda in the west to Kalemie in the east with the axis of the plain trending from NW to SE. The probable age of this plain would have been Jurassic to late Tertiary.

Drainage throughout this area would, we believe, have been from northwest to southeast prior to the deposition of the Plio-Pleistocene sediments with reversal taking place sometimes in late Pliocene at a time when the elevation of the rift system took place. Most of the early drainage toward the present mouth of the Zaire probably took place via the Luvua/Lomami. These two rivers were probably joined somewhere south of Kabalo and north of Ankoro. It appears that a similar valley parallel to the above developed the Luika/Lualaba basin. The Lualaba captured the entire drainage area of the Lomami East of Kabongo by headwater erosion after cutting the gap at the Gates of Hell. The Lualaba was able to do this because of its proximity to the rejuvenated regions of Rift.

This rejuvenation produced rapid downcutting of the underlying rocks and transport of sediments to an area just east of Yangambi. These sediments partially blocked the mouth of the Lomami and caused it to become sluggish and less capable to transport its load. This blockage caused early Holocene sedimentation in the Lualaba (then the Luvua/Lomami) just west of Manono and in the upper Lomami, (near Kabinda). Meanwhile the Lualaba became more rapid and quickly breached additional thalwegs, capturing more streams until it controlled the entire system as far south as Lake Bangweolo. The recent development of Lake Upemba graben has slowed down this process somewhat. The construction of retaining dams in the area of Kambove and Kolwezi has also had this effect. Were these dams not built, capture by the Lualaba of Zambezian drainage would continue. (In some cases it does, as in the Luapula (Robert 1956).

D. <u>La Province des Hauteurs Bushimaienne-Mesozoic</u>

This area is characterized by relatively smooth poorly dissected plateau between Kabinda and Kabongo. It is underlain by Mesozoic rocks with a few remnants

of Tertiary (Kalahari) rocks in a central syncline which is flanked by two broad anticlinal valleys underlain by Bushimaian rocks. The eastern anticline has a core of mid Bushimaian dolerites which control the course of the Lomami for about 100 kilometers. The core of western anticline is occupied by the Lubilash River.

It is the belief of the authors that these three major folds have controlled the direction of drainage in this area since pre-Kalakari time. The patterns of the outcrops of these rocks clearly suggests this and supports the hypothesis that drainage was in a south-easterly direction at least until the Neogene.

E. Le Plateau de Lubao-Manono/L'ancienne Vallee de la Lomami-Luvinza

Although this region is composed of several small geomorphic units, the title we have given it refers more to its paleogeomorphology as we believe it to have existed. Various of the above sections have treated the subject. In these descriptions we have suggested that the plain which is only interrupted by a few hills west and south of Ankoro has in fact remained much the same since Jurassic time. The major changes which have taken place in this area are we believe, (1) the reversal of drainage in this depression so that now Manono is on a plateau whereas in Jurassic time Lubao was the plateau area and, (2) the capture of the upper Lomami(now the Luvua,)the Lukishu,and the Luvinza by the Lualaba in recent times.

We believe that these interpretations are correct, and they demand careful verification because of their implications on mineral exploration programs.

Conclusion:

The geomorphic history of the region can be summarized as follows:

1. Jurassic- A high plain, or plateau dipping gently to the east-south-east, drained by intermittent streams during a relatively dry period

2. Triassic- The ingression of shallow seas of short duration. The area was denuded and erosion similar to that in the Jurassic began while continental red beds (sheet deposits) formed and filled intermontaine depressions; a very dry period set in.

3. Early Tertiary-Erosion to the southeast continued very slowly until rifting began when differential uplift caused the damming of the southeastward flowing streams and the deposition of a small amount of sediments along these streams. During this period eolian activity took place with little aqueous erosion. The eolian sequence is represented by the Kalahari sands. During the end of this period (in the Eocene) the rift was elevated to nearly its present height and the continent tilted westward to permit the drainage of the Congo Basin to begin toward the Atlantic. A wet period began at this time and an erosional cycle was reinstituted in this area. Erosion was rapid but deposition was within closed basins during Pliocene Pleistocene times as evidenced by the sediments in the Kabalo area.

4. Late Pleistocene-Holocene. Due to the headward erosion by the Zaire River the inland basinal lakes of Mid Pleistocene time were captured by the Zaire system and the effect was to create widespread erosion in the Lukuga basin which in turn captured the Lomami Lufura and Luvua drainage basins, and established the present topography.

10. Geology and Tectonic Framework

Based on the available information, the following outline of the geology of the region is proposed:

Precambrian

a. Ruzizian

The oldest rocks in the region are said to be Ruzizian (approximately 2.72 billion years old). These rocks are poorly known and poorly mapped but are described as migmatitic gneisses, mica schists, amphibolites with large lenses of quartzite and occassional crystalline calcareous rocks.

Particularly in the region of Monono and Kongolo the ERTS team found it very difficult to correlate outcrops with mapped data. For instance the composition and structure of metamorphic rocks north of Kongolo at the Keba bridge which are said to be Ruzizian differ very little from rocks found east of Monono on the road to Kiambi which are simply mapped as "granitic" rocks of post Kibaran age. (970 million to 1.0 billion years ago based on radiometric dating.) Further confusion is added by the fact that analysis of microfolded rocks surrounding the Manono pegmatite sugest two periods of folding. One of these produced folds trending NW-SE parallel to known Ruzizian folds in the Kivu, the other superimposed on the first produced folds trending parallel to established Kibaran structures and striking NE/SW (I.Popa (1980) Geomines; personal communication), yet the area is mapped as being post Kibaran.

The above inconsistencies made it very difficult to establish a coherent sequence of events or even to map these units from Landsat images particularly because of the heavy alluvial and forest cover which mask the few outcrops.

Until further radiometric data is available for this region few if any conclusions can be drawn concerning the so-called Ruzizian basement complex in this region except that the rocks do have a NW/SE trend.

b. Kibaran

Most of the areas mapped as Kibaran rocks in this region are undifferentiated as to their relative position within this system. These rocks are similar to those described for the Ruzizian and include quartzites, phyllites, quartzitic conglomerates, sericite schists, chlorite schists, some calcareous lenses, intercalation of quartzites and conglomerates with mica schists and amphibolites at the base. Dolerites are said to intrude the mid-Kibaran rocks. Such is the case at Monono. Kibaran rocks in the southern portion of the ERTS area are well defined near Mwanza, and southeast of Manono, where large folds have been mapped and the upper and lower Kibaran can be differentiated.

In the central region between Manono and Nyunzu little work has been done and the rocks are simply mapped as granitized rocks of Kibaran or post Kibaran age. In the north, between Kongolo and Zongwe, Kibaran rocks are relatively well mapped though large folds are either not mapped or are poorly defined.

Both Kibaran and Ruzizian rocks have undergone retrograde metamorphism, especially in the central region where phyllites predominate.

Structurally Kibaran rocks have been mapped as folded and striking northeast though some exeptions can be noted, especially north and south of Piana Mwanga.

c. Bushimaian Rocks

These rocks have been relatively well mapped and occur mostly in the westernmost portion of the area.

The upper Bushmaian consists of calcareous rocks, mostly dolomites and stromatolitic calcareous rocks. These rocks are underlain by quartzites, schistes, arkoses, conglomerates and at the base quartzites chert, with another sequence of quartzites, and red schistes.

Igneous activity during this period apparently occured between the upper and middle Bushimai time and was responsible for the intrusion of a very large laccolith north, east and south of Kabongo. These basic volcanic and intrusive rocks could be economically important as they or marine rocks deposited concomittantly are very good host rocks for massive sulphide deposits and biogenically concentrated sulphides.

d. Permo-Carboniferous Rocks

The Permo-Carboniferous rocks of this region are represented by glacial and periglacial continental deposits and are relatively thin in this region. Their maximum thickness is attained in the highlands north and east of Lubao. This thin mantle has in many areas been eroded. The outcrop areas of this series are to be found in a number of river valleys which may represent the original extent of this formation and implies the existence of some of these valleys in Permo-Carboniferous time.

In the region of the highlands between Kongolo and Makutano, these glacial erosion products fill intermountain valleys indicating a region of valley glaciers with its apex some 25km east of Makutano. Westward toward Lubao these sendiments become more extensive and may represent glacial outwash plain deposits and continental, lacustrine and sheet deposits.

These deposits are affected by orogenesis and have undergone some metamorphism which has produced well cemented tillites, schists, argillites and psamites. This metamorphism is not explained in the literature and suggests that post Permo-Carboniferous orogenies may have been more intensive in this region than previously supposed. Work by the ERTS team in the area of Maya Moto 20km south east of Kongolo found that the hot spring and the associated igneous rocks had intruded Permo-Carboniferous rocks and is evidence at least of some strong local contact metamorphism.

Structural descriptions and existing maps of this area do not show any major faulting to have affected these rocks.

No mineral deposits of great value can be expected in these rocks although some coal deposits are known. In regard to gold and tin deposits Permo-carboniferous glacial events would have had the effect of disseminating the alluvial ore eroded from earlier rock sequences.

e. Triassic Rocks

The Triassic rocks of this region are typical continental "red beds" and arkoses whose extent is widespread. These rocks occupy much of the length of the Lomami drainage basin from Kabongo to north of Lubao and in an area north of Nyunzu and east of Kongolo. These rocks would appear to be derived from the Permo-Carboniferous and Precambrian rocks they overlie and are usually not resistant to erosion. Most typically they are either not cemented or poorly cemented.

These sequences apear to represent playa type deposits, much as those found today forming in the U.S. Basin and Range Province This suggest the possibility of some faulting and the formation of Grabens in a NW/SE direction.

Triassic arkosic sands may well be good targets for gold tin and diamonds exploration especially in areas where fossil rivers flowed or where present streams flow across these ancient channels.

f. Cretaceous

Cretaceous rocks rest immediately upon Triasic rocks of this region thus providing evidence for Jurassic hiatus in the area and suggesting that an erosional cycle was in progress during the Jurassic.

Most outcrops of the Cretaceous occur west of the Lomami, although a small basin has been identified north of Kalemie. In the west the rocks have been described as a thin succession of lacustrine, lagoonal and shallow marine sediments representing a transgressive sea environment. The rocks from top to bottom are represented by coarse sands, argillites, schists, fine sands, argillites, sandy shale, and cross bedded very fine sands. This succesion is marked by ostracods and fish, some of which appear to have marine origins.

Based on evidence derived from available geologic maps it would appear that these rocks have (along with underlying sequences) been gently folded from NE to SW or subparallel to the Tanganika Rift.

According to various authors the Mbuji Mayi Kimberlites were intruded after the deposition of these late Cretaceous sediement; most probably at the time of the above mentioned folding which may have been brought on by the initiation of rifting in early Tertiary time. This rifting probably initiated a late Cretaceous cycle of erosion which culminated in mid-Tertiary continental deposition. If these Cretaceous rocks are in fact the hosts to the Kimberlite intrusions then they become major targets in the project area. On the other hand if the Kimberlites are pre-Cretaceous as some authors hold, (Veatch 1935) they remain nevertheless target area for alluvial diamonds.

g. Tertiary Rocks (Systeme du Kalahari)

Rocks of this age occur in the same region as the

Cretaceous but their extent and thickness is limited especially to an area north and south of Kabongo.

These rocks are described as the "gres polymorph" and tend to be a combination of continental type deposits exemplified by eolian deposits. Beneath this series are found the "serie des sables ocre". These are of limited thickness and consist of sands, mud and are of lacustrine origin.

Generally these rocks represent erosion products derived from the newly elevated terraines of the rift massif. Specifically, in this region, they appear to be erosion products derived from the denudation of a region between Lubao and Kananga. This region previously mentioned was slightly and broadly folded during late Cretaceous or early Tertiary time. This cycle of erosion removed part of the Cretaceous record while depositing Tertiary rocks directly on the Bushimaian sequence.

There is no allusion to faulting in the literature. No mineral deposits are noted in the literature for this sequence of rocks. This subject will be taken up in another section.

h. Quarternary System

The Quaternary for this region is poorly mapped and is split into two divisions. Late Tertiary (Pliocene/Pleistocene)and Holocene. As mapped by previous authors the sediments of Pliocene/Pleistocene age are confined to the region between Manono and Kongolo. They are particularly notable in the lower reaches of the Lukuga and Luvua Rivers and interspersed in a broad plain for 40-80 kilometers in every direction from a central point at Kabalo.

These deposits are described very generally as fluvial terrace, lacustrine clay, fossilized soil horizons, laterites gravels and slope deposits.

These descriptions do not do the area justice, and in many cases Plio/Pleistocene and Holocene sediments aren't mapped in major rivers such as the Luika, Luvinza, Lukushi etc.

Only one fault is shown in these sediments and this

is shown as occuring parallel to the Lake Upemba Graben.

Sediments of this age are extremely important sources of alluvial minerals such as tin and gold.

11. Structural Geology

The structural geology of this region is highly complex and is partly described in various other parts of this report. A short recapitulation will suffice to introduce the interpretative Landsat work.

Geologic maps indicate the regions'major structures with corresponding ages as follows.

1. Ruzizian folding with movement from southwest toward the northeast; thus suggesting a Ruzizian PreCambrian continental land mass to the north east toward or beyond Lake Victoria.

2. Kibaran folding with movement from southeast and east toward the northwest and west suggesting a landmass to the northwest and west.

3. Katangan folding with movement from the northwest although this is not certain. Katangan movements (post Bushimaian) were complex and may have come from the south and southeast as well. This is evidenced by the great arc of folds in the Kolwezi to Lubumbashi region. This complexity is not suprising in view of the mineral deposit found in the region. The authors interpret this multidirectional folding as being responsible for the syngenetic deposits found in south Shaba. It is thought that the region was only slightly depressed and permitted mineral rich saline waters to transgress the area. The area appears to have been unstable and folding may have gone on intermitently during a long time. This diastrophic action had the effect of isolating small embayments and permitted the concentration by biogenic factors of base metal rich deposits.

4. Faulting during the late Mesozoic and early Tertiary which produced the great Rift grabens and which continues to this day.

Mineralization is related to the first three of these events and, until now at least, we have no evidence of primary mineralization due to late Mesozoic or Tertiary diastrophic events.

Tin and gold are probably associated with the folding and migmatitization of both Ruzizian and Kibaran rocks, and both metals could be associated with and introduced during the Katangan folding.

12. Lithologic and Structural Analysis by means of Landsat Imagery

The methodology used for the preliminary analysis of four Landsat scenes in North Shaba was described in the first part of this report. In the sections that follow we will describe the method used in the final interpretation and how the method was changed for a variety of reasons.

Methodology

The first interpretation effort made on the Landsat imagery upon the return of the ERTS group from the field was to conduct a structural analysis on imagery, black white and colour and multi date, at a scale of 1:1000,000. In this effort three separate interpreters were used, one of whom had not been in the field and was not prejudiced by any notions acquired through anything more than a rudimentary knowledge of the area.

Linears

This first interpretation attempted only to plot linear features. Each interpreter provided overlays of his finished work, at which time the overlays were composited. Whenever two or more interpreters agreed on the position and direction of a linear that feature was plotted on a final overlay. After all common features had been plotted each interpreter defended the linears not accepted or seen by the others. The results showed that about seventy percent of the linears were mapped with full or bipartite agreement; approximately 15 percent were discarded and another 15 percent were successfully defended and accepted by the group.

Faults

In the case of certain linears, apparent movement along these which is indicated by obvious displacement, at the junction of two linear features allowed us to map these as faults and to indicate relative displacement. This relative displacement may be incorrectly indicated but unless further field work is done the real geometric relationships in certain cases can only be considered as conjecture .

Thrust faulting appears to be much more prevalent than one would suppose from the literature. This is particularly true for the region between Lake Moero and Lake Upemba. Thrust faults in this region can be identified by rather abrupt topographic and vegetative changes particularly at the base of long undulating linear fronts. A number of these fronts appear on the Landsat images in the region mentioned above. Some of these cannot be mapped as thrusts with enough certainty and have therefor been shown as complex faults.

Folds

A large number of folds occur east of Kongolo and north of Nyunzu where these appear quite clearly on the Landsat imagery. The folds are symmetric and so relatively easely mapped. Faults occasionaly transect them and help in the task of understanding their inherent geometric relationships. Slopes and vegetations patterns also help in establishing the nature of the folds. Aerial photos helped to differentiate anticlinal from synclinal folds. Low level overflights and field work corroborated this interpretation. In addition this work was facilitated by the synoptic view from Landsat (e.g. once one fold is identified as an anticline, it follows that the next one will be a syncline).

Lithology

Lithologic units were very difficult to map from Landsat with some exceptions. These exceptions are: recent surface sediments, areas of thick colluvium and alluvial filled valleys and marshes.

Ruzizian rocks were seperable from Kibaran rocks wherever their strike was different. Where it was the same or similar, great difficulties arose. Where flat

lying sediments discordantly, overly folded rocks the mapping was simple. When certain sediments or rocks, though concordant, have distinct granulometry and texture, these textures and variations were clearly discernable on Landsat. The method used for lithologic mapping was simple but extremely time consuming. Three geologists made separate interpretations at 1:1,000,000 scale and each used the geologic map of Zaire at 1:3,000,000 as a guide. These interpretations were composited and no more than 40 percent agreement was found. A new method was introduced to solve this problem. This consisted of enlarging the geologic map by means of a pantograph to a scale of 1:200,000 and overlaying the image on these enlargements over a light table. This approach solved many of the problems and errors on the map became quite obvious as did those on the interpretation.

Although our task was simplified it was not solved. Based on field work in the area we knew that there were many mistakes on the geologic map, neverteless this system permitted us to map the lithologies with what we believe to be a certain measure of success. Beyond this we used aerial photos in a few chosen spots to verify our interpretation as well, of course, as using our field notes.

Finally obvious discrepancies between map and interpretation were lengthily discussed and the necessary compromises were reached.

We believe that our results would have been far better had our time in the field been adequate and the financial means more readily available. Our methodology took these constraints into account and we believe the results to be very good under the circumstances.

13. Image Interpretation (Planches 11 A-D)

A. Lubunda Scene (Planche 11A)

Introduction

As has been mentioned earlier, no field work was carried

out in this region and only one overflight (Planche 12A) was conducted. The reader must therefore take into account that no field checking took place.

Structural Geology

Landsat imagery clearly shows three major directions of jointing or faulting. The first and apparently oldest is a north west trend parallel to the Ruzizian basement folding. The second direction is north east and parallels the Kibaran folds found to the north east. Some of these faults show displacements of the southern block to the north east. A third direction of faulting appears to be recent and is parallel to the Lualaba River from south of Kabalo to the mouth of the Lukuga. This set of faults are apparently normal and parallel the great Rift system of structures, suggesting a westward migration of tectonic activity in this region.

Lithology

The lithology of this region is difficult to interpret on the micro level but gross lithologic units were easely distinguishable. For example the boundary between Permocarboniferous rocks and Triassic rocks east of the Lomami is quite obvious as is the boundary between Ruzizian and Triassic rocks. Kibaran rocks are relatively easy to map because of erosion resistant rocks of this age form folds which are quite clear on the Landsat images. The units which are difficult to map are those units which have never been clearly defined in the literature or only described as granitized rocks. During interpretation the tendency was to include those either with Ruzizian or Kibaran rocks.

Economic Implications of Landsat Interpretation

Because this area was not visited on the ground and because it is not known as a mineral producing area our ability to arrive at useful conclusions regarding the potential for mineralization in this region is limited.

Unquestionably and without hesitation we would suggest that the Kibaran and Ruzizian rocks of the area should be evaluated for their tin and gold potential especially in the area west of Ankoro and west of Kongolo. The southwest portion of this area also has

potential for diamonds both alluvial and in Kimberlites and deserves further attention.

B. Nyunzu and Kongolo Scene (Planche 11B)

Some field verification and aerial photographic interpretation was conducted on this area. We can say with a good deal of assurance that we have advanced geologic mapping of this region through Landsat interpretation.

Faulting and Jointing

A similar set of faults exist in this region as were noted in the area of the Lubunda scene previously described.

Those faults or joints which are parallel to Ruzizian structures (NW/SE) also cut across Kibaran folds. These joints and faults may simply be tensional and due to folding, on the other hand they may also indicate reactivation of movement in the basement along Ruzizian Trends. These joints and faults are dominant in this region. The second most important system appears to be a NNE/SSW trend more or less parallel to the Lualaba, along which we believe there has been vertical movement which is creating a trough or graben controlling the direction and flow of that river.

Folding

The area to the north of the Lukuga represents a tightly folded Kibaran terrain. Landsat interpretation revealed the location and nature of nearly all of the folds, many of which had not previously been mapped.

Lithology

In the area north of the Lukuga as well as that to the south east, lithologic relationships were relatively easy to map. However in the south east an elevated vegetated plateau proved very difficult to interpret. The main problem posed by this area relates to previous mapping of the region. In these maps much of this area

is mapped as Kibaran. Within this so called Kibaran, the ERTS team noted some NNE/SSW ridges many of which do not parallel the typical strike of Kibaran rocks nor are they parallel to Ruzizian rocks. Our initial interpretation proposed that these elongate ridges might well be doleritic dykes. No such dykes are mentioned in the literature and we were not able to visit any on the ground to verify our interpretation. We do not believe that these rocks can be Kibaran, allthough we have mapped them as such, because they appear uncomformably in the area just north of Kabeyi Mayi. In this region these anomalous ridges begin to trend due north and some even strike NNW. Aerial photo-interpretation suggests that they may be intrusive also but this was not verified. It is also known from field work and photo interpretation that the dolerites in the region from Kongolo to east of Makutano strike parallel to Kibaran structures (NE).

Ruzizian and Kibaran rocks were difficult to distinguish in the northeastern part of the region and their relationship became more confused because of the appearence of the ridges mentioned above in areas previously mapped as Ruzizian. This is so because in nearly all cases these ridges occur in areas mapped as Kiboran and younger rocks.

The solution to this problem will have to await further field work.

Economic Implications of Landsat Mapping Analysis

This zone has great potential for tin and gold as explained in the section on economic geology. Landsat analysis has permitted the elimination of certain areas and the focus of attention on others. It is our contention that tin and gold exploration should be focused on the area of tightest folding in the north corner of this degree square area. We believe also that the geomorphic model proposed in this report which suggests a southwestward flowing set of streams from Permocarboniferous through Triassic time and possibly up to the Miocene should be considered when prospecting for alluvial tin and gold in this region.

C. Manono Scene (Planche 11C)

This area can be separated into two regions: an area north of the Luvua and one south of that river. The northern area also includes much of the mountainous eastern section of this degree square area which was difficult to interpret because of the problems mentioned previously. The relationships between weathered, highly granitized or migmatized rocks of various ages were confused by previous inadequate mapping and the existence of the anomalous unidentified ridges mentioned earlier. In addition, the heavily wooded nature of this peneplained terrain made interpretation even more problematic. This same statement can be made for the area around Manono where peneplanation and surficial colluvium has eliminated or covers nearly all vestiges of bedrock. Thus it was only in the southern protion where interpretation was conducted with much certainty.

Structures

Faults and fractures were found in this region to have very similar trends to those in the area to the north. The major trends here follow Kibaran structures which in this area also occur in Bushimaian and other younger rocks. Some very long fractures occur in a northwest-southeast direction (parallel to Ruzizian structures) and control some of the major rivers including the Luvua and probably the Luvinza.

Folds

Folds were successfully mapped from Landsat and were verified in a few cases by photointerpretation at a scale of 1:40000 (see Appendix B, Planches 1.1 and 1.2). The nature of these folds is quite clear and the mapping of the relationships certainly has shown the value of Landsat interpretation.

Lithology

As explained in the introduction, determination of the lithology often proved difficult for the reasons mentioned. We believe we were relatively successful in this effort. In

certain cases doubts arose and compromises were made. It might be said that had we had no existing geologic maps to guide us we might have produced more realistic results. The obvious inconsistencies in the existing maps tended to confuse the issue but nevertheless forced us to adhere to this existing information for fear of diverging too far from the accepted data.

Economic Potential

Based on Landsat work we have proposed, in other sections of this report, that the emplacement of tin bearing pegmatites in this region is related to folding and that it is important to be able to locate the core of certain folds such as those at Manono and at Kiambi. We believe that further analysis of aerial photos in conjunction with the use of Landsat would have yielded additional data of significance. Unfortunatly time and financial constraints did not permit this work to be completed.

A significant contribution was also made by Landsat interpretation in deciphering the geomorphic history of the region. We believe that the model proposed based on this interpretation will assist future exploration programs.

D. Mwanza/Kabongo Scene (Planche 11D)

This scene was perhaps the easiest to interpret because of the variety of rock types, the very diverse topography and the sparse vegetation.

The relative scarcity of vegetation provided a much clearer view of the texture of the rocks and the highly dissected nature of the region permitted us to define rock types by means of drainage pattern identification.

Faults, Fractures and Joints

Because of its hilly nature, this area is highly dissected by streams and many of the streams have cut their channels in joints, fractures and of course along faults. The most important fault in this region bisects this Landsat image area from SW to NE and follows the course of the Luvidjo River. Along much of its course this fault separates rocks of very different age and appears because of its length and uneven nature to represent a crustal

suture. In the southern portion, the rocks to the east of the fault are Kibaran and those on the west are younger which implies, either reverse faulting or thrusting. In fact the entire region from Lake Upemba westward to the above mentioned fault is composed of a series of small thrusts within the Kibaran rocks. Farther north and west another thrust fault acts as the bound ry between the Kibaran and Bushimaian rocks. In the far north of the scene area, movement is indicated along faults perpendicular to the thrust front. These displacements do not seem to exceed 2 Km and were more probably on the order of one kilometer. This thrusting is obviously post Bushimaian,because.Kibaran rocks rest on the Bushimaian. Of interest also is the fact that the Bushimaian rocks in this area are not folded parallel to the direction of thrusting but perpendicular to the main direction of Bushimaian folding. This suggests that these small Bushimaian folds have been emplaced as a result of a massive thrust front moving from an easterly direction.

Folds

The folds in the Kibaran rocks of this region are highly broken up by faults parallel as well as perpendicular to their axis. Of interest is a small fold/dome in the Permocarboniferous rocks east of the Luvidjo River (6 50' South latitude; 26 40' East longitude). This fold suggest that there may well have been some orogenic activity after Permian time which produced the thrusting mentioned above.

Lithology

In many areas the ERTS team was able to refine the location of the boundaries of formations whose locations previously were vague. We were able to define three granite apophyses and may have located some Kimberlitic intrusions. Most important, some major folded units within the Kibaran have been mapped for the first time and the extensions of these folds have been traced so that lithologic continuity can be traced for the first time. The ERTS effort provides the first map on which one can clearly see the tectonic relationship of this region.

Implications of Landsat Interpretation to Economic Geology

The extent of detailed mapping conducted by the ERTS team on this image without the aid of field work and the conclusions drawn therefrom has added a great deal of basic geological information to that collected and in itself will have a great bearing on future exploration programs.

Of very great importance is the possibility that Kimberlites occur in the northeast section of this area. Landsat images shows some very small circular features which appear in Neogene and Bushimaian rocks. These circular features are apparent because of vegetative differences over the areas in question. The fact that they are all circular or nearly so and confined to two rock type under geologic conditions similar to the Kimberlites at Bujimai is significant. Field verification was not possible and could be easily accomplished should our conclusions be considered valid.

In addition,field work in the Bushimaian folded rocks in the central area could prove fruitfull if a search for syngenetic biologically concentrated lead zinc deposits is initiated. Once the proper geological horizon is identified Landsat could be used to simplify the search.

Summary of Landsat Interpretation

The ERTS team conducted a geologic demonstration project to acertain the potential of Landsat imagery for mineral exploration in a 4 Landsat scene area of North Shaba.

The 3 man team conducted a 45 day field exploration effort in support of this goal.

The team spent approximately 18 man months interpreting the images and integrating all the available data to produce maps at a scale of 1:200000 which can be used to assist future exploration in this region.

These are the first maps of this kind and the first published geologic maps of this 135,000 square km area at a scale of 1:200,000.

The team has provided in "grosso modo" a generalized exploration model which should assist exploration teams working in this region to locate with more certainty,tin, gold and possibly base metal and diamond depòsits.

Conclusion

The objectives of this demonstration excercise were to show that Landsat could assist the government of Zaire in evaluating its mineral resources and to show that the ERTS Zaire geologists could and therefore will be able to use such data for the development of Zaire.

We believe that the report and maps produced unquestionably prove that these goals were achieved.

SECTION 3

ECONOMIC GEOLOGY

14. General

The region under study covers four major geologic provinces each having its own mineralogic characteristics and potential for a wide variety of economic minerals. The minerals which are presently being exploited are,tin columbo-tantalite, gold and diamonds.

The potential for this region appears to be much greater than production figures would suggest. This suggestion is based on the large number of prospects located throughout the region and the fact that very little systematic prospecting has been conducted except in the area of Manono (for tin). No records have been found of gold or diamond production and none seem to exist for tin other than for the mines at Manono.

The four major lithotectonic provinces are,the Ruzizo/Kibaran province in the region of Manono and Mwanza; the Kibaran/Permo/Mesozoic province of Nyunzu/ Kongolo; the Katango/Mesozoic province of Kabongo and the Katango/Mesozoic province of Lubao. Each of these regions has a specific economic potential and each will be discussed separately.

15. Zone Manono/Mwanza

This zone is the largest of the 4 lithotectonic areas studied by the ERTS team. The region is composed mainly of folded and faulted Ruzizian and Kibaran rocks which in the region of Manono have been peneplained. To the east toward Piana and Kiambi and southward toward Malemba Nkulu as well as westward toward Miwanza the region is hilly and more highly dissected.

This zone which is known for its tin and colombo-tantalite mineralization, associated with pegmatites has not been thoroughly explored except in the environs of Monono.

Geology

The tin bearing region which centers on Manono is a much larger cone shaped area beginning some 50 km north of Kolwezi and extending north-eastward to Kalemie on Lake Tanganyika and Kabambare to the north west. The distance from SW to NE is 650 km and from NW to SE 300 km.

The most productive region includes Mitwaba, Bukama, Limba and Manono. There are two reasons for this: that tin bearing rocks are better exposed in this area and because exploration has been centered on Manono where a major deposit was found during the early colonial period.

Three types of deposits occur throughout the zone; alluvial;ie.in river gravels, vein or hard rock deposits, and elluvial deposits which occur in weathered rocks overlying vein deposits. About 90% of all the tin mined in this district has been derived from this last type of deposit although the potential for vein (hard rock) and alluvial deposits is good to excellent.

Rock Types

The main rock types enclosing the tin deposits consist of two main types small masses of pegmatites and granites intruded into metamorphic sequences of rocks of Ruzizian and Kibaran age.

The variety of rocks with which tin is associated is far more varied and not enough work has been done in this district to pin point a source rock. In fact so little work has been done that during our field work we found many errors in mapping and erroneous nomenclature applied to mapped rock units. Such errors tend to eliminate certain areas from the prospectors or the geologists study as these rocks are considered incapable of hosting tin deposits.

Work in the field indicated that the area is almost exclusively underlain by highly metamorphosed rocks whose age is very difficult to determine. These rocks consist of in the main of highly foliate gneisses and schists trending 50 east of north.According to work conducted by Ivan Ropa geologist for Zairetain, these rocks

were deformed twice, by two successive but district orogenics; the first post Ruzizian and the second post Kibarian. This suggests that the tin deposits are not necessarily inherent to Kibaran rocks as has been proposed by previous authors but are probably related to both Ruzizian and Kibaran rocks. In any case this conclusion broadens the prospects for exploration in the region as it does not exclude rock types of Ruzizian age as had been proposed by previous workers.

The work conducted by ERTS Zaire showed that tin occurs in a wide variety of metamorphic rock types but usually where pegmatitization occurs. Field work did not locate real granite ad has been mapped by various previous geologists and that therefor tin mineralization is not related to massive granite intrusions but rather to a more widespread granitization phenomenon. Such work indicates that the potential for tin in the region is much greater than had previously been thought.

Certain conclusion concerning the geology of the deposits and the regions potential have been arrived at based on the work done in the field and the analysis of Landsat imagery.

1. Tin bearing veins and pegmatites occur in parallel bands and tend to be nearly continuous over great distances as shown on the enclosed map.

2. Based on Landsat analysis and previous work (ibid Mumba district), it is believed that the tin occurrences are related to the position of major synclinal throughs. These synclinal basins were deeply buried and more highly metamorphosed during the successive orogenics of Ruzizian and Kibaran time. The result was the creation of solid solution melts which later crystallized as pegmatites and which occur in the care of the major synclines of the region.

3. Mineralization is widespread and very little scientific prospecting has been done. Field work indicates that work should be concentrated

on the trends established in 1 above, e.g., between Manono and the Luizi River to the north east, between Luiba-Bukama and Kisinga on the Lukuga River and between Kifinga and Mukai on the Luiboro and Lukuso Rivers.

4. Structural guides, such as the location of synclinal throughs, should be sought and a careful analysis of the region should be undertaken to develope a structural model which would show the other structural controls on the region including: block faulting Mwanza, Malemba-Nkulu and thrust faulting Kiabukwa-Misongwe.

5. The regions in which alluvial tin has been mined by local labor should be explored with greater care to locate possible deposits.

16. <u>The Manono Deposit - Production, Potential Reserves</u>

The Manono tin deposit was discovered in approximately 1918. By 1925 surficial deposits of about 3 meters in thickness had been mined and the main ore body (hard rock pegmatite) was discovered.

This deposit consists of a lenticular pegmatite deposit which extends over a total distance of 14 km. This lens like deposit is separated into two distinct ore bodies trending south west to north east. The southwesterly ore zone is known as Kitotolo whereas the northeasterly zone is called Manono.

The ore grades that have been mined until recently exceeded 2 kg per m^3 of SnO_2 or about 1.5 Kg tin per m^3 for a value of approximately $24.00/$m^3$. These tenors do not include values of associated Columbian and Tantalum.

<u>Type of Material Mined</u>

All the material mined to present has been secondary type alluvial or weathered (altered) bed

rock. No hard rock material has ever been mined though similar values are known (have been sampled for) in the hard rock pegmatites.

This material is and has been mined in two ways.
1. The residual soils overlying the deposit or the rotten, altered,bedrock are shoveled, mechanically or manually on to conveyor belts which transport the material to a washing shed where the tin is washed out of the surrounding waste and processed through a series of trommels, jigs and vibrating tables.
2. The tin bearing overburden is washed in situ by directing water under pressure through "monitors" at tin rich sections, the material then is carried by gravity towards sluice boxes which lie on the ground where the tin collects behind riffles.

According to local sources, mining recovery does not exceed 75% for case 1 and 66% for case 2. No system exists for recovering the fine grained cassiterite (tin) columbite and tantalite.

This information has been verified by testing at least two of the "dumps". One of these was found to contain in excess 300 grams of SnO_2 per $m^3$the other in excess of 500 grams of SnO_2/ m^3.

At no time has bedrock been mined although it is a well known fact that it is as rich in places as the overburden that has been exploited.

A drilling program was conducted at the Kitotolo pegmatite in the late 1950's. This drilling was limited in area and especially depth. No drill hole found the bottom of the pegmatite ore body, tenors exceed 1.5 kilos/ton in every case. The deposit is open to the south east, and in both directions along it's strike.

Although this material is hard rock it would not be very difficult to mine it in an open pit or to set up crushers. The prevalent feeling is that the material is extremely hard and would not lend itself to crushing. This is not the case as pegmatites are extremely friable due to (the large crystal size) their coarse nature and the fact that 85% of the components have cleavage

planes along which breakage occurs. In addition the cassiterite (tin) and colombo-tantalite occurs in distinct grains and not as compounds with gangue elements. These grains crystallized at depth under great pressure and remain under pressure presently. Any blasting of the deposit will produce a release in pressure and loosen these grains before they arrive at the crusher.

The conclusion to be drawn from observation of the mine is that the superficial, secondary, deposits are very easely worked either by primitive or modern mechanized methods and that primary, hard rock deposits would not create undue engineering problems. Of course an engineers report would provide details on the exact nature of the problems if any existed.

Production

According to available sources, total production for the mine from 1918? to 1972 was 177,000 tons of SnO_2 . Since 1972 best estimates place production at 18,750 tons of SnO_2 for a total production of 195,750 tons of SnO_2. Production in 1979 was (according to reliable sources) 760 tons of SnO_2. The most recent production figures from Zairetain indicate that production has gone from 40 tons in November and has stayed at an average of 37 tons for December, January and February. If production continues at this level production for 1980 cannot be expected to exceed 450 tons.

This decreased production is not due to a decrease in reserves. In 1972 reserves were said to be on the order of 140,000 tons SnO_2. The decreased production is due to mismanagement, poor and very old equipment, no supervision, lack of parts, lack of maintenance, lack of training of a Zairois cadre, extremely low wages and low morale.

The production numbers above noted do not include approximately 3 percent columbo-tantalite which has been mined since the opening of the mine (approximately 6,000 tons of columbo-tantalite).

Production figures are also somewhat misleading because Zairetain buys tin concentrates from local producers at other mines. For example we are aware of a purchase of at least four tons from a small operation

at Kiambi from June '78 to June '79. Even with the equipment available production could be increased by improving wages, by repairing some of the equipment on site and by improved supervision and control. With a doubling of wages it is certain that production would double.

Reserves

By subtracting the figures given as reserves in 1972 and the tin produced since then, we arrive at reserves of 121,000 tons SnO_2, not including approximately 3 percent columbo-tantalite which would amount to 3,700 tons.

The source for these reserves is the "Notice Explicative 1974", and it does not specify whether these reserves are in hard rock or in superficial alluvial/elluvial deposits.

These reserves must also be taken with a grain of salt since very little work has been done by Geomine/Zairetain outside the immediate mine area and areas with tenors of less than 500 grams per cubic meter are not considered in these calculations.

Reserves of hard rock have been calculated for a very small area in the central quarry at Kitotolo. No drilling program has been conducted outside of this quarry. Where tenors in bedrock appeared to be on the order of 200-500 grams/ton when seen by the ERTS team, Robert (1957) states that tenors in the area drilled are 2 Kilos/m^3 and that the drilled reserves are 100,000 tons SnO_2.

In addition, the pegmatite ore body dips to the south east under the dumps and no drilling or sampling has been carried out on this area. Mineralization (tenors) in the quarry walls do not appear to decrease in the entire south east wall in the Kitotolo quarries or those of Manono.

A more important and immediate source of tin and one which has not been figured into reserve estimates is the tin to be found in the very large dumps located south east of the entire deposit. Work by Zairetain confirms that one dump at Manono has in excess of 300 gr/m^3 of SnO_2 and one at Kitotolo in excess of 500 gr/m^3. This figure corresponds to the losses approximated; ie. 25-33 %, during processing if we use a tenor of 1500 to 2000 grams/m^3. Thus it could be expected that the 8 dumps which total approximately

200,000,000 m^3 (based on spot calculation) could yield a minimum of 50,000 tons SnO_2 if we calculate a minimum tenor of 250 grams/m^3.

The following calculations are based on maps and figures found at the mine site. Where no tenors were available the authors assumed a maximum thickness of 1 meter versus the local average of 4 and a maximum tenor of 500 grams/m^3 where most figures suggest 700-2000 grams/m^3.

Reserves Manono

A. In superficial gravels, elluvial and alluvial deposits, based on data as shown on maps found at Zairetain.

Area	Tonnage (m^3)	Tenor (g/m^3)	Concentrates in tons SnO_2
NORD MPEIL	7,200,000	811 (tested)	5,840
BORD NORD LIMITE MPETEU	325,000	500 (assumed)	162
NORD KITOTOLO BOUCHERIE	420.000	500 "	210
QUEST CARRIERES ROCHE DURE	1,260,000	500 "	630
COLLINE MANONO	159,500	500 "	80
RAVIN KAHUNGWE/ BORD NORD KAHUNGWE	813,500	500 "	407
RAVIN LUAMBWA	372,300	500 "	186

B. Dumps at Manono (Terile) - These figures are for two dumps which have been sumpled by Zairetain.

MANONO HOSPITAL	35,402,500	300 (tested)	10,500
KITOTOLO CARRIERE ROCHE DURE	30,000,000	500 "	15,000

C. Reserves Hard Rock - No definitive figures were available for the hard rock reserves as it appears that Geomines is guarding this information rather carefully. As mentioned, Robert (1957) says 100,000 tons SnO_2 were blocked out in a small area of the Kitotolo quarry.

What we do know is:

1. That values of cassiterite continue within the same levels as in the superficial (alluvial) deposits i.e., from 300 grams to 2.5 kilos per m^3 (this was done by drilling).

2. The pegmatite ore bodies are unmapped as to depth and extent towards the south east.

We can therefore make some basic assumptions concerning reserves in the hard rocks at Kitotolo only.

<u>Case 1</u>		
Minimum depth	100	meters
Minimum width	300	meters
Minimum length	1,000	meters
Giving a minimum of	30,000,000	m^3
at a minimum of	300	grams/m^3
or a minimum of	9,000	tons SnO_2
<u>Case 2</u>		
Probable depth	150	meters
Probable width	500	meters
Probable length	2,000	meters
giving a probable	150,000,000	m^3
at a probable	750	grams/m^3
giving a probable	112,500	tons SnO^2 *
<u>Case 3</u>		
Possible depth	150	meters
Possible width	50C	meters
Possible length	3,000	meters
giving a possible	225,000,000	m^3
at a possible	1,000	grams/m^3
giving a possible	225,000	tons SnO_2

* This figure approximates Roberts (1957) reserves.

D. Total Reserves for the Manono Mine

Based on various estimates the reserves for the Manono mines are as follows:

1.	Hard rock "probable" reserves	112,500 tons SnO_2
2.	Superficial gravels minimum	7,515 tons SnO_2
3.	Dumps calculated (2 dumps only)	25,500 tons SnO_2
	Total probable reserves	145,515 tons SnO_2

The maximum reserves have been calculated at:

1.	Hard rock	225,000 tons SnO_2
2.	Superficial gravels	11,168 tons SnO_2
3.	Dumps (all dumps)	50,000 tons SnO_2
	Maximum total reserves	286,168 tons SnO_2

17. Tin Potential of Areas Outside Manono Mine Proper

Various old workings, prospects amd mines were visited in the tin district of Manono. Time did not permit a careful evaluation of the potential of this district. However, some conclusions can be drawn based on overflights and short visits to places such as Kiambi and Kalemba. The area of Kiambi is of particular interest and will be discussed further.

Kiambi Tin Zone (See Appendix B)

The village if Kiambi lies 80 km east of Manono on the Luvwa River.

The geology consists of Ruzizian/Kibaran rocks which have undergone retrograde metamorphism and now consist of phyllites,friable schists and some gneisses. These rocks are intercalated with pegmatites which in at least 3 locations are tin bearing. One of these locations, Kisinga, has been worked for some years but no information is available on production and the site was not visited because the road was impassable and time was short. It is,

according to local mines, an elluvial deposit, overlying a tin bearing pegmatite. Production has been sporadic and derived from the richest gravels in this quarry. Estimates given by local miners suggest that tenors exceeded 1500 grams/m^3.

A similar deposit on the west side of the River Luvwa has been exploited but was not visited. This deposit appears to be an extension of the Kisinga pegmatite zone.

Of more interest is the recently discovered deposit of Kabanga-Kasinda approximately 5 km south east of Kiambi.

This deposit occurs near a small tributary of the Puzi River. The ore body was discovered in 1977 by a local miner "Sismond". It consists of a very coarse boulder deposit in which high concentrations of tin occur on a tin bearing pegmatite. The pegmatite forms a lens of at least two kilometers in length and is intruded by a dolorite/fine grained diabase dyke. The deposit resembles in every way the materials seen at Manono. The tin is angular and all mineral constituents of the matrix are macrocrystalline masses of subhedral nature.

The material being worked is sandy mud in a very coarse matrix of boulders. These boulders are rounded and appear to be erosion products of the Luvwa when it occupied a higher bed. Three men are working an area (quarry) 120 meters x 30 meters. Maximum depth is 3 meters and overage depth worked is 1 meter. Three men dig, move and wash approximately 75 wheelbarrows full or approximately 12 m^3. Daily production varies from 15-25 kilos of SnO_2 plus culumbo-tantalite.

Official documents, in the form of receipts from Zairetain which bought the production of this mine in 1978-1979, show the following:

1. June 1978-December 1978: 1,372 tons cassiterite (SnO_2) plus 260 kilos of magnetic portion which includes columbo-tantalite.

2. January 1979-June 1979: 2,702 tons SnO_2 plus 300 kilos magnetic portion.

Thus for the period of 1 year (June 1978 to June 1979) production was 4,074 tons of cassiterite from 3600 m^3 of overburden giving a tenor of 1.13 kilos SnO_2 /m^3.

The methods used are very inefficient and so should not be considered as anything but inefficient high grading. On the contrary, it is thought approximately 30 percent of the tin is lost in washing and an additional minimum of 2 percent columbo-tantalite is not even counted.

The significance of the Puzi River pegmatite deposit in relation to the areas potential is that:

1) It lays to rest the commonly held view that all deposits were discovered by the Belgians (it was discovered in 1977).

2) It is a rich deposit, approximately 1.3 kilos/m^3.

3) That it occurs on a pegmatite, tin rich,ore body that appears at first sight to be large.

4) That it occurs very near another deposit well known for 30 years.

Tin District of Bukena

The village of Bukena is located 70 km south of Manono and less than 12 km north of lake Upenka.

Locally the geology consists of metamorphosed Kibaran rocks which presently appear as phyllites schists and gneisses. Occasional pegmatite bodies and veins of quartz cut the county rock and these rocks are often tin bearing.

At the time of the ERTS field effort in March of 1980 exploitation had not been effected for four years previously. Local well established sources advised us that the Bukena deposits are the richest in culombo tantalite of the deposits found in the North Shaba area.

In any case this deposit, which appears to be an extension of the one at Mwanza, on the left bank of the Lualaba, seems relatively rich,in view of the fact that during the first 5 years of exploitation annual production went from 29 tons to 167 tons. Present production is unknown.

In conclusion we feel that this area deserves careful attention and modern equipment could more efficiently exploit the eluvial deposits that remain.

18. Other Deposits in the Manono Region

Haut Luizi (Upper Luizi River) Area

In the headwaters of the Luizi, near the villages of Senge, Masumbuko, Makumbo, Mukanda, tin has been known to occur since about 1925 but no information is available.

The ERTS team was unable to reach this area because of a series of broken bridges.

Certain conclusions can be drawn based on work done by the ERTS group to the north of this region on the Luweyeye River and on the basis of linears and structures visible on the Landsat imagery.

Notwithstanding that the geologic interpretation of this region is not definitive, textural and geometric patterns suggest a Kibaro-Ruzizian granitized basement assemblage comparable to the tin bearing zones of Monono and Kiambi.

Field work on the Luweyeye River and southward toward the Luizi indicated granitized rocks interspersed with schists and gneisses and "intruded" by pegmatite lenses. On the Luweyeye River we located a pegmatite dyke from which a perfect crystal of cassiterite was identified.

In the Haut Luizi area, Landsat imagery shows river channels (of Holocene age) with broad flood plains. It is in the drainage system of these rivers that the tin prospects have been noted. It is possible that stanniferous gravels of economic tennor exist in the flood plain terraces of these rivers.

The area of the Luizi can be considered as an exten ion of the anono field. The presence of many tin prospect points clearly to the existence of stanniferous pegmatites some of which may be economical.

Area of Mpiana Mwanga

A heavy mineral sample taken 3 km West of Mpiana Mwanga on the road toward Manono and near a north striking ultrabasic dyke showed after a careful analysis by binocular microscope the existence of 20 percent cassiterite.

This very high tenor suggest a source of tin nearby.

The relationship between basic rocks and cassiterite is also significant because this resembles what we saw in the Manono and Kiambi deposits. No further and more advanced work was conducted in this region. It is recommended that a careful grid geochemical sampling survey be conducted in this area.

19. Zone of Kongolo/Nyunzu

This zone is composed of NE/SW trending folded Kibaran metasediments with inliers (in anticlinal cores) of Ruzizian granitized metasediments, related pegmatites and some dikes of mafic rocks. The folds in this region seem to be typical of thin geosynclinal belts. In addition, Permo-Carboniferous and early Tertiary sediments occupy portions of this area which at the time of deposition of these sediments represented topographic lows usually associated with the cores of previously eroded anticlines. These Kibaran and post-Kibaran rocks appear to occupy a basement depression in the Ruzizian trending NW/SE. Nyunzu is located in the center of this trough.

Because the boundary of the Kibaran and Ruzizian was extremely difficult to ascertain, it is difficult to state whether the gold and tin deposits of this region are derived from one or another of these groups of rocks. A simple deduction can be made based on the widespread association of gold occurences with known Kibaran rocks as opposed to the almost complete lack of such association with Ruzizian rocks. It appears that the gold deposits in this zone are associated with the basal Kibaran epi-continental marine facies of sandstones and shales which are now found as folded quartzites, phyllites and schists.

This conclusion apparently contradicts the evidence from other parts of Zaire (see Cartes des Gites et Indice d'or et Argent; B.R.G.M.) nevertheless without better field evidence to the contrary, it must be supposed that basal Kibaran rocks are the host rocks for the gold deposits in North Shaba.

On the other hand current thought suggests that the tin deposits of eastern Zaire are genetically associated with Kibaran aged rocks exclusively. We do not believe this to be necessarily true as evidenced by heavy retrograde metamorphism in rocks previously mapped as Kibaran which suggest at least two major epochs of orogenesis

and the indication at Manono (I.Popa, personal communication, 1980) that at least 2 and possibly 3 phases of deformation have affected the mica schists and gneisses which are the host rocks in the Kitotolo-Manono mine area. We would suppose that the granitization process, during which localized pegmatitization and associated mineralization took place affected both Ruzizian and Kibaran rocks and we suggest that both these rock systems are mineralized. We also suggest that structural controls might play a more important part in the mineralization process than lithostratigraphic controls. Notwithstanding the above, the tin placer found in conjunction with gold located in the region from Kungulungu to Zongwe are found in areas underlain by Kibaran. In conclusion the best that can be said is that stratigraphic relationships in this entire region are poorly known, that the rocks have not been dated and that the genesis of the mineral deposits must await further in depth work on this area.

The Gold Deposits

This region has been known as a minor gold producer. No estimates of production have ever been made but local production was and has been persistent. Appendix A, Heavy Mineral Analysis, describes the areas sampled and the volume removed from various streams both by ERTS and local prospectors hired by ERTS. It is significant to note the large number of rivers which contain gold in this region. Practically every stream from Mbulula eastward, between the Luika and the Lukuga in the area studied, has been identified as a producer. An area northwest of Sola has also been identified as a small producer and this was one of the areas visited by the ERTS team. The rocks in this area are Kibaran metasediments and include bands of quartzite as well as veins of quarts in phyllites, mica-schists and gneissic rocks, which are all thought to be possible sources of the gold. In the case of the Kingulungu area cited above, the area prospected is located in the core of a steeply folded anticline and the gold has probably been eroded from the apex of formations where it migrated in a fashion similar to that described at Bendigo and Ballarat in Australia and in the Lunenburg gold fields of Nova Scotia, Canada. If this assumption is correct, then gold concentrations should be sought in the eroded cores of similar anticlines and the streams which drain them.

Economic Deposits

In the region of Zongwe, Belgians are said to have mined gold in a small placer operation (prior to independence) No other known organized mining efforts have come to light during our work. However it is possible that other small operations existed during colonial times. Presently innumerable local farmers take time out, during the dry season especially, to mine gold and this gold is sold locally. Work by the ERTS team shows that the gold in this region is fine but generally not rounded and thus must be near its source rock. Tenor in this area was approximately $3.45/m^3 based on $500/oz gold. In no way can this be considered a viable deposit but the various constraints imposed on our efforts (see Appendix) we believe, have very much lowered the real value of the deposit.

Various results were provided us by Cit Simuko of Makutano and though these figures are based on non scientific prospecting, nevertheless they indicate that the region has some potential particularly should gold remain above the $300.00/oz level.

The area of greatest interest is near Zongwe where various streams were prospected by Simuko. Two of these are listed below.

Stream	M^3	Quantitiy Grams Au	$/$M^3$
Kakala	92.8	174.0	$ 28.12
Kamikamba	1.5	6.5	$ 65.00

Although these figures may be exagerated, nevertheless the area warrants further attention particularly because of the large amount of cassiterite found in association with the gold. In the case of the Fleuve Kakala, Sumiko estimates cassiterite content in the 92.8, m^3 to have been 15 kilos or 162 grams/m^3 or an additional approximately $1.26/m^3 at current world prices.

Although Zongwe itself lies in a Permo-Carboniferous terrain, the surrounding rocks consist of the limbs of a Kibaran anticline and it is possible that the sediment filled valley occupied by Zongwe is composed of gold rich erosion products from these Kibaran sources. A careful analysis of this and other such valleys should be undertaken to establish the suitability of a dredging operation.

Cassiterite-Tin

In nearly every sample collected in this region cassiterite was found in small quantities. Since most of the samples were panned concentrates, in which gold was the objective, much of the tin may have been lost. Suffice it to say that the tin potential of this region should not be considered inferior to that of producing regions to the north and south (i.e. Kivu-Manono). As previously stated the cores of tightly folded rocks would be the ideal search areas in which granitization/ pegmatization and tin mineralization would have occured.

Geothermal Resources

A number of hot springs exist in this region; only one was visited at Maya Motto near Kongolo. Here mafic rocks with fine texture outcrop in 300 by 300 meter area. These rocks appear to be basalts and exhibit gross flow structures. The possible source of these flows is to the southwest where these basalts have been cut by a small stream flowing north northwest. A series of terraced hot springs occur which flow constantly and at temperatures of about 90°C. These springs are not particularly rich in sulphur and do not give off a very powerful odour. However they have a comperatively high radioactive content as evidenced by the scintilometric measurements taken at the site. This measurements were at least 10 times background over the waters. In addition 3 times background readings were measured over the basaltic rocks to the south. The rocks immediately surrounding the hot springs are typical chalcedonized and jasperized breccias.

It is obvious that this and other similar hot springs could easily be converted to a source of power. It should also be pointed out that the radiation levels in this area are quite high and may in fact be a health hazard to those who habitually use these springs for cooking or washing.

Other Radioactive Rock Sources

Scintillometric measurement were made at various locations in this and the Manono region. Certain pegmatitic schists rich in muscovite mica tended to register readings 2 to 3 times background. However in no case other than at Maya Moto do such readings warrant further attention.

Conclusions Concerning the Economic Potential of the Kongolo-Nyunzu Region

It is evident that the work conducted by ERTS in the field is by no means conclusive, nevertheless it can be stated with some degree of assurance that the widespread Kibaran rocks and associated smaller areas underlain by Ruzizian rocks are in fact good sources of tin and gold. It is also important to note that a large region of similar rocks west of Kongolo was not visited due to lack of time and funds and that this region too has similar potential. It is proposed that a thorough exploration program be conducted in the Kibaran anticlines throughout the zone to verify the existence, and to pin point possible economic occurences, of gold and tin.

20. Zone of Lubao

This zone includes the degree square area of Sentery/Lubao and the western portion of the degree square area of Kongolo. The region is generally monotonous in its flatness and is bisected from SE to NW by the Lomami River. According to the literature and available maps it is a region dominated by a broad smooth NW/SE trending trough occupied by the Lomami River and underlain by quasi-horizontal Triassic continental deposits. To the northeast Permo-carboniferous rocks predominate whereas to the southwest Cretaceous and Triassic rocks form the northeast limb of an anticline whose core consists of Bushimaian rocks.

Although there is some potential for tin in the south-eastern most region where the Lomami River has cut its bed into Ruzizian basement, nevertheless this entire region has never been considered a target area for any particular mineral.

Recent Landsat analysis has however brought some observations to light which may prove fruitful. In the area of the Lomami-Mulofia confluence a few diamonds have been found in the past. Production figures are unavailable and little is known of the region. Landsat analysis has shown very small (250 m to 600 m diameter) circular patterns, particularly just south of the Lomami. These are visible mostly in areas underlain by Tertiary and Cretaceous rocks. These may simply be vegetation patterns but they may also represent changes in vegetation over Kimberlite plugs.

Our reasons for making this supposition are based on the similarities between the geologic setting here and that found at Mbujimay. Both areas are dominated by very broad anticlines whose cores are composed of Bushimaian rocks, the flanks of both these NW/SE trending folds consist of Cretaceous rocks with some Tetriary cover. In both cases these folds have been intruded by large doleritic sills, dykes and plugs. These similarities and the fact that NE/SW faults are prevalent throughout these regions as well as being the controlling factors for the emplacement of the Angolan Kimberlites in the Lucapa graben, strongly suggest that Kimberlites may well be found along such NE/SW trends, particularly where the Lomami, Lukasi, Kayeye and Ludimbi flow parallel to these faults in the region between Kabinda and Sentery (Lubao).

The possibility of finding kimberlite in this region is not certain but should not be excluded for the reasons given above and particularly because diamonds do occur in this area and therefore their existence requires an explanation.

Conclusions

Because of lack of time and funds this area was not visited on the ground and little therefor can be said for its potential. However, based on Landsat imagery interpretation, we believe Kimberlites could be located in this area. Gold and particularly tin could also be found in the eastern and southern part of the region.

21. The Kabongo Zone-Ruzizian/Mesozoic Lithotectonic Province

From what little we know of this region only two types of mineral occurences have been found. Occasional copper and nickel mineralization associated with the dolerite sill which intersects the region from NW-SE and the placer diamonds mentioned in the Lubao section which are also found in the northernmost portion of this area.

Geology and Possible Minerals of Economic Value

Basically the Kabongo region extends from the headwaters of the Lomami eastward to the Luvidio and the Lualaba. The southern and western portion is underlain nearly entirely by Cretaceous, Tertiary and Holocene sediments. The central

portion is underlain by Bushimaian sediments and related volcanic and intrusive sequences, whereas the eastern portion is composed of a basin of Permocarboniferous rocks overlain by Triassic sediments and underlain by Ruzizian basement.

The Ruzizian basement is said to be highly metamorphoed and could well host gold and tin deposits such as those found in Manono and Nyunzu/Kongolo areas.

The Bushimaian rocks consist of a series of marine calcareous rocks that are occasional fossiliferous. The fossils are stromatoporid reefs in dolomitic sequences. These rocks are important hosts for base metals in other parts of the world (Mississipi Valley, Newfoundland, South Africa) and could conceivably be mineralized in this area also. This is particularly true of the upper Bushimaian sequence which was deposited at least at the edges of the basin at a time when the central portions were being filled by volcanic sequences. Such a combination of rock types is the ideal environment for the accumulation of massive sulphide deposits and the concentration by biogenic factors of base metals.

Diamonds could well be found in this little known region, not only in the area of the Lomami-Mulofia confluence but also in the Mesozoic highlands between Kabinda and Kabongo.

These highlands are underlain by Mesozoic and Tertiary sediments which at Mbujimay are the host sediments for many of the alluvial deposits of the area. Based on paleogeographic studies (Veatch 1935)(Stancioff 1974) pre Tertiary (Triassic) and possibly early Tertiary drainage in this area was from NW to SE. Thus it is possible that Mesozoic and early Tertiary rocks in this area may well be the hosts for alluvial diamonds. The best targets would be the upper Lomami River as well as the Mwenze and Kilubi Rivers south of Kabongo.

Conclusions

Landsat analysis and previous work suggest that this area may have potential for diamonds and volcano-sedimentary base metals in the western portion and massive sulphides and tin in the south and eastern portion respectively.

APPENDIX A

ANALYSIS OF SAMPLES

During the ERTS mission a number of rock and heavy mineral samples were taken at various locations in the Nyunzu/Kongolo and Manono image areas.

In some cases the sites were chosen prior to the ground truth work whereas in other cases samples were taken at sites which were found to be of interest after the mission had begun.

The samples consist of two types; rock and heavy mineral sands. The rock samples were analyzed on the spot and relevant information concerning position, content and granulometry were noted. Later these samples were described in the laboratory by Cit. Mayuba. Observation was limited to visual (hand lens) observations and by scintillometer. Sample locations are noted on Planch 12 A-D and the following numbers correspond to these samples.

Rock Samples

Most of the rock samples taken were typical of a granitized and highly metamorphosed region. The rocks described were granites, schists, pegmatites, guisses, amphibolites, diabase, quartzite, shale and phyllite as well as rocks typical of basic metal rich hot spring areas.

Since the description of these samples could not go beyond hand sample analysis and no thin section work seemed to be warranted, no further description of these rocks is thought to be necessary.

Heavy Mineral Sample Analysis

Sand samples and panned concentrate were collected at various locations in the North Shaba area, some of these were systematical volume samples related to the evaluation of gold deposits, especially in the region of Sola and Makutano, whereas others were grab samples of heavy mineral consentrates found in streams or along the roads of the region in which tin deposits are found.

The analysis was conducted by the consultant and Cit. Kazadi using a 20 power binocular microscope. Identification and percentages of mineral species are tentative. The sample numbers relate to the numbers on maps Planche 12 A-D

Kongolo-Nyunzu Area

Sample K-1 This sample was collected at Kingulungu, on the north slope of the core of a Kibaran anticline.The ridge strikes NE and the rocks in the stream strike 10°15° East of N with very steep dips. These rocks are mostly quartzites and phyllites and probably basal Kibaran in age. The stream sampled was shown to us by Nzuzi who claimed to have taken 2 match boxes full of gold from an area 10 m x 4 m x 1.5 meters deep, in a stream called Katanda.

After making arrangements with the local chief we proceeded to sample the stream by panning. After seeing a few colors of gold we outlined a work project for some local people and promised to return with tools, a sluice box and a pan.

Upon our return with an 2.45 meter long sluice box, shovels picks, machettes and pan, we showed the team where to work and instructed them to divert the stream and dig a pit 2x2x2 meters at the base of a small waterfall.

The results of this work are somewhat disappointing because of rivalries in the village of Kingulungu. Certain people destroyed the work of our crew and each night emptied the previous days sluice concentrates into the stream. In fact they complained to the chief in Sola and the latter jailed the people we had hired. After regularizing the situation, little time was left. The results nevertheless indicate that this region has potential.

Out of the 7 days worked by the crew, concentrates were lost on 5 days. During the 2 remaining days the total weight of gold found was 2.42 grams. Total overburden and gravel moved was 10.5 m^3. This of course cannot be considered a paying operation and the losses incurred because of the problems mentioned must be considered though they are difficult to assess. It must be added that the gold delivered to us was only from the first two days work and that all the material from near bedrock was dumped by

the competitors of our team. It could, therefore, be concluded that the higher values (near bedrock) were never tested and that the potential for gold in this district is, therefore, still to be assessed.

Binocular microscopic analysis os sample K-1a and b showed it to be composed almost exclusively of gold. The gold is in some cases rounded, but generally plates; the rounded pieces are relatively coarse, a few pieces are angular and in surficial cavities show subhedral geometry. Sample K-1c is quartz, the quartz being milky and angular. Sample K-1d is cassiterite. A few grains of angular metallic cassiterite were found in this sample.

Conclusion:

The occurence of coarse gold and cassiterite in the streams of the Kingulungu area is of more than passing interest. Although these results proved inconclusive, indications are positive and further work should be conducted on this and other streams in the area including the region to the southwest of the Katanda, along strike, in the streams flowing southwest. This region is drained by many more streams and the volume of rocks eroded much greater than at Kingulungu.

Sample K 11a

This sample was bought from Cit. Simuko at Makutano. Because of the large distances we had to cover, we located and hired Simuko to conduct some prospecting on our behalf. Unfortunately Simuko became ill before he completed the work assigned him. The results are that he only sampled a river called Kakala near Zongwe. Simko has had much experience in prospecting this region and showed us his knowledge by taking us to a small stream (Kalumbua) 500 meters from Makutano where he panned some stream sediments and recovered gold colours in each of 2 panning efforts.

Simuko also named all the rivers in the region in which he had worked and found gold and/or tin before independence.

These are listed in Table A1 and indicate that the potential of this region for these two metals is quite good.

Table A1. Gold and Tin Production in the Region of Kongolo and Ahyunzo (from Cit. Simuko)

COLLECTIVITY	LOCALITE	RIVER	SOURCE		M3	QUANTITY	SnO_2	OTHER
MAMBWE	TULAMBO	ASAGA	MTS	IHEVI	1	7 colours	10 gr	coarse gold
		LUBWE	"	"	8	5 "	TRACE	
		CHOMBE	"	"	3	3 "	"	
		ABEYASUMBA	"	"	0.1	2 "	"	
		NGAZIA	"	"	One pan	1 "	"	
		IHEVI	"	"	0.8	80 "	"	
	KUMBWI	ACHNAZOVU	"	KASENGA	19.8	65 "	± 80 gr	
		TIYWE	"	"	1.5	2 "	Much	
		ANDONDOELE			1.26	4 "	---	
	TUBUNDU	AMUGOMUSOZI	"	MUSHAMI	0.15	5 "	TRACE	
	MUTOMBO	KALUMEMBA	"	"	3.6	60 "	---	
	ZONGUE	KAKALA	"	KAYUMBA	92.8	70 gram+		see
						1600 colours	15Kilo	K-11-A
		KAMIKAMBA	"	MBIGILE	1.5	100 colours		
		KALUHEMBA	"	"	0.175	80 "		
	LUGUNDA	KALALA	"	KAYUMBA	?	?		
			"	MALIMBA	?	?		
	KASANGA/NDEGA	MUGWEYI	"	NYANGWE	?	100 colours	much	
		MULUNGUYI	"	"	?	?		
KITENGITENGE	KINTU	KAKULUMAZIBA	"	KALUMAZIBA	?	25 "		

Samples K 11a and b were collected by Simuko in Kakala River near Zongwe. Sample K 11a is nearly pure gold. Whereas K 11b consists of the black sands remaining after panning of 11a.

An analysis of sample K 11a shows the following:

Gold - The larger pieces are flat with some rounded and generally smaller more angular pieces; some pieces are coated with iron oxide, others are intergrown with white milky quartz. This suggests a nearby provenance. Weight of the gold = 1.3 grams.

Quartz-Two types of quartz are visible; angular, milky coarse grains and much smaller rounded clear to transluscent grains. Ninety five percent of the total quartz is of the former type.

Cassiterite- 3 or 4 grains of angular cassiterite (SnO_2) were also seen.

Magnetite - Some very fine magnetite grains occur in the sample.

An analysis of sample K 11b which was the panned concentrates of heavy minerals showed:

Illmenite - flat,platey, rounded equigranular, 80%-85%.

Magnetite - Octahedrous, magnetic 5%.

Garnet - Highly rounded, almandite, rose to orange coloured, about 1%.

Rutile - elongate, primatic, transparent to transluscent "rice" like grains.

Quartz - rounded and angular, usually milky, some clear, about 5%.

Cassiterite- a few coarse, angular, lustrous grains, about 2%.

Chromite ? - non magnetic,sub-metalic octahedrons.

Olivine ? - two or three transluscent,greenish yellow,grains.

Corundum ? - some elongate,well rounded,deep red,prismatic grains.

Kyanite ? - elongate, striated, angular, white to translucent,prismatic with pinacoidal terminations.

Colombo-Tantalite - 1 grain, bladed, prismatic,orthorhombic pyramidal, metallic, irridescent.

Gold - one piece, thin, platey, poorly rounded.

Sample K-16

The region north of Kabeyi Maji,from Bulamayo in the west to Kalemie in the east,has long been known as a gold prospecting area. Although much of this region is thought to be underlain by rocks of Permo-Carboniferous age, field work suggest that these rocks type do not in fact occupy as large an area as previously supposed. Outcrops on the road from Kabeya-Maji as far as Londo consist of series of NE/SW striking phyllites, schists and quartzites. These last are massive and have very obviously undergone,(as have the former) at least 2 and possibly as many as four periods of deformation as evidenced by microstructure and jointing. Similarly rocks from Mutabu to Bulamayo consist of intermittent black shales grading to slates, quartzites and phylites, which strike 57° East of North and dip steeply SE. These rocks also have undergone much deformation and it is unlikely that they are Permocarboniferous. Recent work (Alaska 1965, Newfoundland 1975; Stancioff) suggests that particulate and colloidal gold could eas ly originate in black shale and sandstone nearshore sequences such as those found in the folded rock sequences in north Shaba at Bulamayo and Maliangi. The authors believe the rocks in this region to have been deposited in such a near shore environment during Kibaran time.

Analysis

Sample K-16 is a panned heavy mineral concentrate taken two km. north of Maliangi in a stream called Misito. The rocks here are mostly quartzites with a few gneissic bands and some phyllites.

Quartz - Large quantities of angular to subangular grains, clear to milky, frosted and unpolished 60%.

Ilmenite - Highly angular, platey masses, some rhombohedral crystals, with pitted surfaces, about 30%.

Magnetite-Highly angular, massive, (coarse), with some octahedrons and pyramidal terminations, rusty reddish surface coloration, some hexoctahedrons, magnetic, about 5%.

Cassiterite- Very angular with pseudo-conchoidal fracture, metallic to submetallic luster, some small ditetragonal crystals, most grains black, lustrous, some vitreous resinous, some deep redish brown transluscent on edges, about 5%.

Sillimanite) Small transparent prismatic crystals with
Kyanite) rough terminations, streaked vertically
Spodumene) along C axis.

Gold - one flake well rounded.

The occurence of relatively high values of cassiterite and the occurence of gold in this sample make this area a good target for exploration. The source rocks are obviously to the northwest and therefor suggest that the entire fold of Kibaran rocks may have potential.

Sample K-19

Sample K-19 was collected by another prospector, Cit Kasongo and his sister on a small stream near Bugana Lumbu just south of the Luika River. The sample consists of heavy mineral panned concentrates.

Analysis

Quartz - Three types are seen in this sample, coarse, yellowish, brown,pink and white, anhedral and without striae
- Coarse, angular, transparent to white with visible gold attached
- Fine, very well rounded, lozenge shaped, about 50%.

Cassiterite - Many medium to coarse grains, angular, submetalic, about 40%.

Magnetite - Small amounts of fine, angular, sometimes platey pieces, with dull metallic luster, magnetic, about 3%.

Topaz - Many euthedral crystals or crystal fragments of light pink to yellowish, with complex pyromidal terminations, transparent to transluscent,basal cleavage.

Garnet - small amounts of well rounded to angular red to pink almandite, about 1%.

Gold - very fine, very angular,sub crystalline 1%

The large percentage of cassiterite (tin) and the coarse angular nature of the gold in this area make it a prime target. Source rocks seem to be folded metasediments of Kibaran age to the south and east.

Heavy mineral sample analysis Manono-Kiambi area

The heavy mineral samples of the Manono-Kiambi area were collected with the object of establishing the presence or absence of tin deposits in this region.

Sample M-1 - This sample was collected 38 Km east of Manono on the Piana Mwanza Road.

Quartz- Very coarse to very fine, angular to very rounded, opaque to transluscent. Some large grains have submetallic non prismatic (not Tourmaline) inclusions which may be cassiterite, 97% of sample.

Magnetite-Magnetic and metallic, dark luster,angular to rounded, this mineral represents about 55% of dark mineral fraction.

Illmenite-a few, small, metallic, lustreous, rounded to subrounded grains.

Tourmaline-large, brown and blackish, transluscent prisms, plus many angular pieces, inclusions in quartz with typical elongate prims and hexagonal cross sections makes up 40% of dark mineral fraction.

Spodumene-one large subcrystalline cleavage mass with typical striae.

Cassiterite- one or two metallic to submetallic, lustreous, black, angular fragments as well as those mentioned above (see quartz).

"Sismond" Mine Kiambi

Sample M-4 taken from the "Sismond" Mine Kiambi consists of heavy mineral concentrates from a small opencast alluvial operation of about 3 or 4km southeast of Kiambi and 1km north of the EMZA concession (PE 86 and 87).

This sample consists of 80 to 85% black angular heavy minerals with very few apparent crystal faces. Some particles are composed of quartz, the metallic mineral and mica and in general have the appearance of a typical pegmatite association.

Microscopic Analysis shows the following:

Cassiterite- Angular particles many with quartz and mica attached, grains have a resinous, to metallic luster, with parallel but discontinuous partings, some are transluscent to reddish brown, about 80% of total.

Columbite/Tantalite- A relatively large number of heavy mineral fragments are lustreous black euhedral prismatic crystals, they are orthorhombic with typical Colombo/Tantalite crystal faces visible (g,d,u,o and k)

Quartz- Mostly angular, discolored with iron staining or coating, some transparent or transluscent.

About 5% of the quartz is well rounded,frosted and pitted. Quartz is about 15% of the total.

Magnetite-Small amount, well oxidized, magnetic metallic mineral, more after rounded than angular,small anhedral grains, about 1%.

Spodumene?- Elongate primatic grains,transparent do transluscent, angular,subhedral particles with striations.

Schist- Small platey particles of weathered, muscovite mica schist with very fine texture.

Beryl - Very small prismatic crystals of brown colour.

Scheelite?-yellow/white euhedral dipyramidal tetragonal crystals

Sample M-6 - was collected on the road 3km west of Piana Mwanza immediately east of the Toy River.

This sample was collected from the road bed after a rain had concentrated the heavy minerals. The nearest outcrop was on the roadside and consisted of pegmatite with gneisses and schists alternating. This outcrop differs markedly from those in Piana Mwanza which are composed exclusively of phyllites, schists, quartzites and gneisses.

Quartz- Angular, transparent to transluscent with iron staining - 65%.

Magnetite - Magnetic, opaque, metallic, oxidized surfaces, about 3 - 5%.

Ilmenite -Flat, platey, pitted, slightly irridescent, metallic luster - 1%.

Cassiterite- black, lustreous, resinous, much red vitreous material, many euhedral or subhedral pieces, generally small crystals predominate, with some rounded edges, about 20%.

Spodumene-In elongate,prismatic,striated,transluscent to transparent grains, about 1%.

Mica - a few flakes of muscovite mica.

Monazite - Tourmaline - Topaz- Beryl -- A large number of euhedral prismatic transluscent to transparent, multicoloured grains exist in this sample these have been identified as the above minerals and their occurence is significant as they are all pegmatitic type minerals, about 5%.

The scintillometer was passed over this sample to verify the monazite content. A noticeable gain was registered indicating that the sample does in fact contain radioactive minerals.

This sample is by far the best indication that tin/tantalum might exist in mineable deposits in areas within the region other than those already found. This sample cannot represent discarded mine concentrates, because the accessory minerals demonstrate the existence of the entire tin pegmatite suite of minerals. Of significance also is the large quantity of euhedral tin which suggests (as opposed to the deposit at Monono) that mineral segregation from the pegmatite melt continued for a longer time in this area. This could mean higher concentration of tin/tantalum than at Manono.

The granulometry of this tin rich sample suggests a source nearby. A deposit at this location would fall within the model proposed in the section of this report which discusses mineral genesis.

Sample M-13 was taken 50km east of Manono near turn off to Kyoyo; sample taken on road.

Quartz - Angular, coarse, mostly transparent to milky, 65-70%.

Garnet - Angular, coarse, brownish red, 25-30%.

Tourmaline-elongate prisms, black to greenish brown.

Magnetite -magnetic less than 2%.

Limonite -small nodules

Cassiterite?- very small grains in the finest (non identifiable) fraction. Possible but unlikely.

The occurence of garnet in this sample is significant because of its absence in other samples which all contain cassiterite. It appears that this site lies in a metamorphosed terrain under anatectic granitized conditions and under conditions in which connate or plutonic fluids content was too low to permit volatilization and concentration of pegmatitic mineral suite.s

Conclusions

A small number of heavy mineral samples were collected in the region of Kongolo/Nyunzu and Manono. The microscopic analysis of these samples clearly demonstrates that the region is mineralized. In the case of the gold bearing rocks, no major concentrations of gold were found, but in the tin bearing region indications are that a systematic (geochemical) sampling program could easily turn up one or two deposits of prime importance.

APPENDIX B

AERIAL PHOTO ANALYSIS

Certain aerial photographs were purchased from the I.G.Z. for the purpose of ground truth verification. These photos were chosen to correspond with areas outlined on the Landsat images in which interpretation was difficult, where a mineral deposit is known to exist,where a large number of formations are known to outcrop in a small area and where accessibility was possible.

Due to financial problems many of the prechosen sites were not visited, however the few on which work was done will be described. Time did not permit in-depth analysis but a cursory view is provided in support of the Landsat interpretation.

The photographs used for this work were produced for the Commitee Special du Katanga from 1952-1957. The scale of these photos is 1:40,000 and the camera used was a Wild. The film is a black-and-white panchromatic film. Most of the photography was flown in the dry season, i.e. June to August. A pocket stereotype was used for interpretation and mylar overlays were made where deemed appropriate and when time permitted.

AREA I Kiambi Manono Landsat Image area

The town of Kiambi lies on a bluff about one km northeast of the Luvua River. The area is of interest because of the existence of a number of small tin mines to the south and south east of the town.

Two flight lines were studied with a pocket stereoscope to establish geologic trends and aid in the interpretation of the existence of the tin deposits. This work was done after the return of the mission from North Shaba. Prior to our departure not enough was known of the local geologic relationships to effectively interpret the geology.

Flight line 2700 (2643-2750) and flight line 2600 (2642-2650) were used. Interpretation was conducted over

the whole area in a general manner but only one photo was described, (2648) which covers an area 12x12 km, south east of the town of Kiambi. This photograph we have named Katumbwe, for the small village centrally located in the area.

Geomorphology

The area represents a poorly dissected peneplain on a complexly folded metamorphosed terrain of Kibaran age intersected from NW to SE by the superposed but reversed Luvua River .

To the north east of the river the effects of regional tilting due to the influence of the Rift system provides a greater relief whereas to the southwest, especially at some distance (2-4 km) from the river the peneplained surface is essentially undissected and unaffected by Tertiary to Recent erosion.

Streams entering the Luvua from the north east appear to be controlled by folds, and faults striking NE to SW as well as orthogonal faults. An occasional east-west stream appears to be fault controlled as in the case of a fault to the north of Katumbwe.

Geology

Based on ground truth verification and the general trends of rocks in the area,(along with information gathered from existing maps,) the rocks in this area are thought to be Kibaran.

The general trend observed is NE-SW and is reflected by drainage and visible outcrop patterns in the Kamamanze River. The rocks vary in strike from north-south to east-west but these variations are only local and it is believed are due to folding. These differences are best exemplified in the pattern of islands in the Luvua River which form a semicircular pattern as in the nose of a plunging fold.

Certain north-south striking geomorphic units as on photo 2747, 6 km north east of Kiambi appear to represent different rock types. In this case interpretation shows

a north south trending hill of different erosional susceptibility than surrounding rocks. This trend reccurs due south and some 5 km east of Kiambi where ground-truth located a dioritic (basic) dike intersecting a tin producing pegmatite. This same rock type and trend was observed 3 km west of Piana Mwanga, 34 km south of Kiambi where the Luvua abruptly changes course from a NW to a north-south direction. It is believed that this change is produced by the north south trending ultrabasic dikes.

There is no evidence on this sequence of aerial photos that Ruzizian age rocks outcrop in the region. All the evidence supports a NW/SE strike for Ruzizian rocks and no such strikes can be found on the photos except in recent terrace materials along the Luvua.

Faulting

Altough it appears that the course of the Luvua must be structurally controlled there is no irefutable evidence that such is the case. Nevertheless this hypothesis is highly probable for three reasons. The first is that many faults of considerable length parallel the Luvua particularly on its north east bank and are clearly visible on the photos. These usually control drainage of the smaller streams, those entering the Puzi and Kamamanze. The second and even more positive proof is the existence of short faults on the river itself as noted in the Luvua just south of Katumbwe. Finally,the very straight and cliffed right bank of the Luvua below the town of Kiambi to a point 2 km west of Katumbwe suggests a complex reverse fault trending about 40° west of north. Based on interpretation of the photos little or no recent movement has occured along this fault.

A series of parallel faults trending 40°to 60°west of north are plainly visible on the photos and are particularly noticeable where they intersect the Kamamanze and Puzi Rivers. Some of these faults are discontinuous and their trace is sometimes displaced by what appear to be a NE-SW set of younger faults which seem to be related to folding trending in the same direction. These faults probably are due to compressional forces associated with Kibaran folding. Finally an east-west set of faults exists, exists, exemplified by a fault 2 km north of Katumbwe which trends about 75° west of north. Considerable movement seems to have taken place along this fault as is shown by the displacement of the diorite dike.

Conclusions

Work on the aerial photos of the Kiambi area support the interpretation of the Landsat imagery in that they show:

1. Lithologic trends striking NE-SW.

2. A parallel fault system (to 1 above).

3. An orthogonal fault system (to 2 above).

Additional information gained from the aerial photos shows:

1. Geomorphic features trending NS, suggesting a different lithology probably representative of a dike system.

2. An east west fault system.

3. A possible NNE/SSW fault system.

4. A suggestion based on drainage patterns and other geomorphic features that rocks in this area are symmetrically folded.

5. By inference that certain movements have occured along various faults.

AREA 2 - 30km EAST OF KIAMBI; Photos, Kiambi 2510-2518-2520

Photo 2518 was choseb because, during Landsat interpretation, confusion arose due to the complex nature of the terrain. The region is marked by intersecting folds which suggests two sequences of folding one perpendicular to the other. With a view to better understanding this area a quick interpretation was conducted on photo # 2518 Kiambi.

Geomorphology- The area is composed of a rapid succession of ridges and valleys. The most prominent ridges trend NE/SW whereas the most prominent valley bisects the photo from NW/SE. In the southeastern and eastern portion of the photo a series of short ridges are found to trend NW/SE and are truncated (especially along the south east) by NE/SW ridges.

Interpretation- An effort was made to understand this complex region by establishing the geometry of the ridges (their strike and dip relationships). Under stereoscopic examination these relationships become quite apparent and the following was concluded as shown on the overlay P.I.2 . The area is dominated by two parallel folds trending NE/SW. The more northerly is interpreted as a syncline with very steep dips and possibly overturned to the NW. The southerly fold appears to be an anticlinal structure similarly overturned and in the core of which occur a series of perpendicular and highly contorted folds. The stream bisecting the photo from NW to SE appears to occupy a fault trend and some displacement may have occured in a left lateral fashion (such that the SW block has moved northwestward in relation to the NE block). The possibility also exists that the northeasterly section has been block faulted downward in relation to the southwesterly block.

Conclusions

Since Kibaran rocks are known to trend NE/SW throughout North Shaba, we believe that similar controls exist in this area. On the other hand Ruzizian rocks are known to trend NW/SE as in the case of the small tight folds found bisecting the photo from NE to SW.

We therefor conclude that in this photograph we see the contact, (an angular unconformity,) between Ruzizian and Kibaran rocks. We believe, further,that the underlying Ruzizian rocks have undergone 2 periods of folding and are thus highly deformed and faulted in a NW/SE direction with a possible movement from north west to south east of the northeast block. The potential for tin in this area is a matter of guess work until field work has been done, The existence of tin deposits cannot be discounted in this area since the host rocks are apparently the same age as those found at Manono, Kiambi and Mwanza.

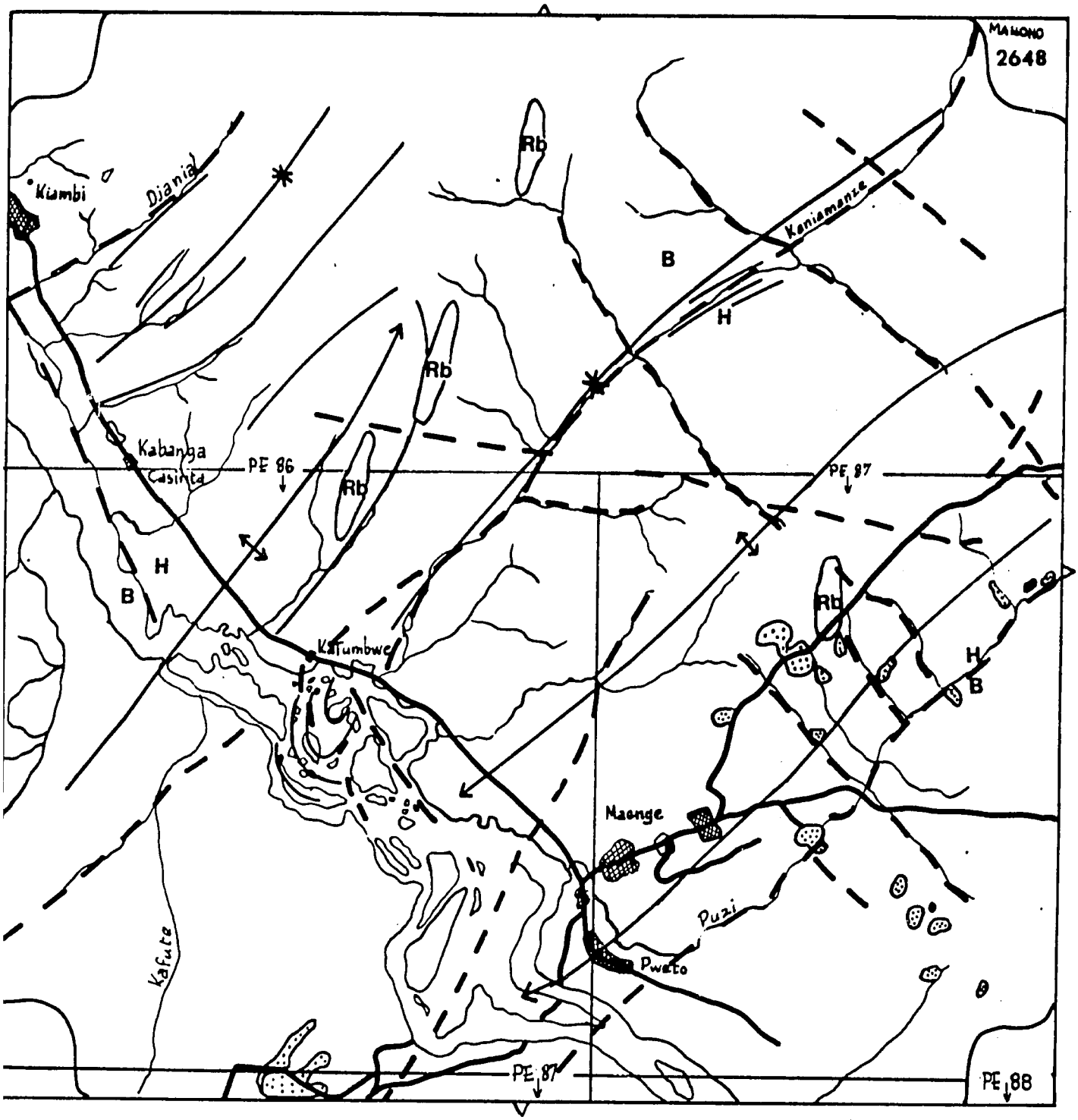
Conclusion on Aerial photo interpretation

The two areas carefully interpreted (in the Manono) region showed that such an approach can help to solve certain problems inherent to Landsat interpretation and at the same time verify the basic inferrences drawn from Landsat data.

Unfortunately all the areas chosen were not interpreted to the degree planned or required. Although some interpretation was conducted stereoscopically in each of the image areas for verification of the Landsat work nevertheless time and lack of funds precluded the completion of the work.

PLANCHE P.I.1

Photo KATUMBUE / Zone KIAMBI



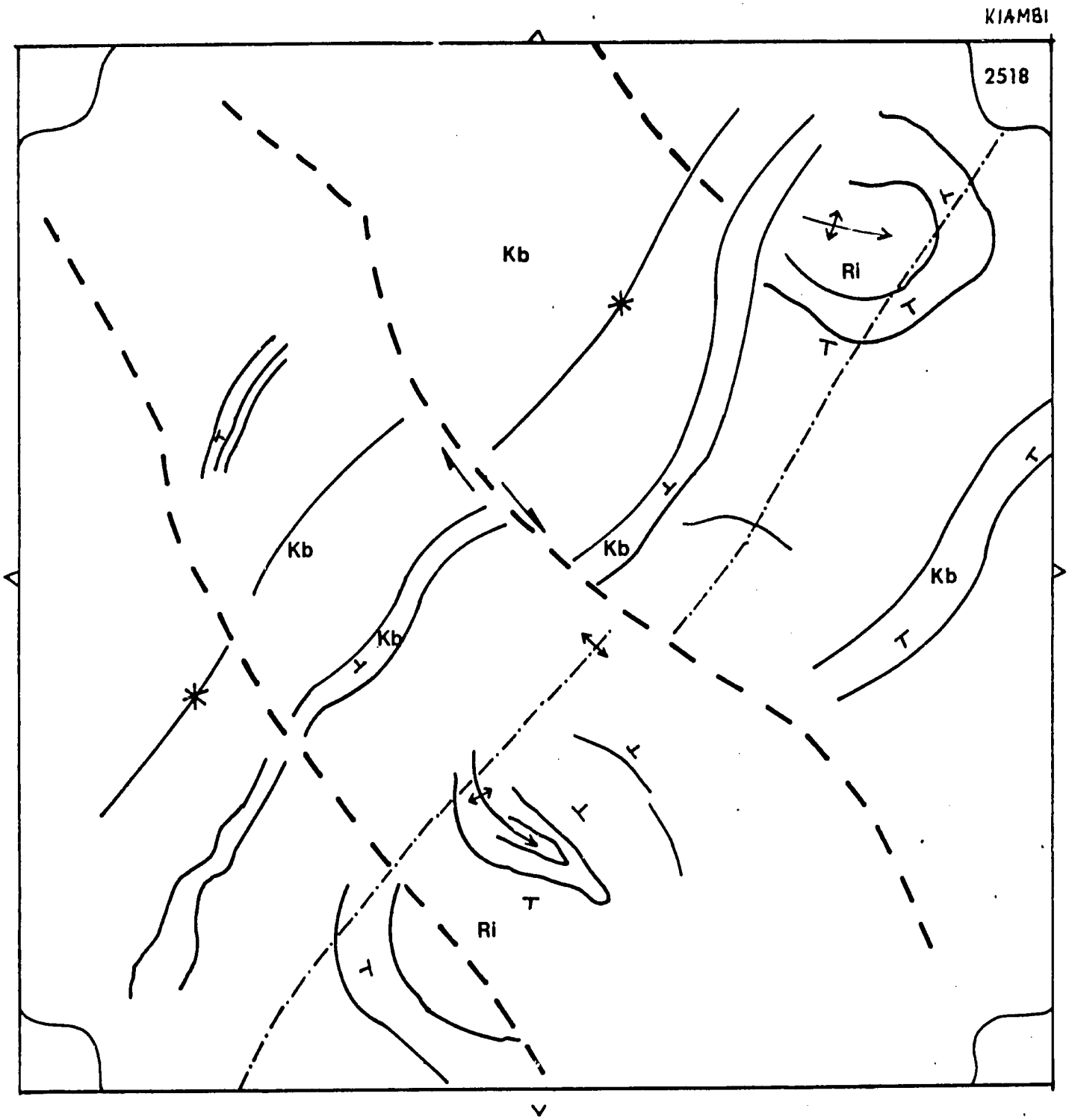
Légende

- Route
- Localité
- Axe anticlinal
- Axe synclinal
- Faille
- Carrière de cassitérite
- Affleurement des roches Basiques.

Echelle: 1/40000

0 1 2 3 km

Photo 30 Km à l'Est de Kiambi 7°20'S x 28°10'E



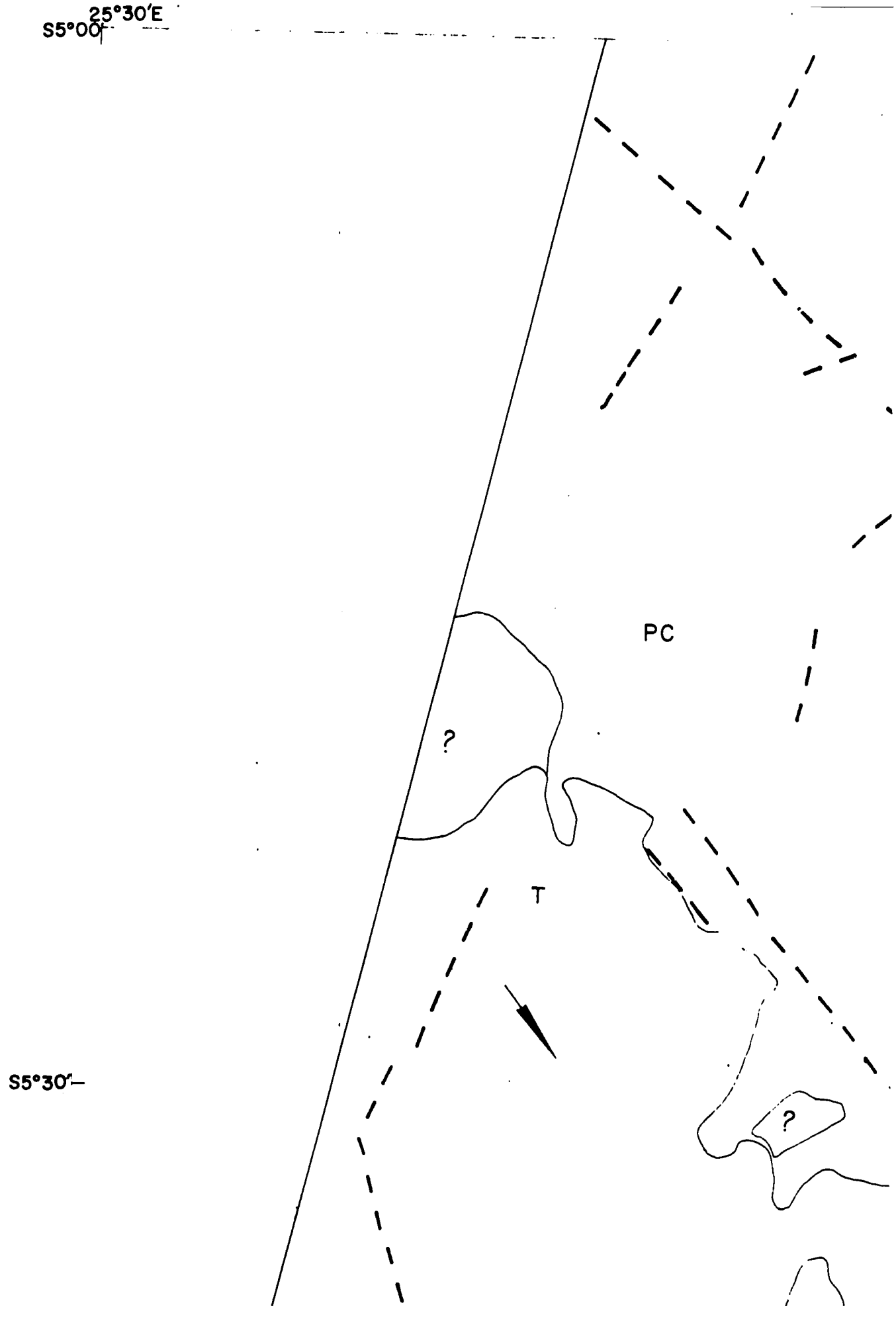
Légende

T	Pendage
	Faille
	Mouvement relatif
	Limite lithologique
	Anticlinal
	Synclinal
Kb	Kibarien
Ri	Ruzizien

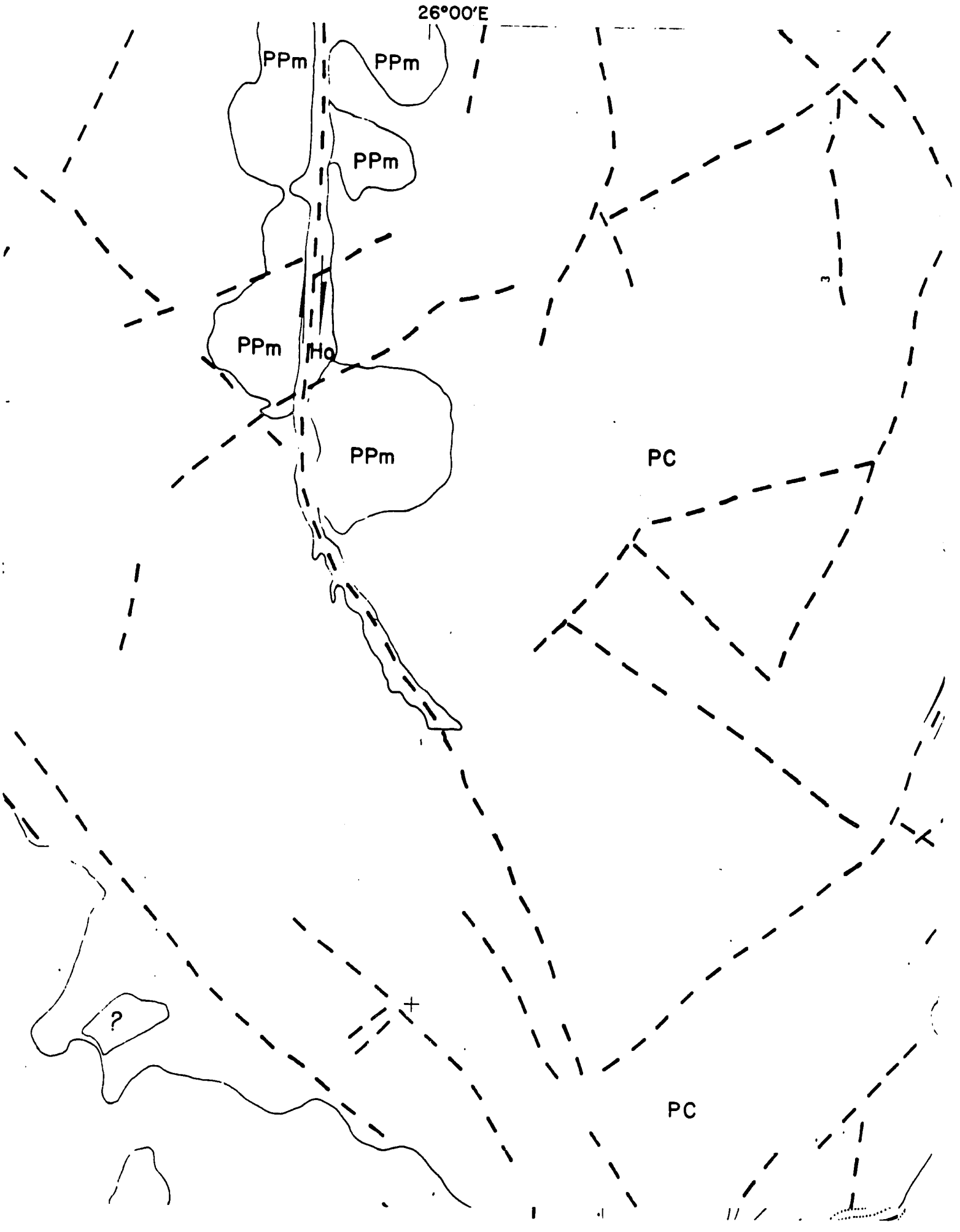
Echelle :

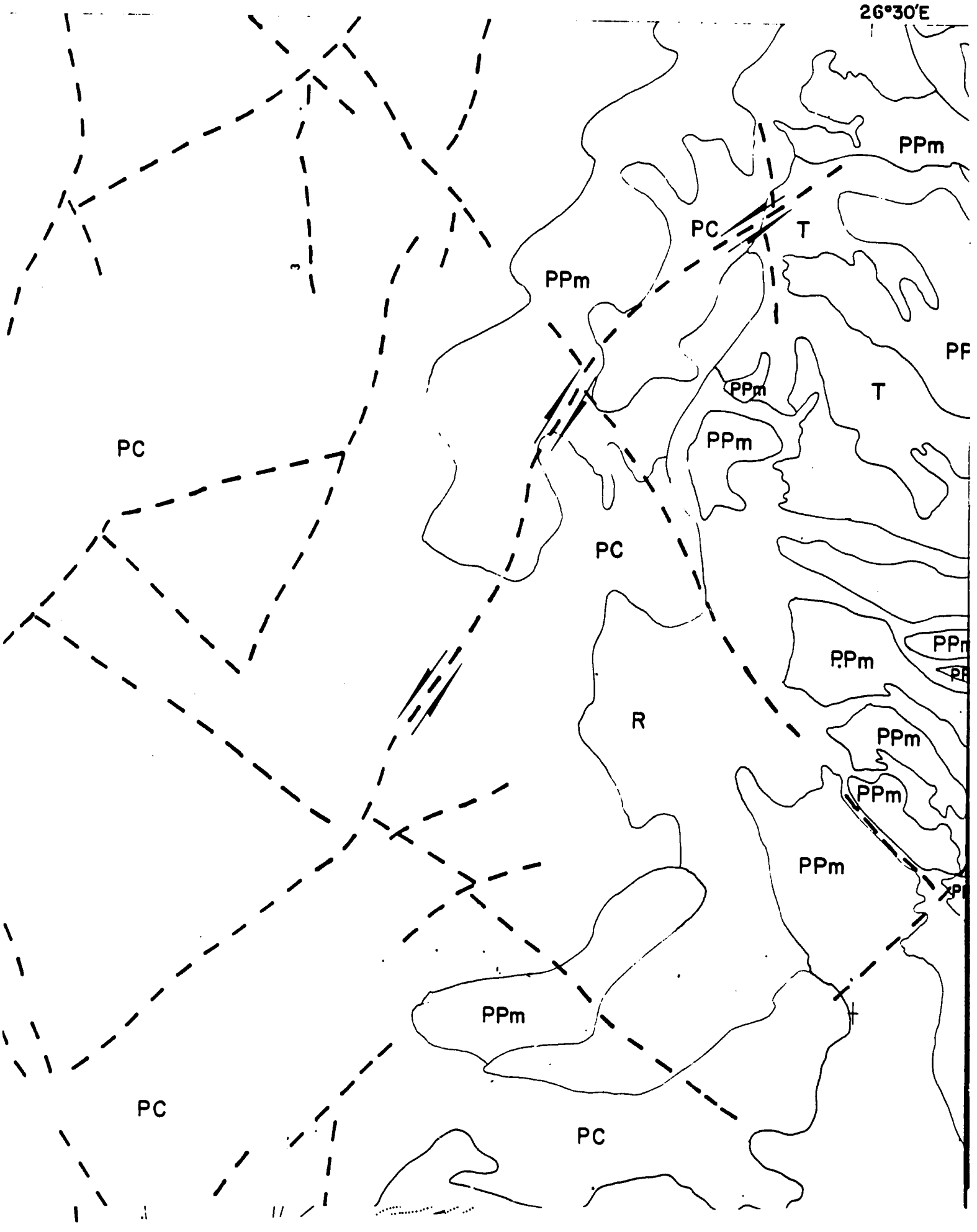
0 1 2 3 Km

a



b

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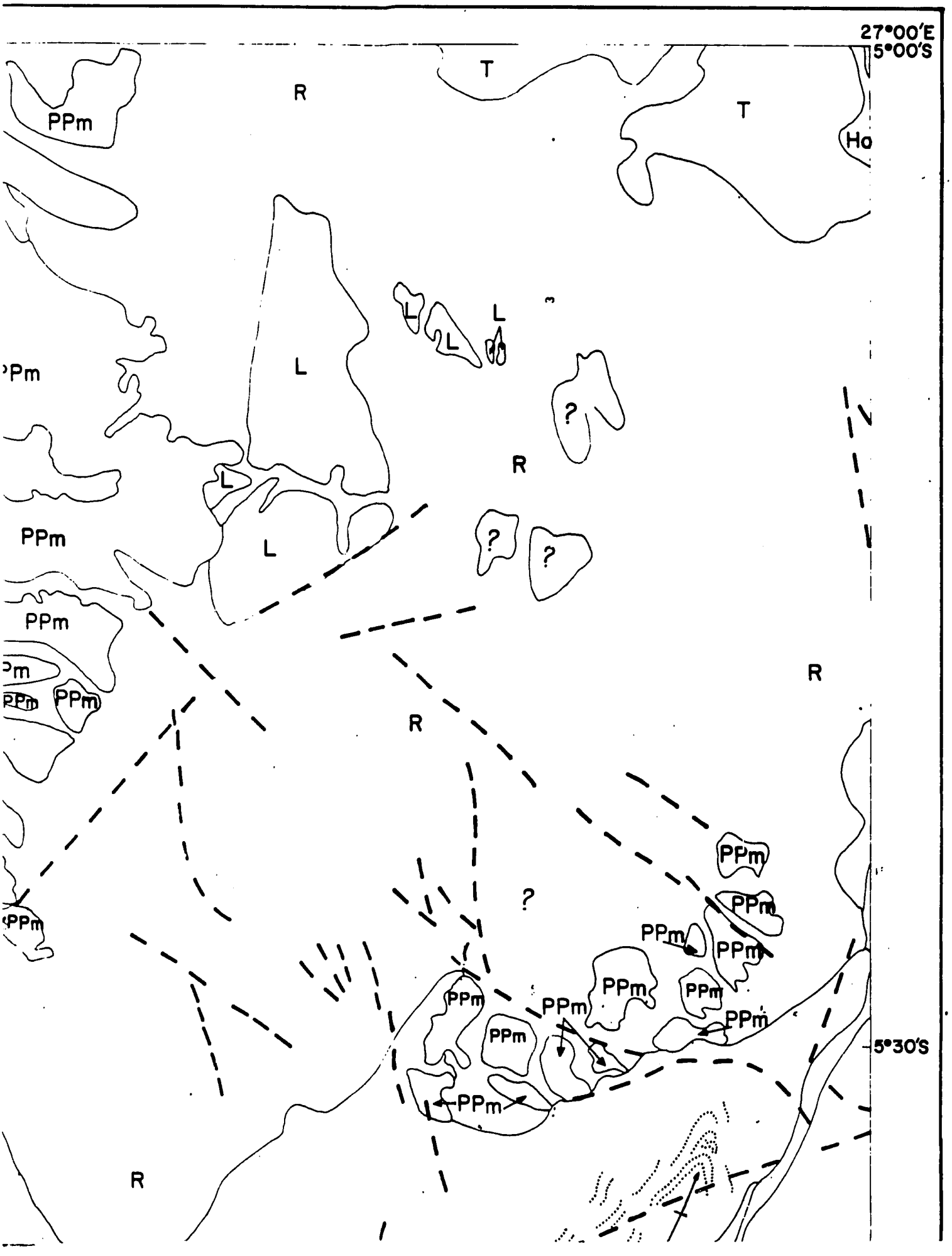
d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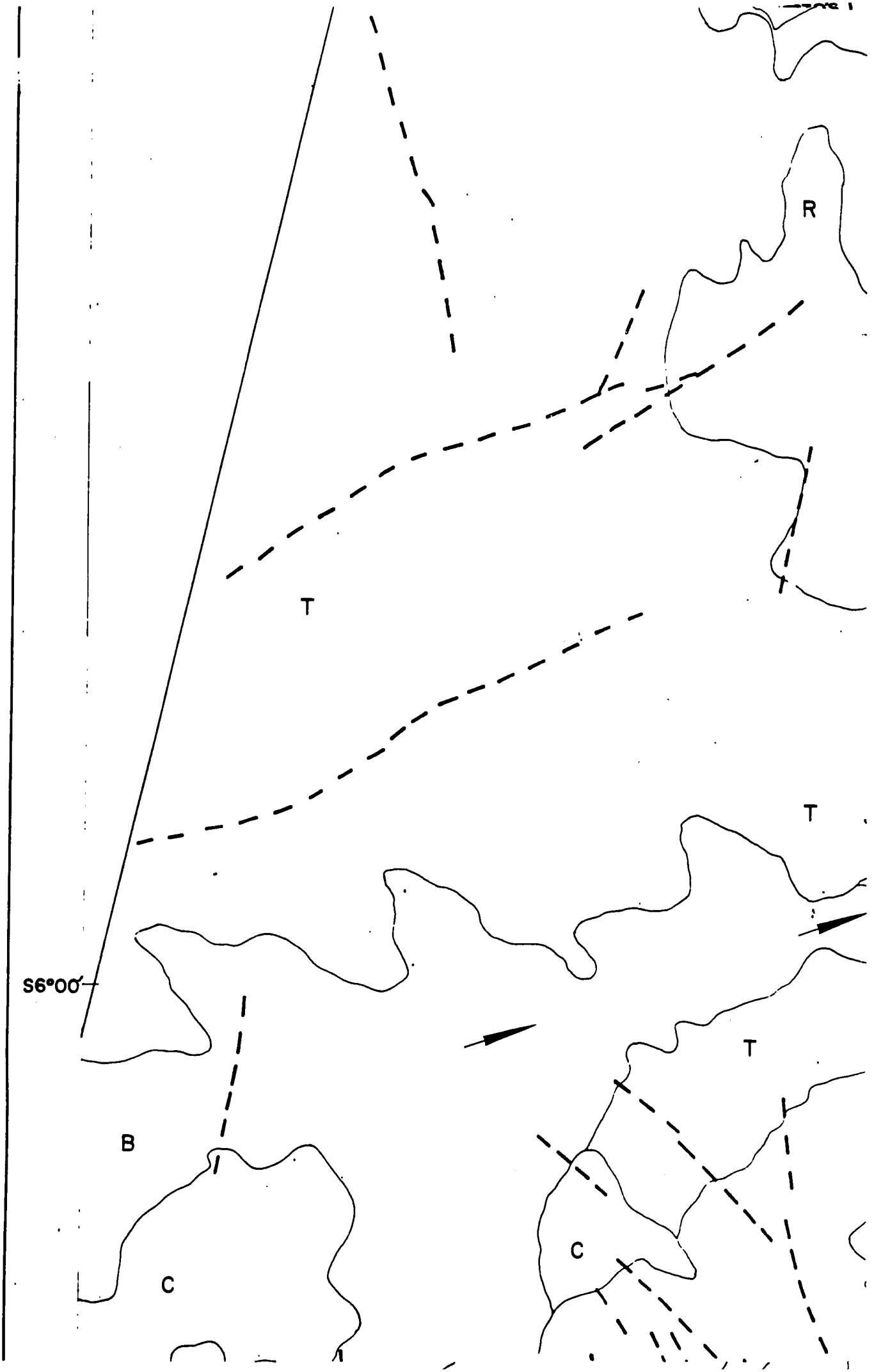

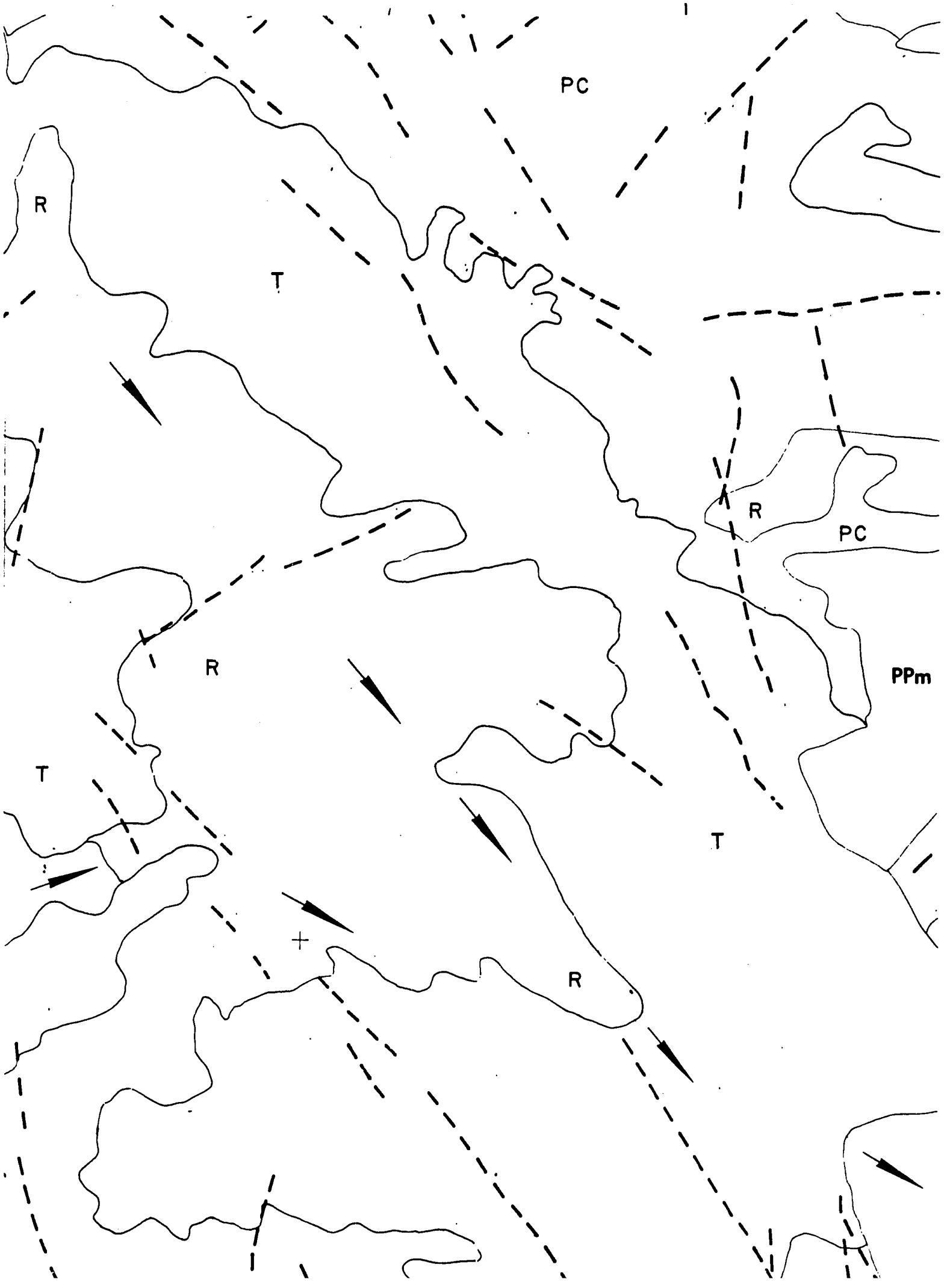
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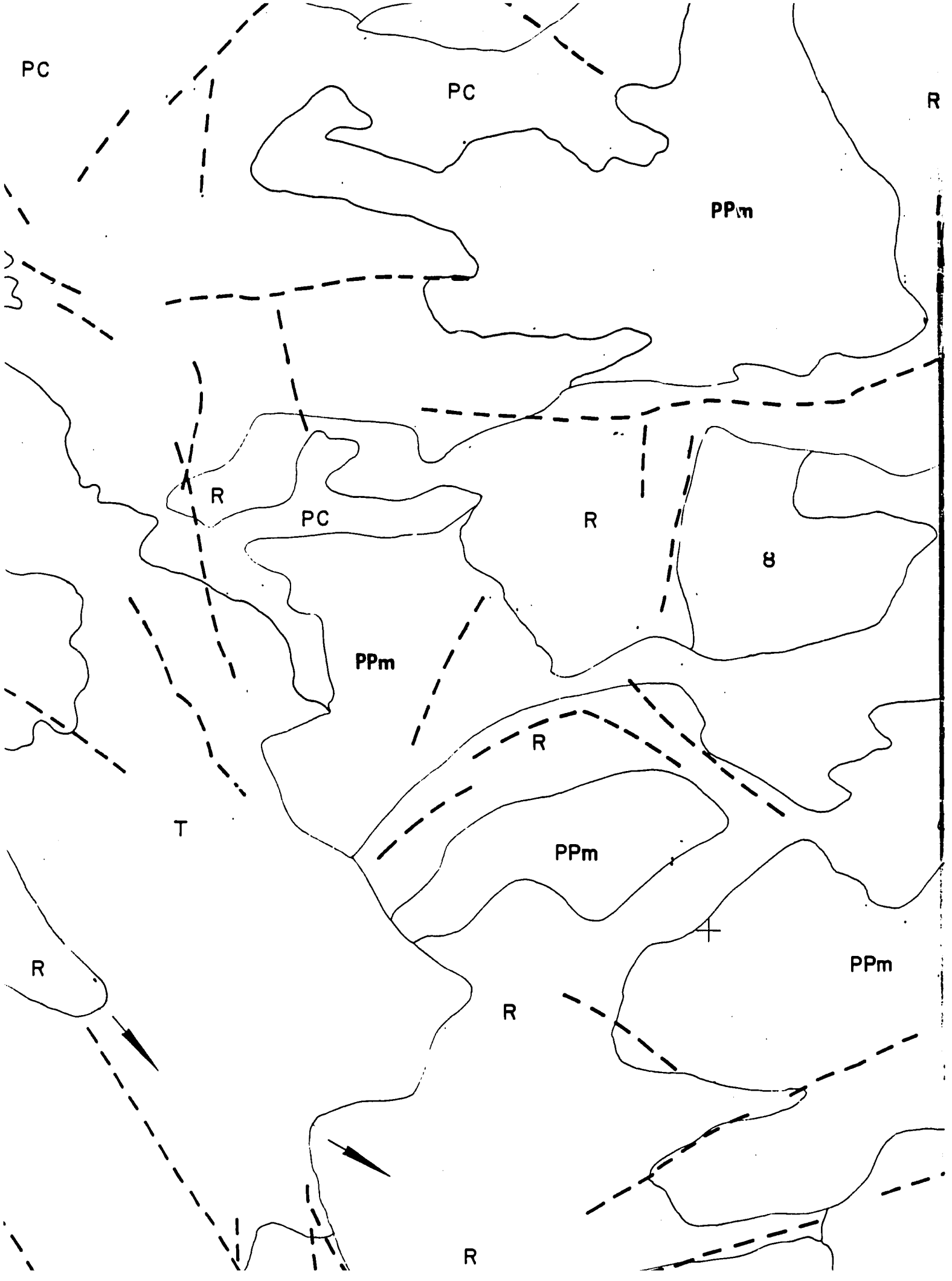
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PC
R
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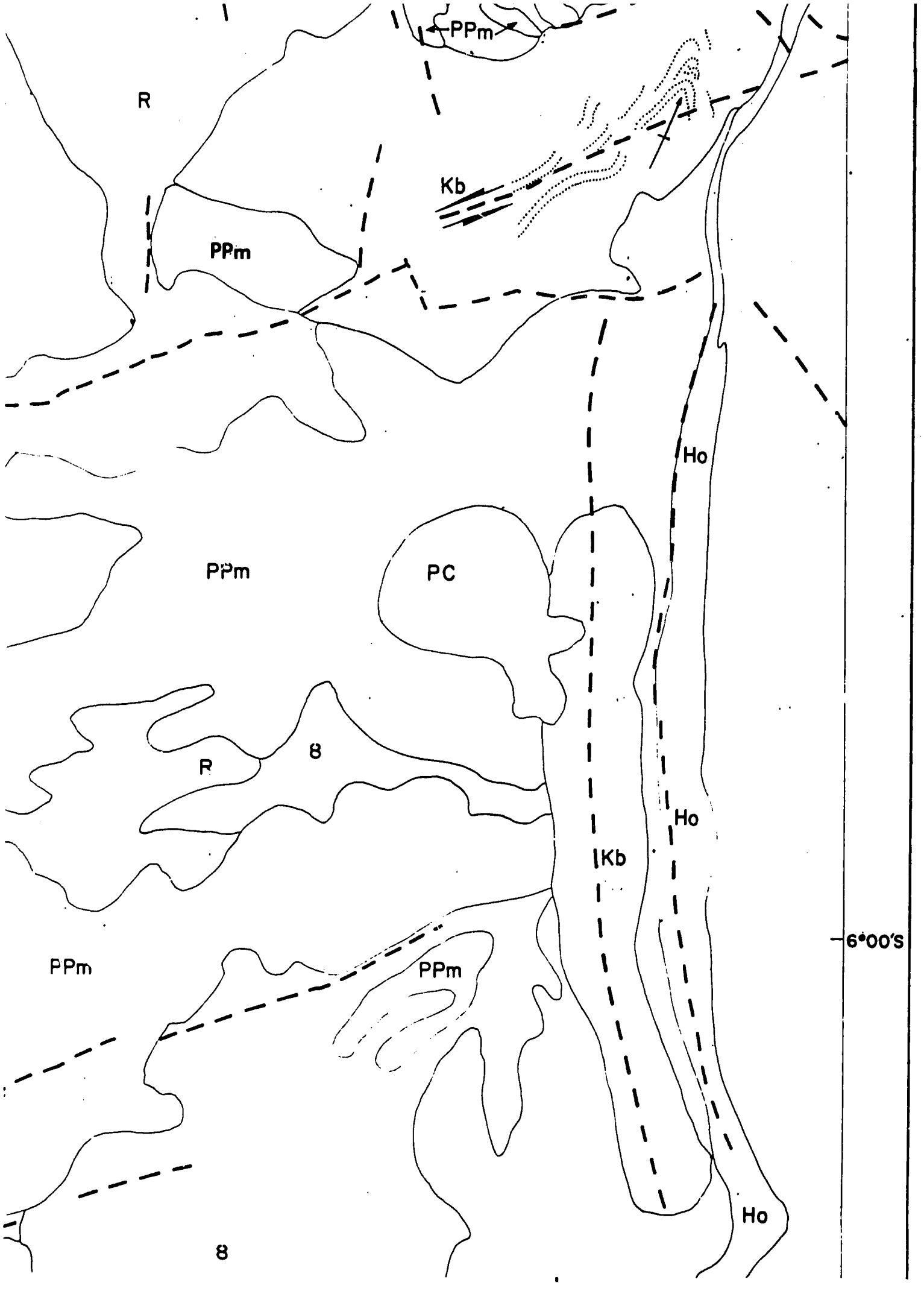
PPm
R
Kb
PPm
Ho
PPm
PC
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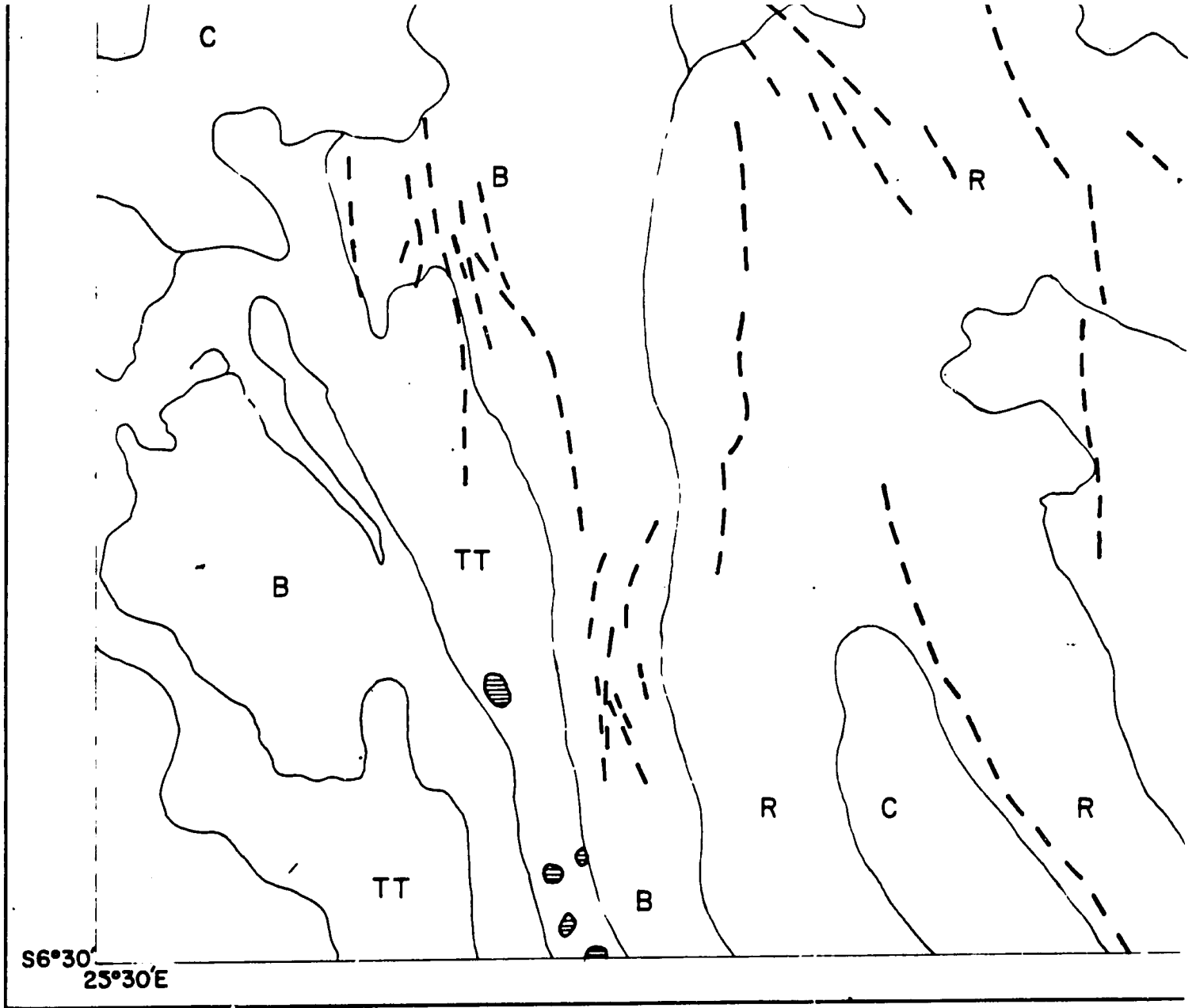
8
Ho
Kb
6°00'S
PPm
PPm
Ho
8



Limite lithologique séparant les systèmes

Limite lithologique douteuse séparant les systèmes

Limite lithologique à l'intérieur d'un système

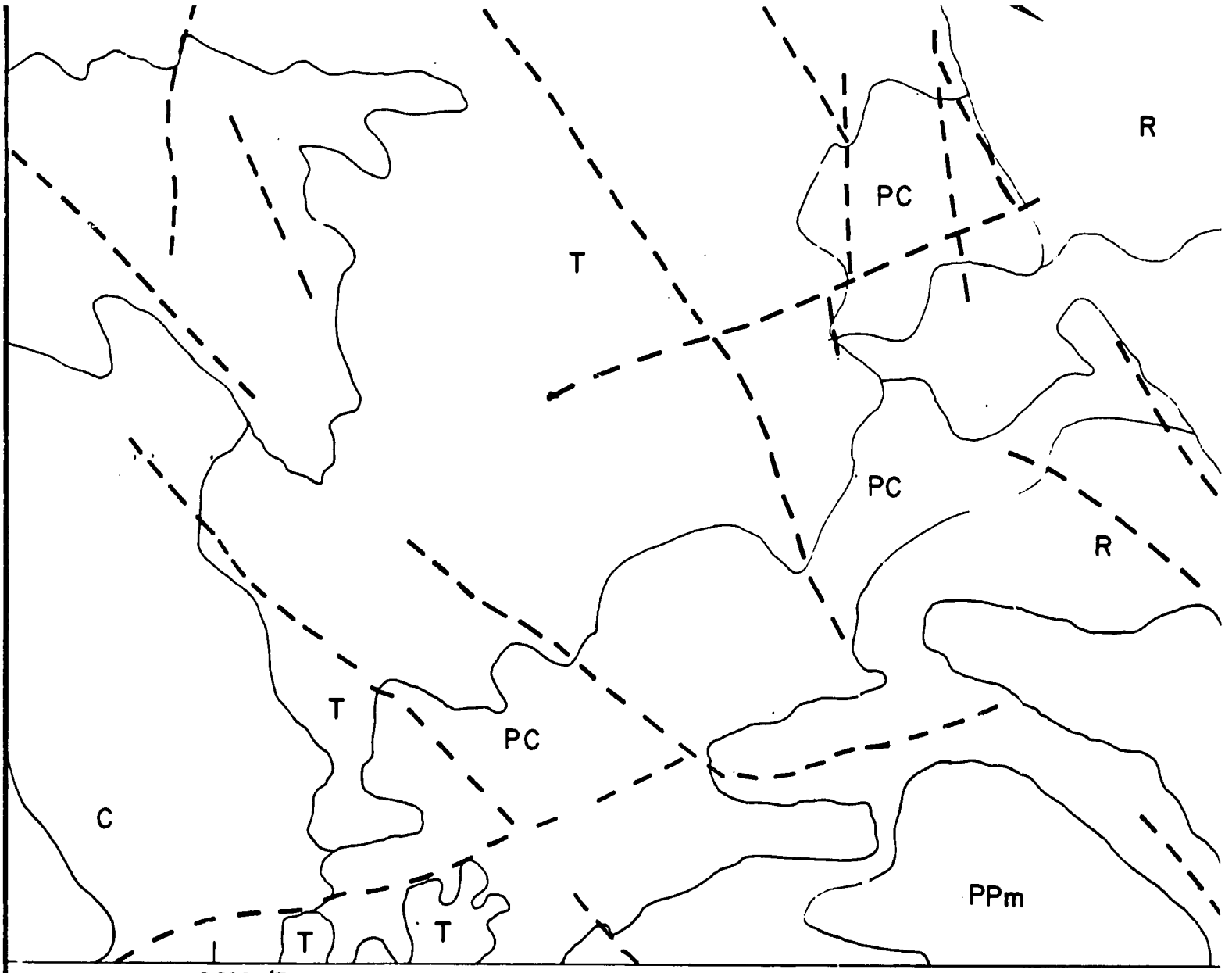
Limite lithologique douteuse à l'intérieur d'un système

Axe anticlinal

Axe synclinal

Plissement à pendage indéterminé

PLANCHE N°II INTERPRETATION GEOLOGIQUE ET STRUCTURALE. A S



LEGENDE

Faille

Faille de cisaillement

H/B Faille avec affaissement (H = Haut; Bas)

Direction et position probable des fleuves au tertiaire (Anté Rift)

Terrasses dans la rivière Luizi; tertiaire (Anté Rift)

TERRAINS

Ho = Holocene, Alluvions mode

PPm = Pleistocene, Pliocene et M "série des cirques"

C = Cretacique

T = Triasique et Liasique sé

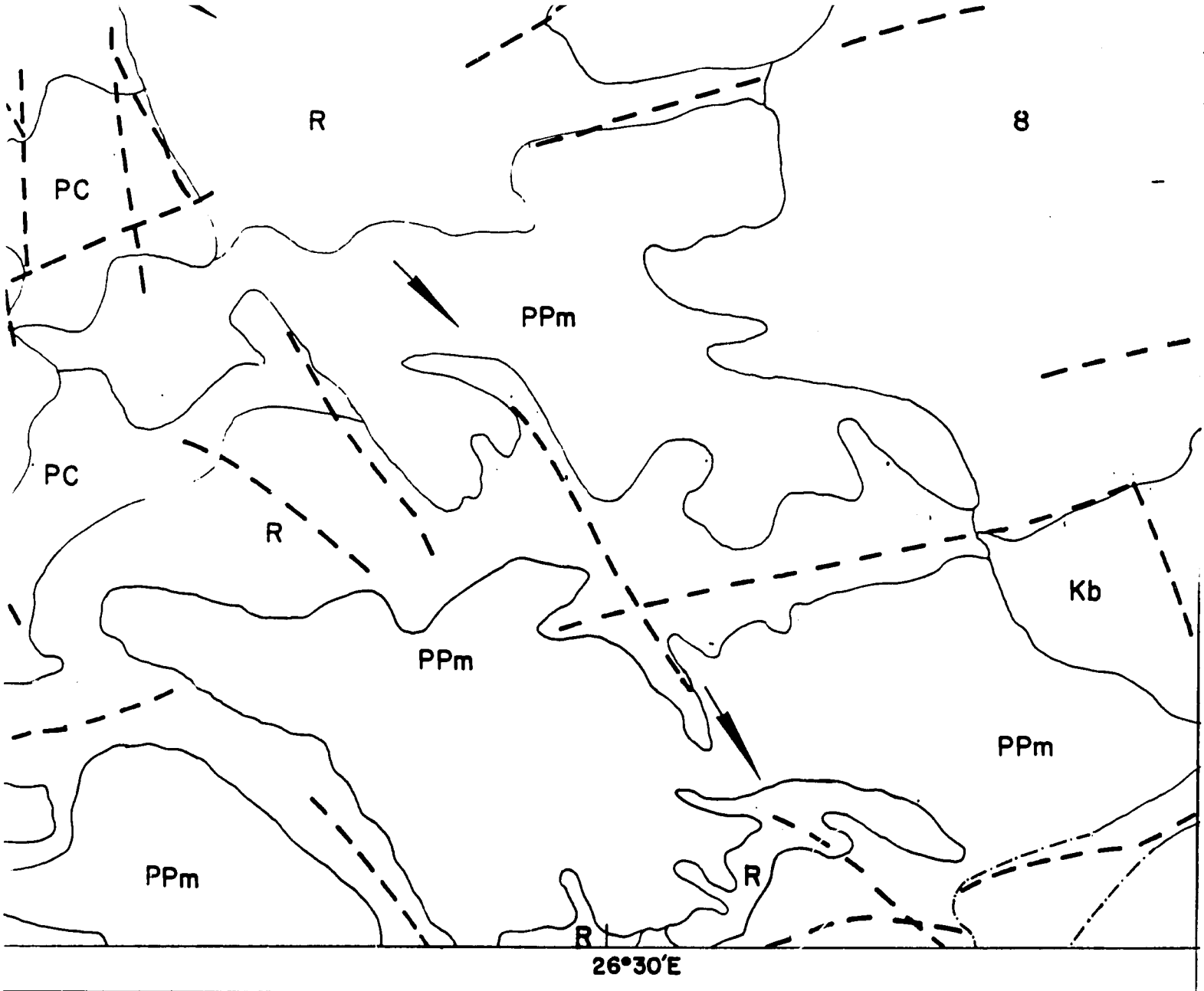
PC = Permien inférieur Carbor

TT = Neogene série des sables

Echelle : 1/200.000

5 0 5 10 15

A Scène Landsat de LUBUNDA



E N D E

TERRAINS PHANEROZOIQUE

Ho = Holocene, Alluvions modernes

PPm = Pleistocene, Pliocene et Miocene supérieur "série des cirques" Quelo

C = Cretacique

T = Triasique et Liasique série de la haute série des "roches rouges"

PC = Permien inférieur Carboniferien supérieur série de la Lukuga

TT = Neogene série des sables ocres

TE

B = Bushimayi

L = Lindien

Kb = Kibarien

R = Ruzizien

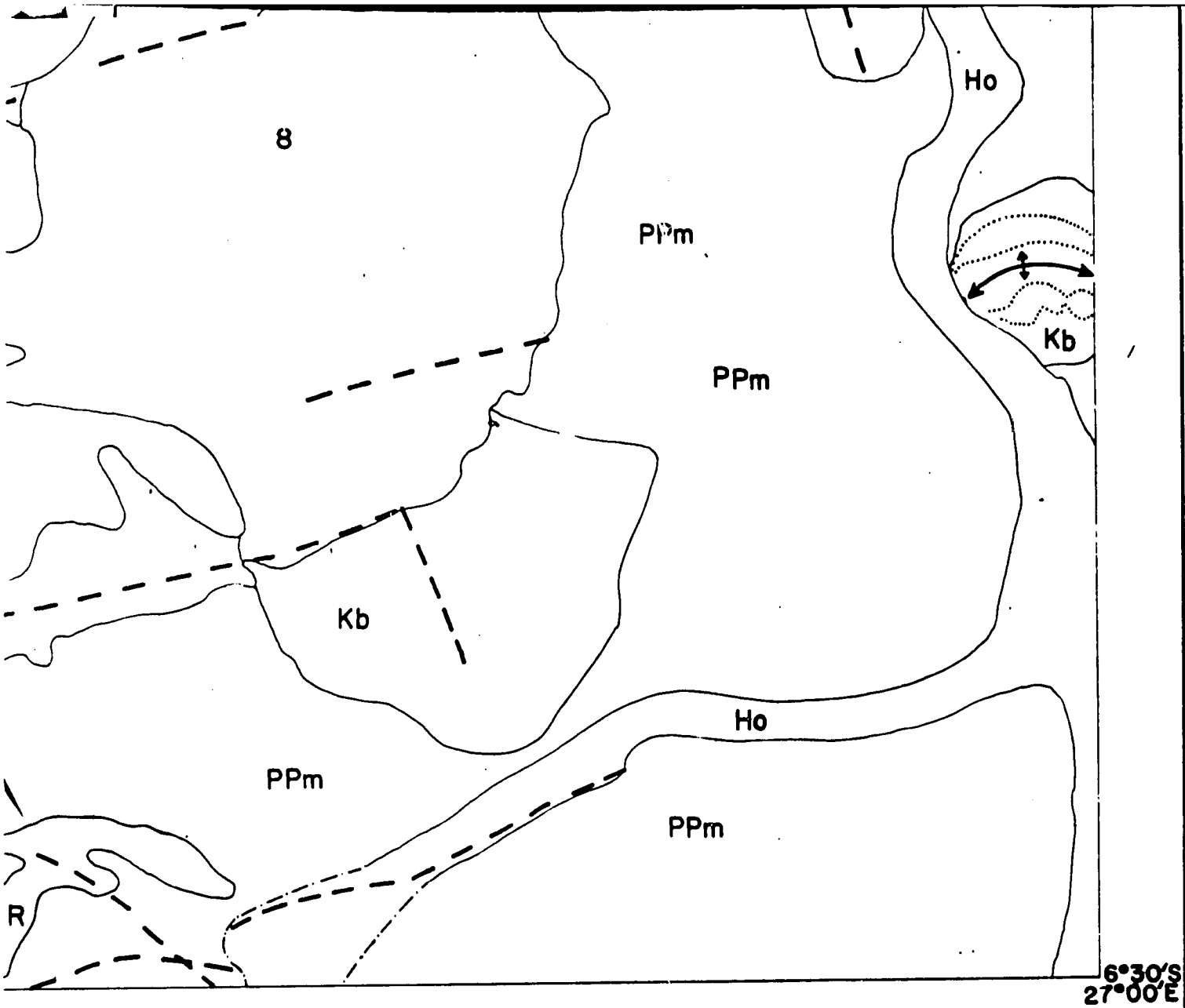
8 = Roche graniti

= Anomalie géo

1:1/200.000

10 15

DESSINATEUR LUMBU



rouges"

kuga

TERRAINS PRECAMBRIENS

B = Bushimayi

L = Lindien

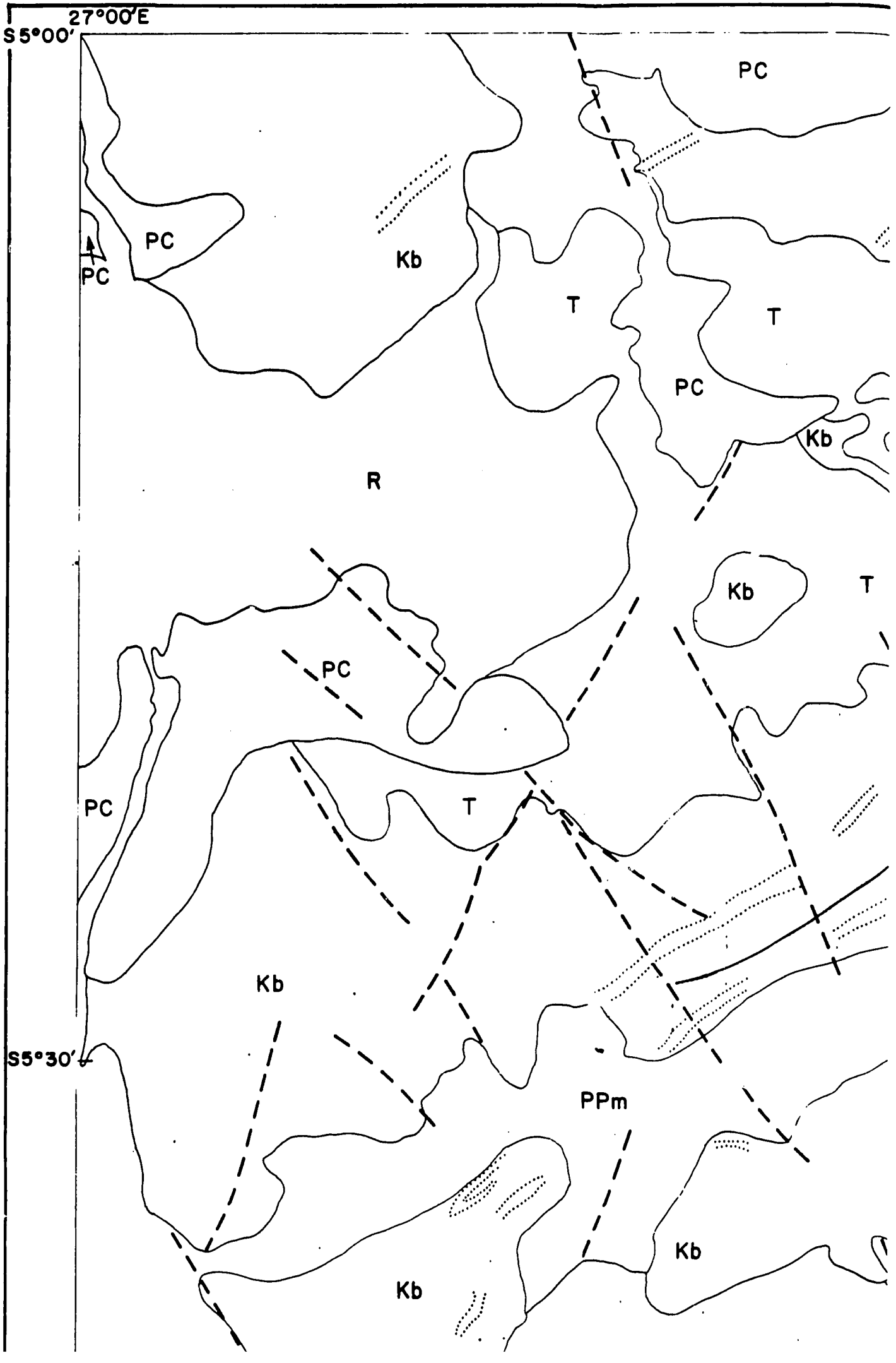
Kb = Kibarien

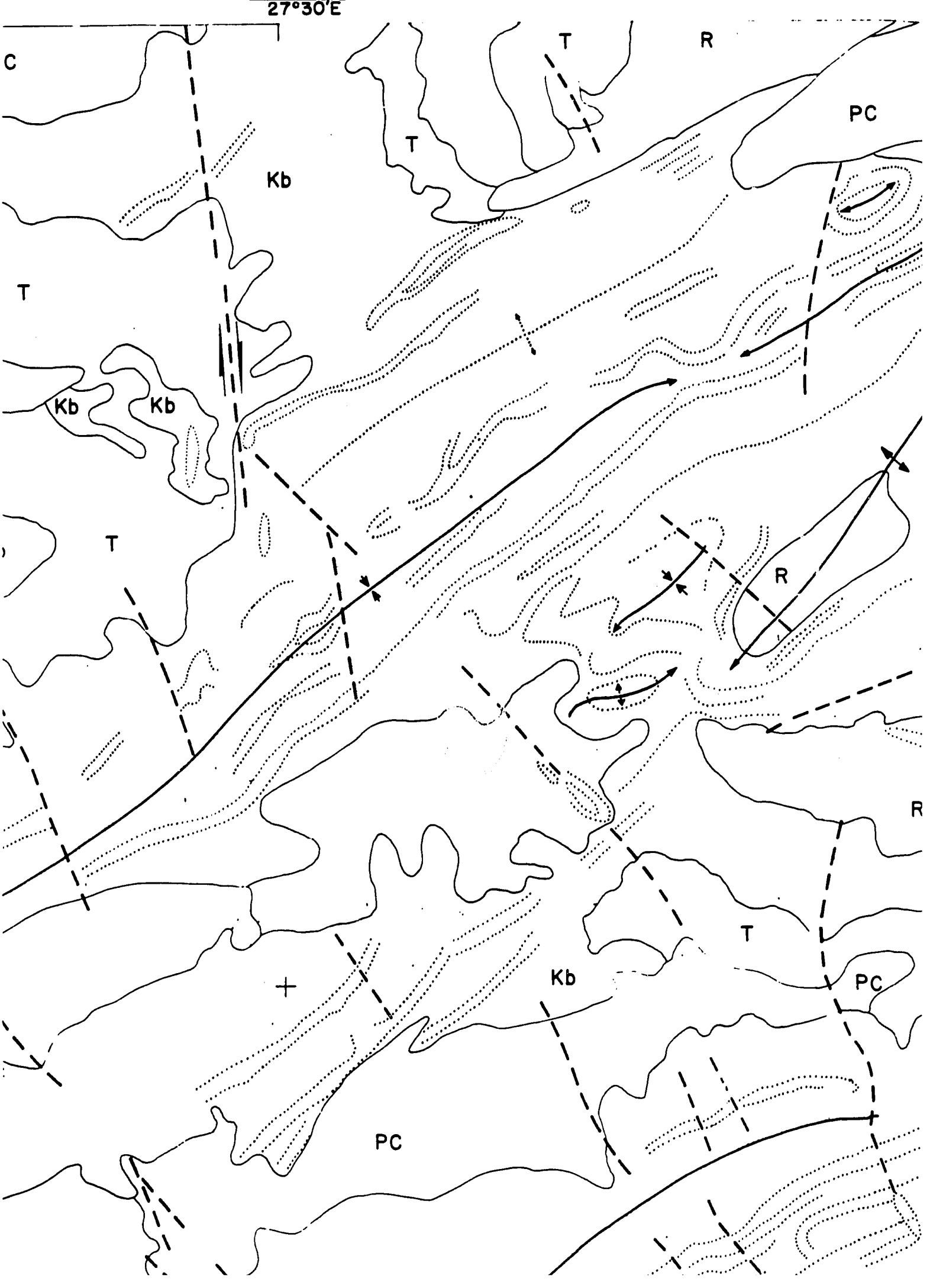
R = Ruzizien

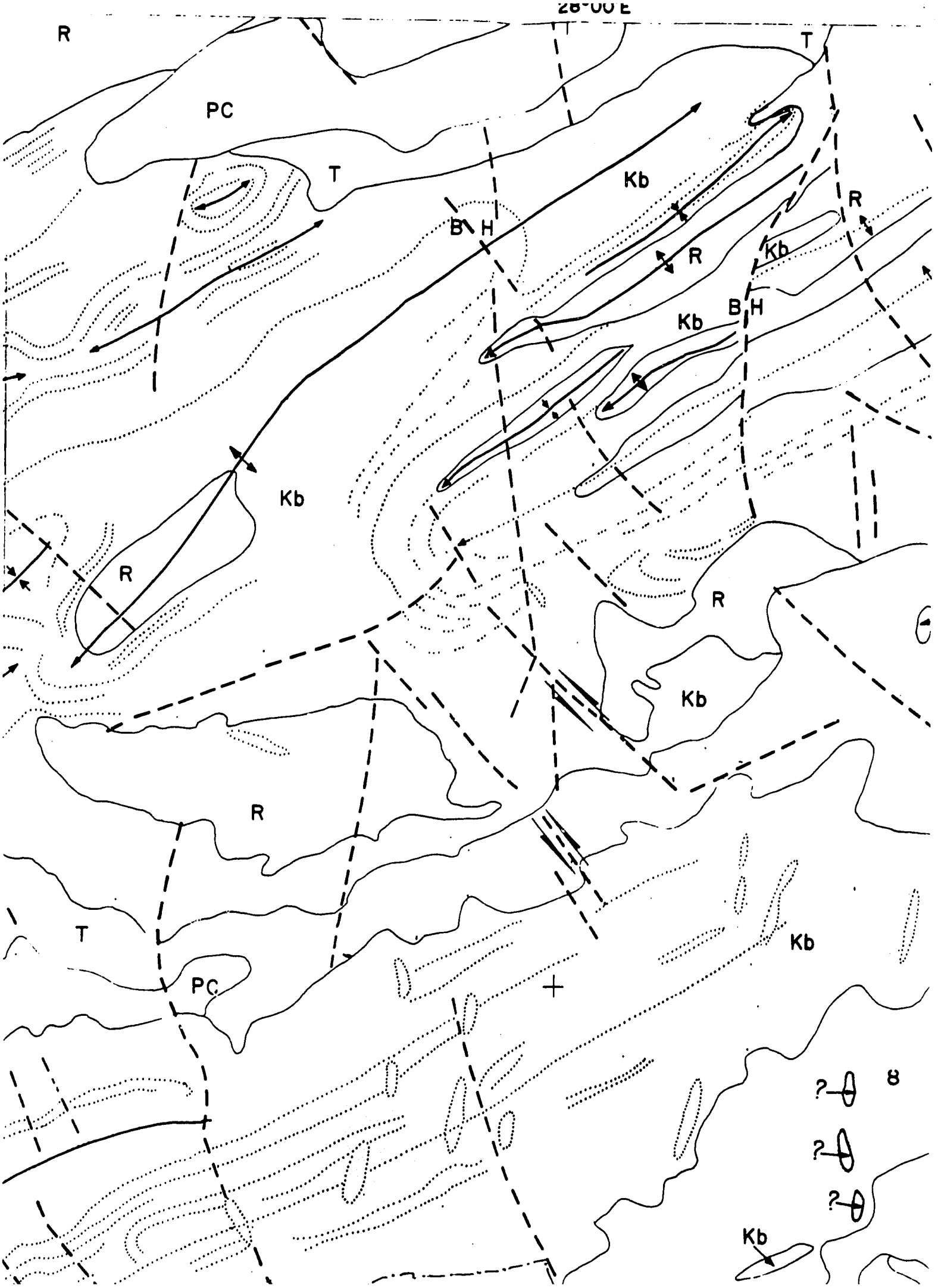
ȣ = Roche granitique

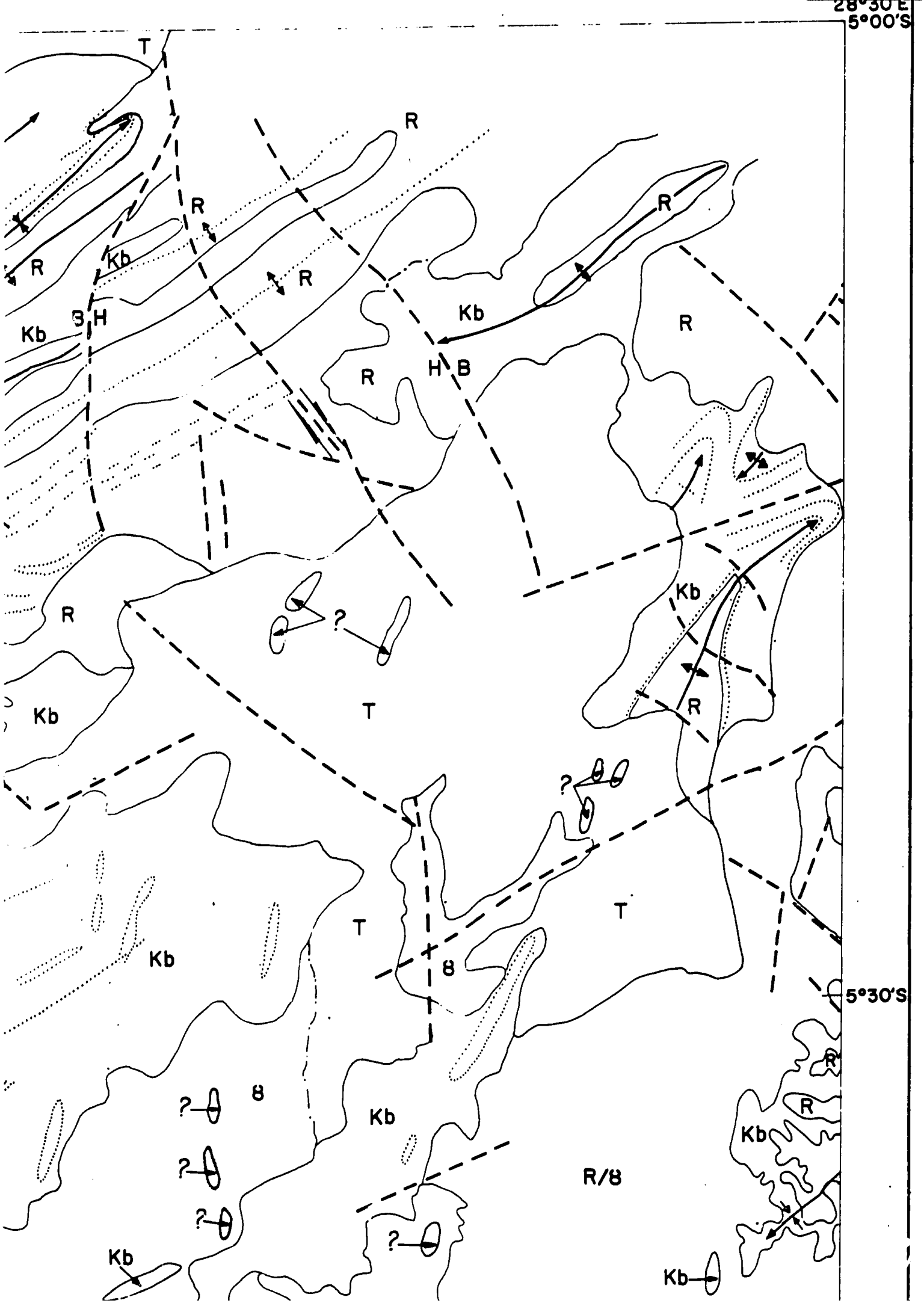
= Anomalie géométrique - Intrusion de Kimberlite supposée

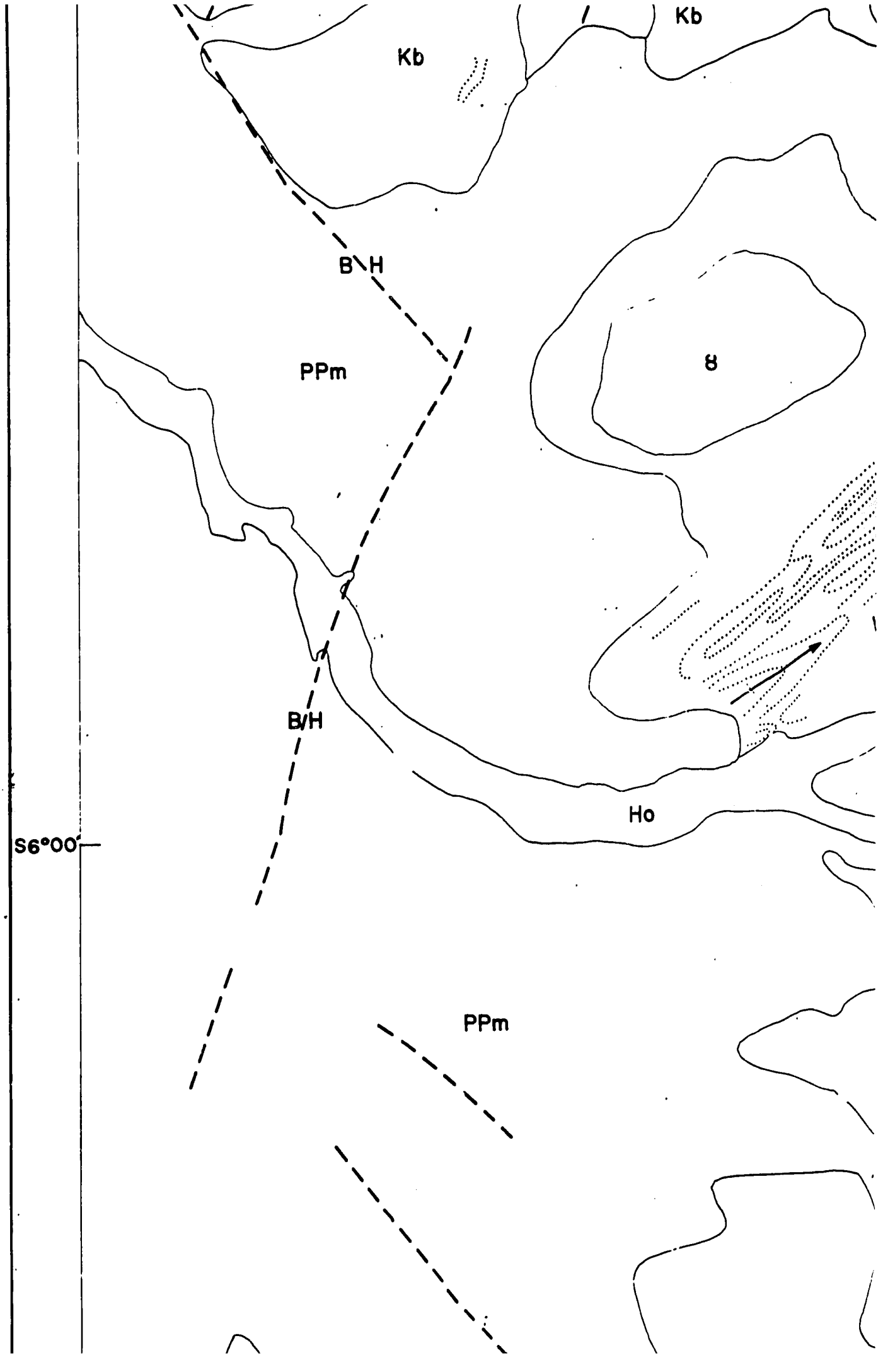
UMBU

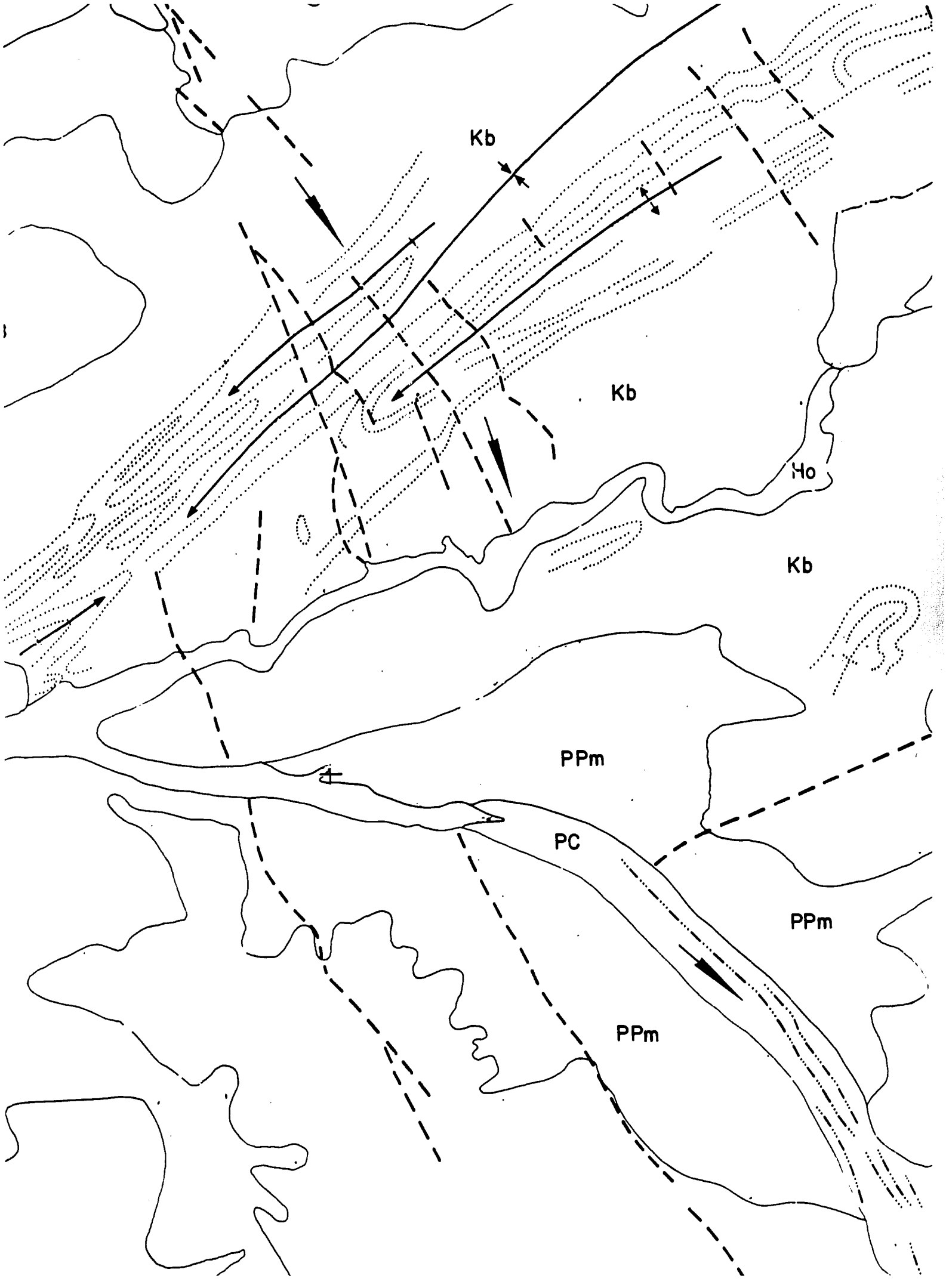

27°00'E
S5°00'
S5°30'
PC
PC
PC
Kb
T
T
PC
Kb
R
Kb
T
PC
PC
T
Kb
PPm
Kb
Kb

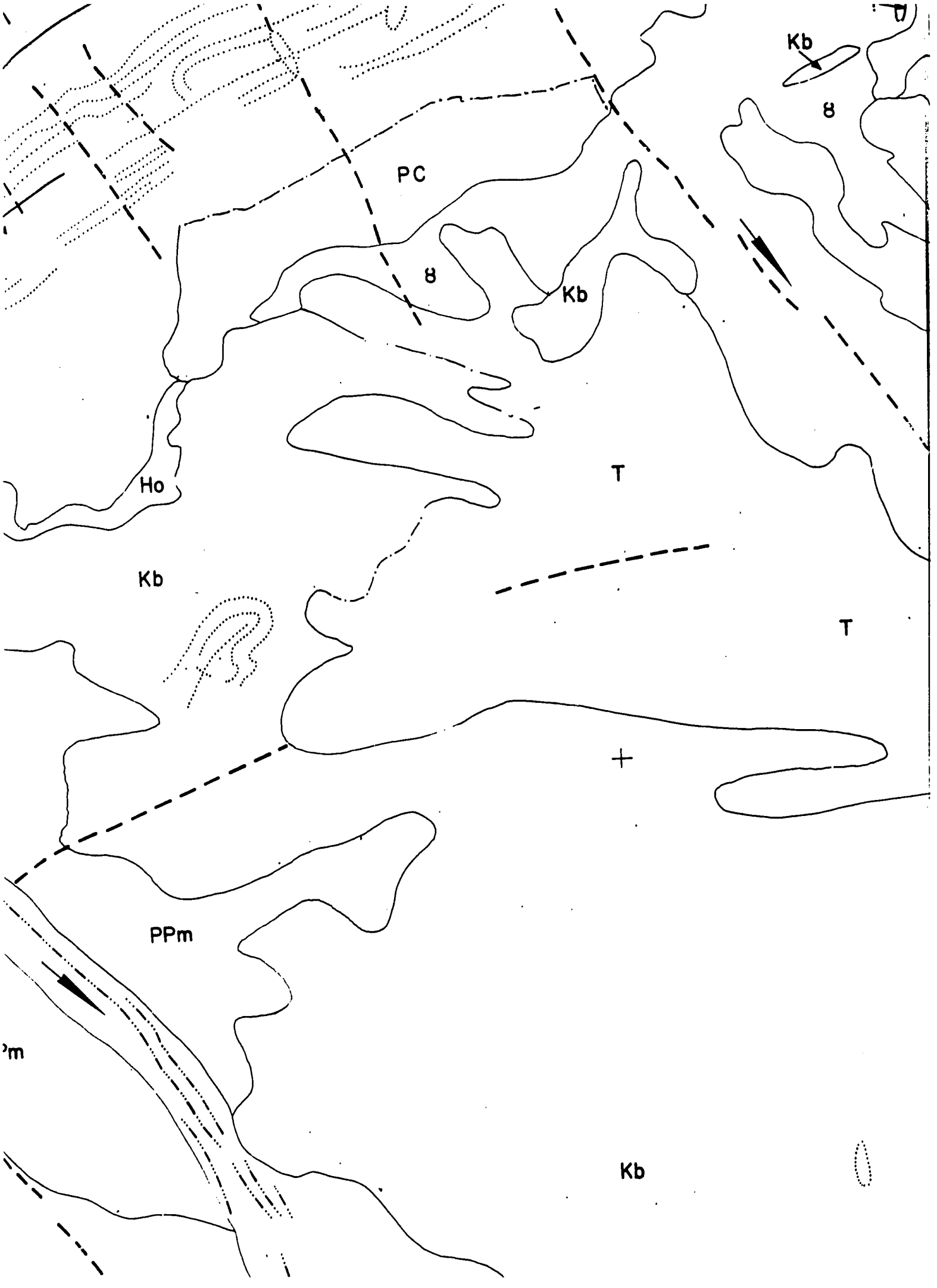

27°30'E
C
T
R
PC
T
Kb
T
Kb
Kb
T
R
R
T
Kb
PC
PC

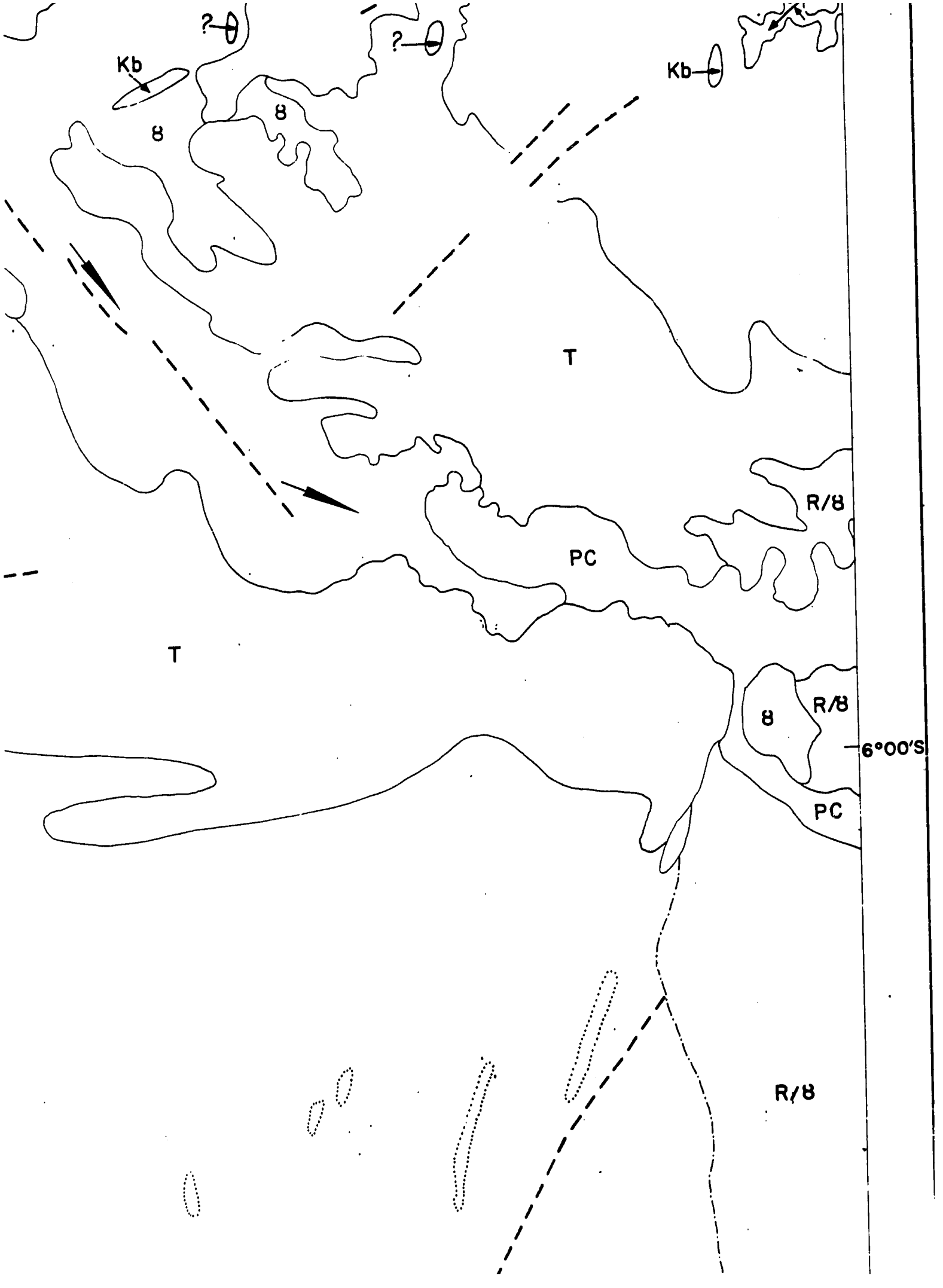

28°00'E
R
T
PC
T
Kb
B H
R
Kb
R
B H
Kb
Kb
R
R
Kb
R
T
PC
Kb
8
Kb

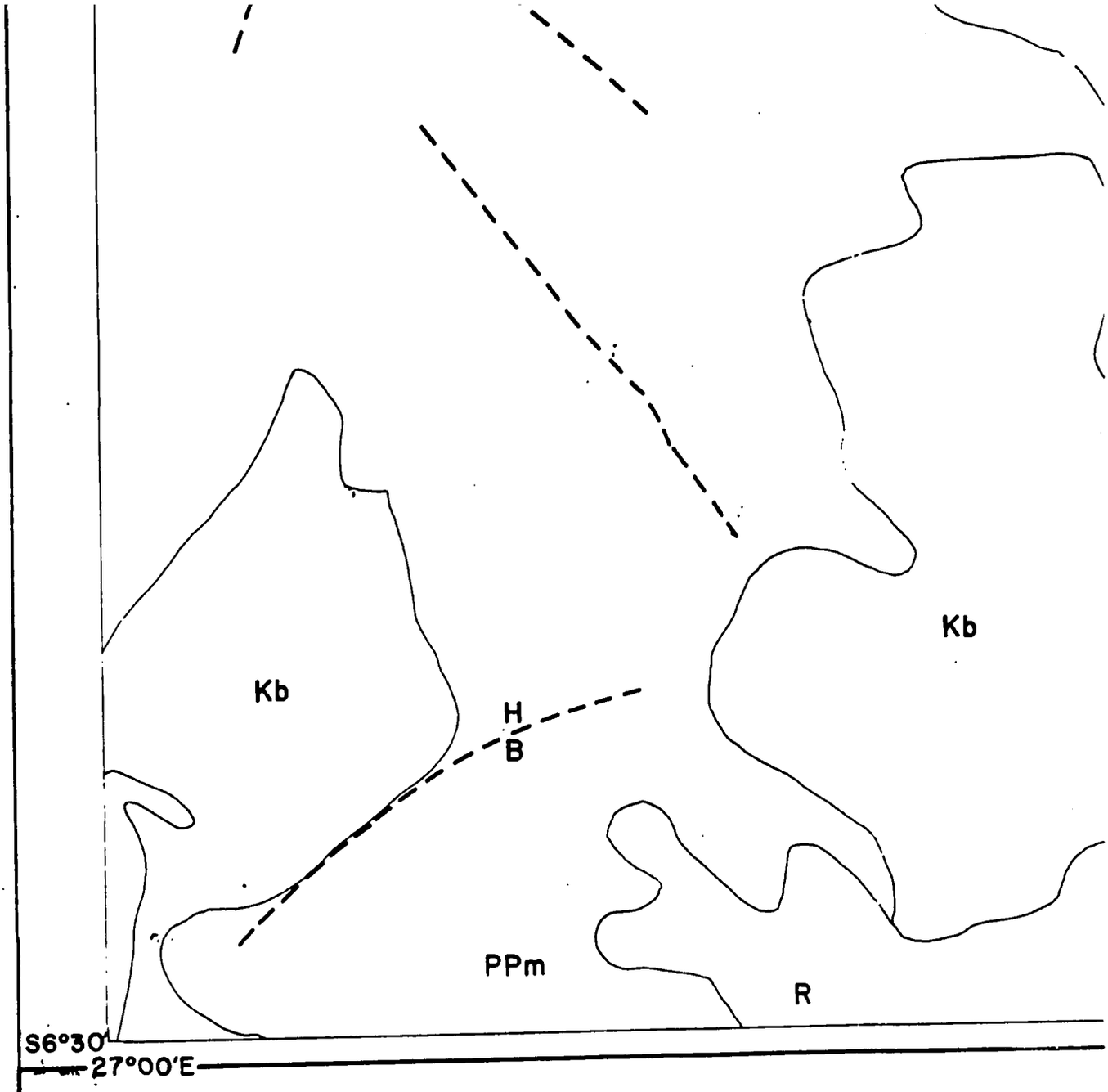

28°30'E
5°00'S
5°30'S
T
R
Kb
B H
H B
?
8
R/8


Kb
Kb
B\H
PPm
8
B/H
Ho
S6°00'
PPm


Kb
Kb
Ho
Kb
PPm
PC
PPm
PPm


Kb
8
PC
8
Kb
Ho
T
Kb
T
PPm
Kb


Kb
Kb
T
T
PC
PC
R/8
R/8
R/8
6°00'S



Limite lithologique séparant les systèmes

Limite lithologique douteuse séparant les systèmes

Limite lithologique à l'intérieur d'un système

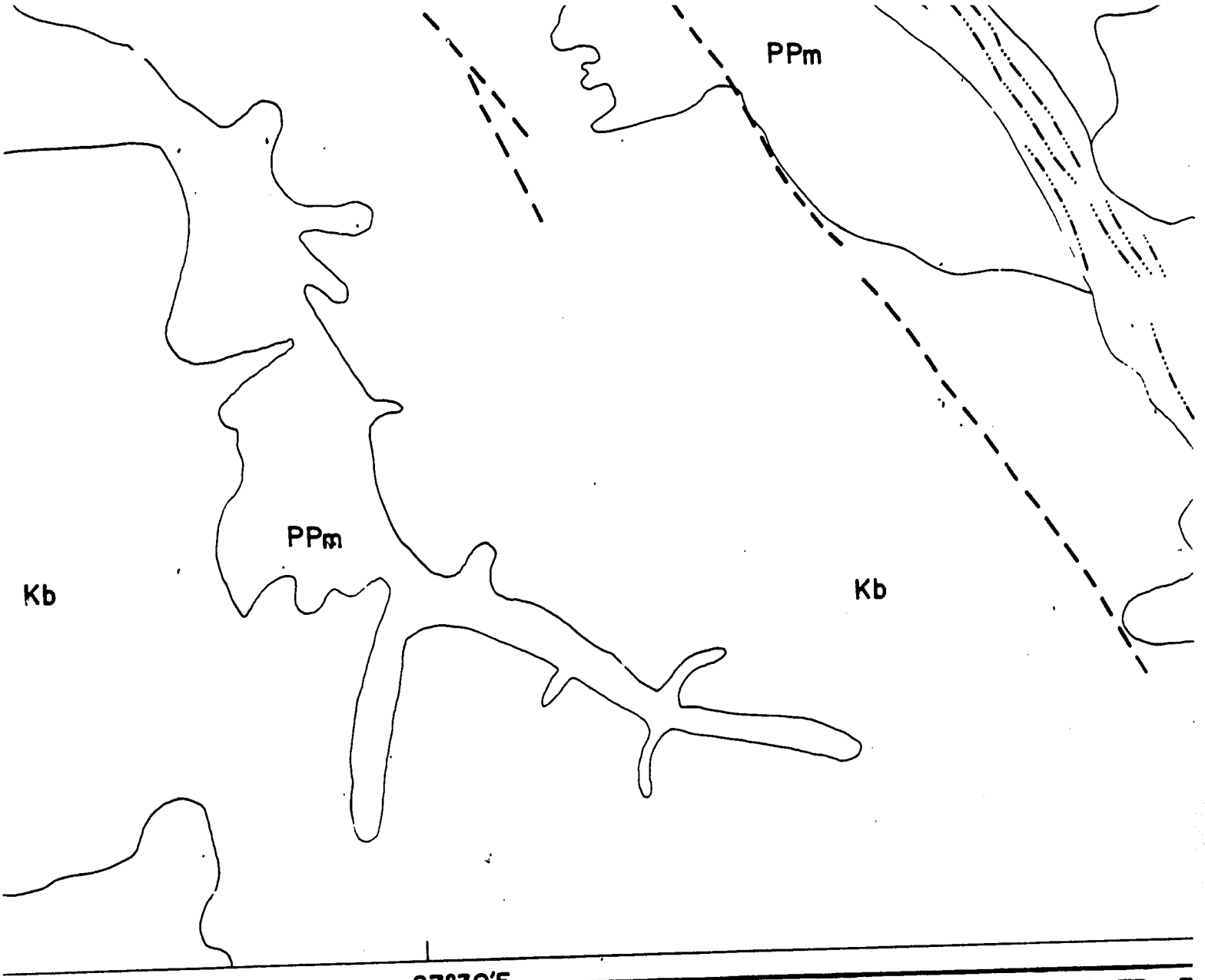
Limite lithologique douteuse à l'intérieur d'un système

Axe anticlinal

Axe synclinal

Plissement à pendage indéterminé

PLANCHE N°II: INTERPRETATION GEOLOGIQUE ET STRUCTURA



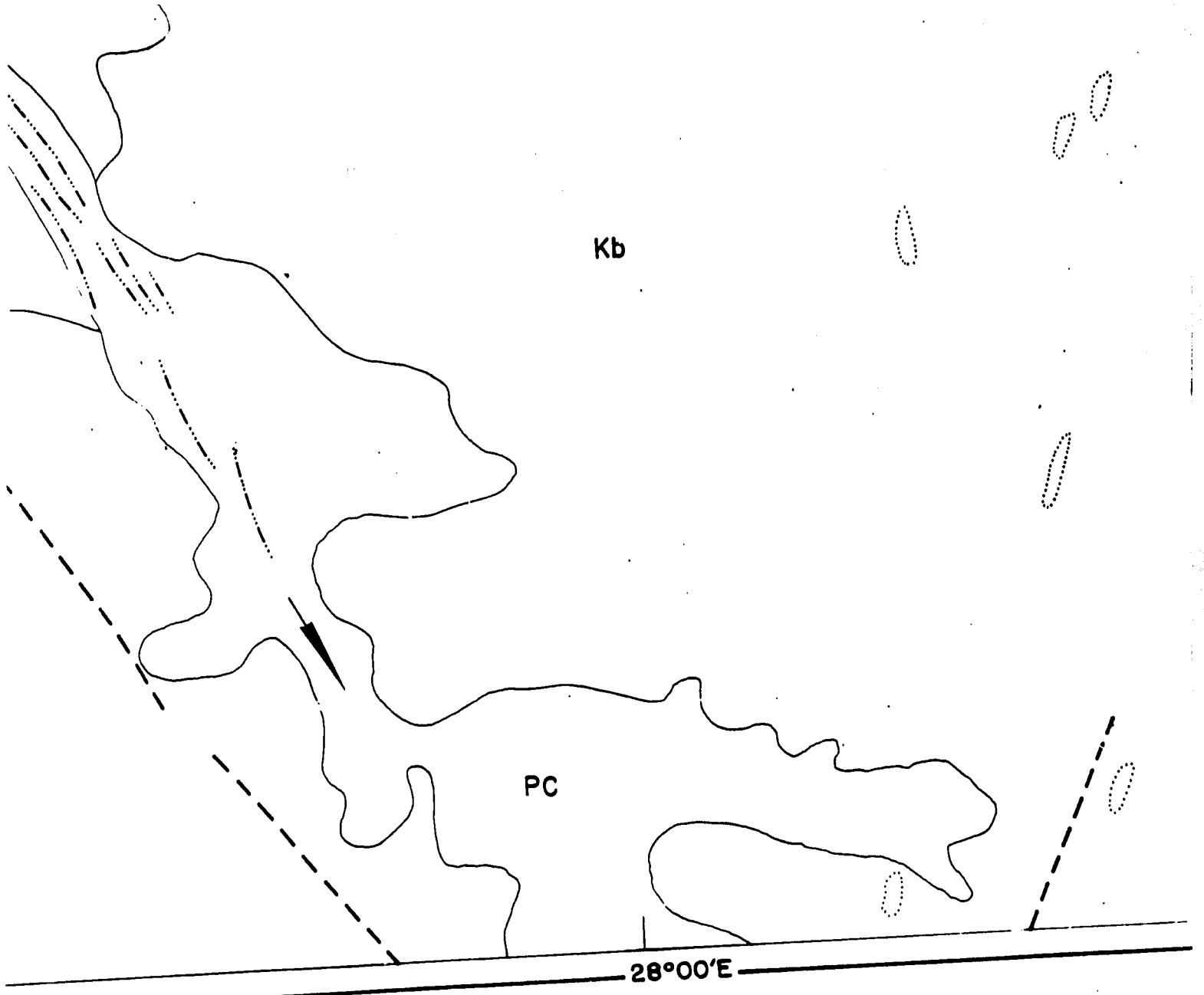
LEGENDE

- Faille
- Faille de cisaillement
- Faille avec affaissement (H = Haut; B = Bas)
- Direction et position probable des fleuves au tertiaire (Anté Rift)
- Terrasses dans la rivière Luizi; tertiaire (Anté Rift)

Echelle : 1/200.000

5 0 5 10

T STRUCTURALE. B Scène Landsat de NYUNZU & KONGOLO



E N D E

TERRAINS PHANEROZOIQUE

Ho = Holocène, Alluvions modernes

PPm= Pleistocène, Pliocène et Miocène supérieur "série des cirques," Quelo

T^{ω} = Triasique et Liasique, série de la haute série des "roches rouges"

Pc = Permien inférieur, Carboniferien supérieur: série de la Lukuga

Kb = I

R =

ȣ =

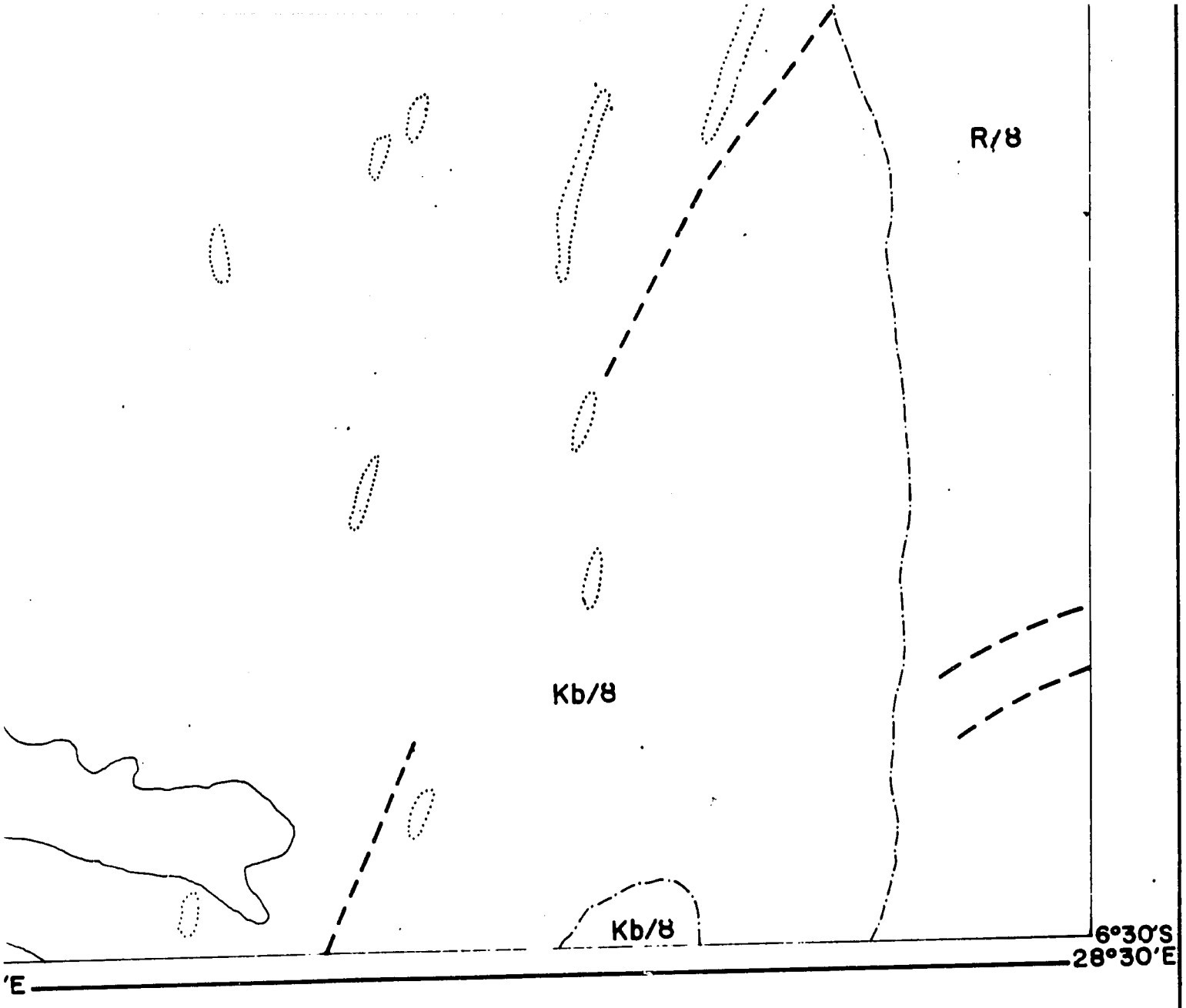
Kb/ȣ=

R/ȣ =

Echelle : 1/200.000

5 10 15

DESSINATEUR LUMBU



TERRAINS PRECAMBRIENS

Kb = Kibarien

R = Ruzizien

ɤ = Roche granitique

Kb/ɤ=Kibarien et/ou Roche granitisée

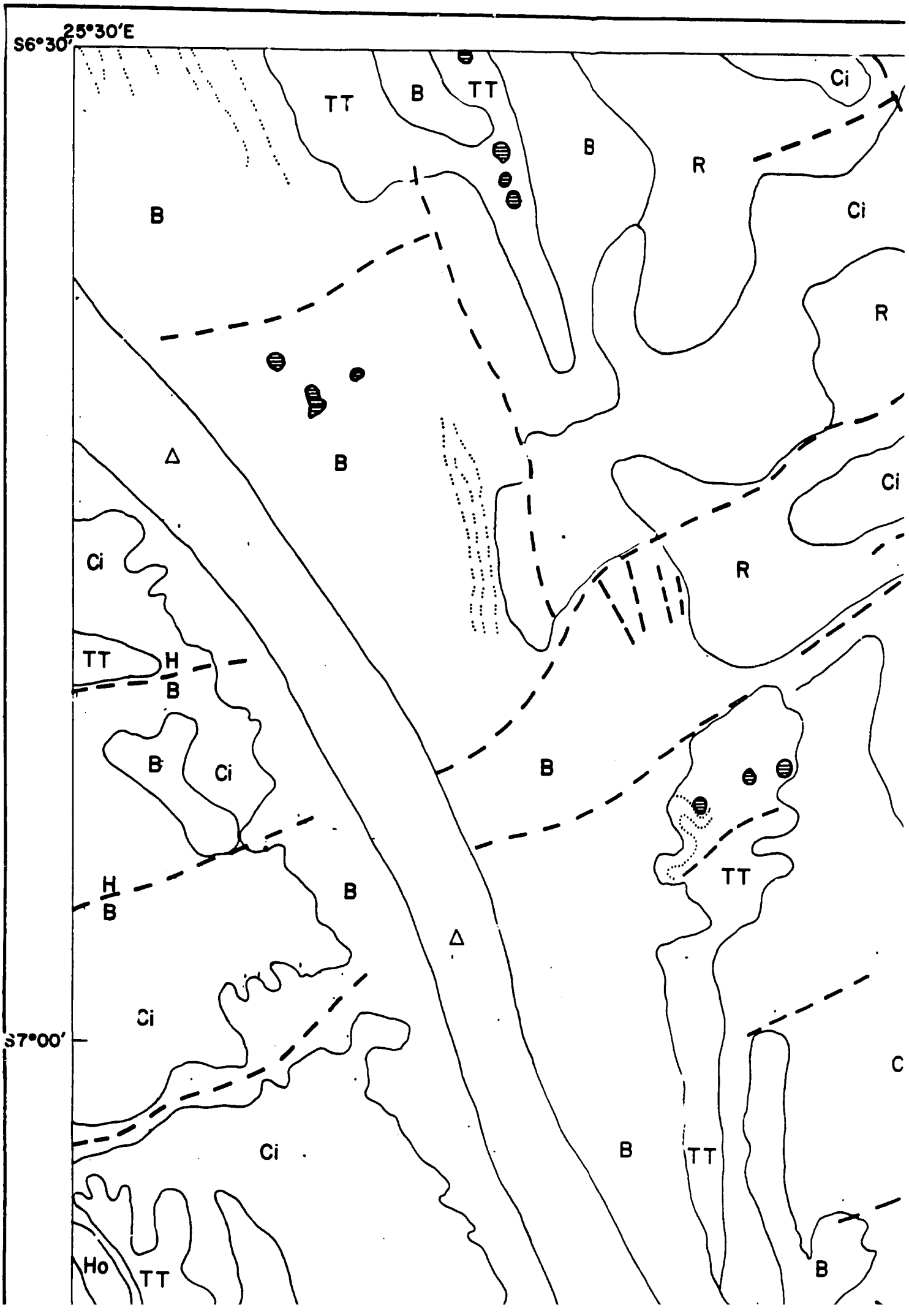
R/ɤ = Ruzizien et/ou Roche granitisée

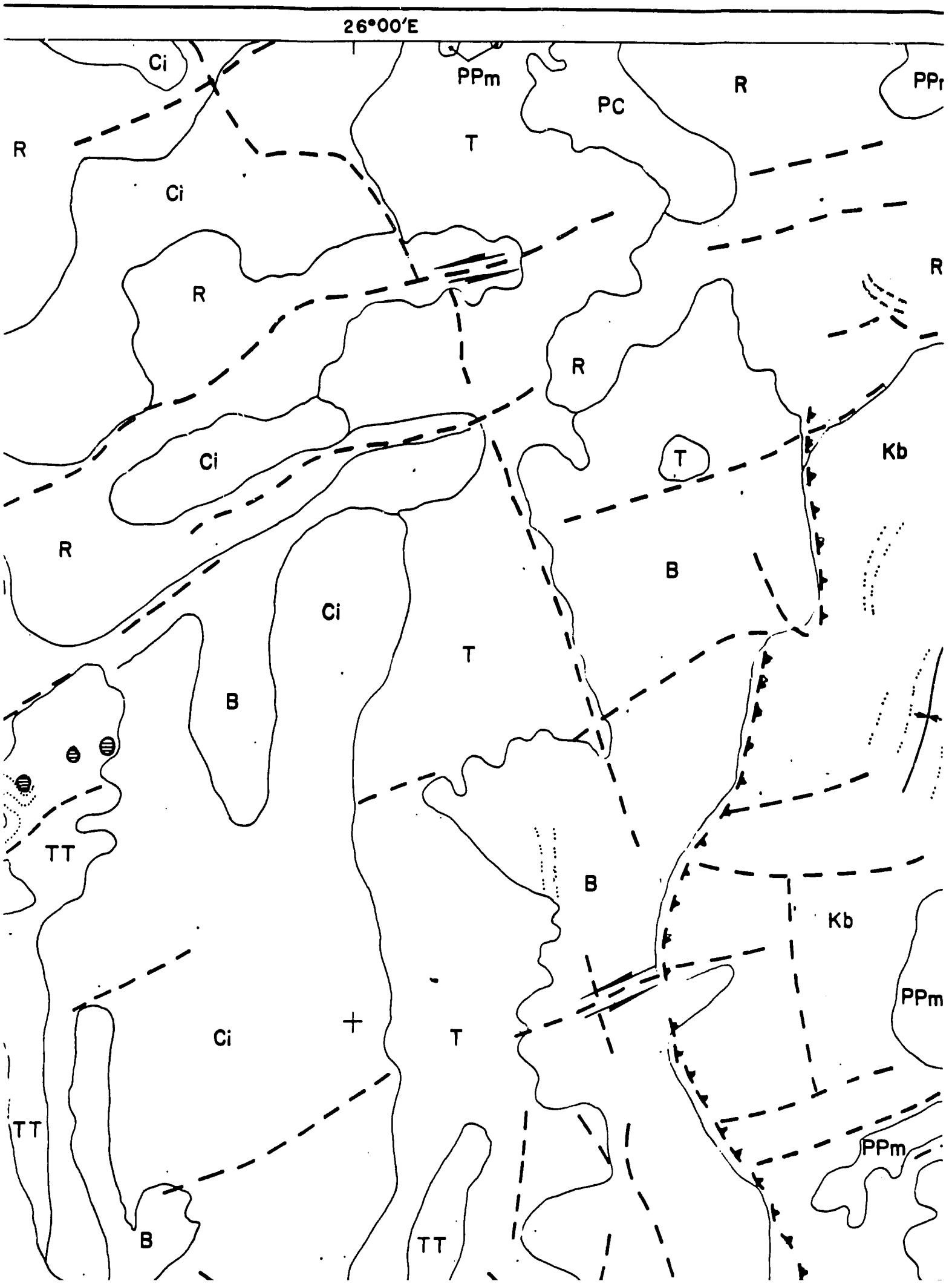
eur

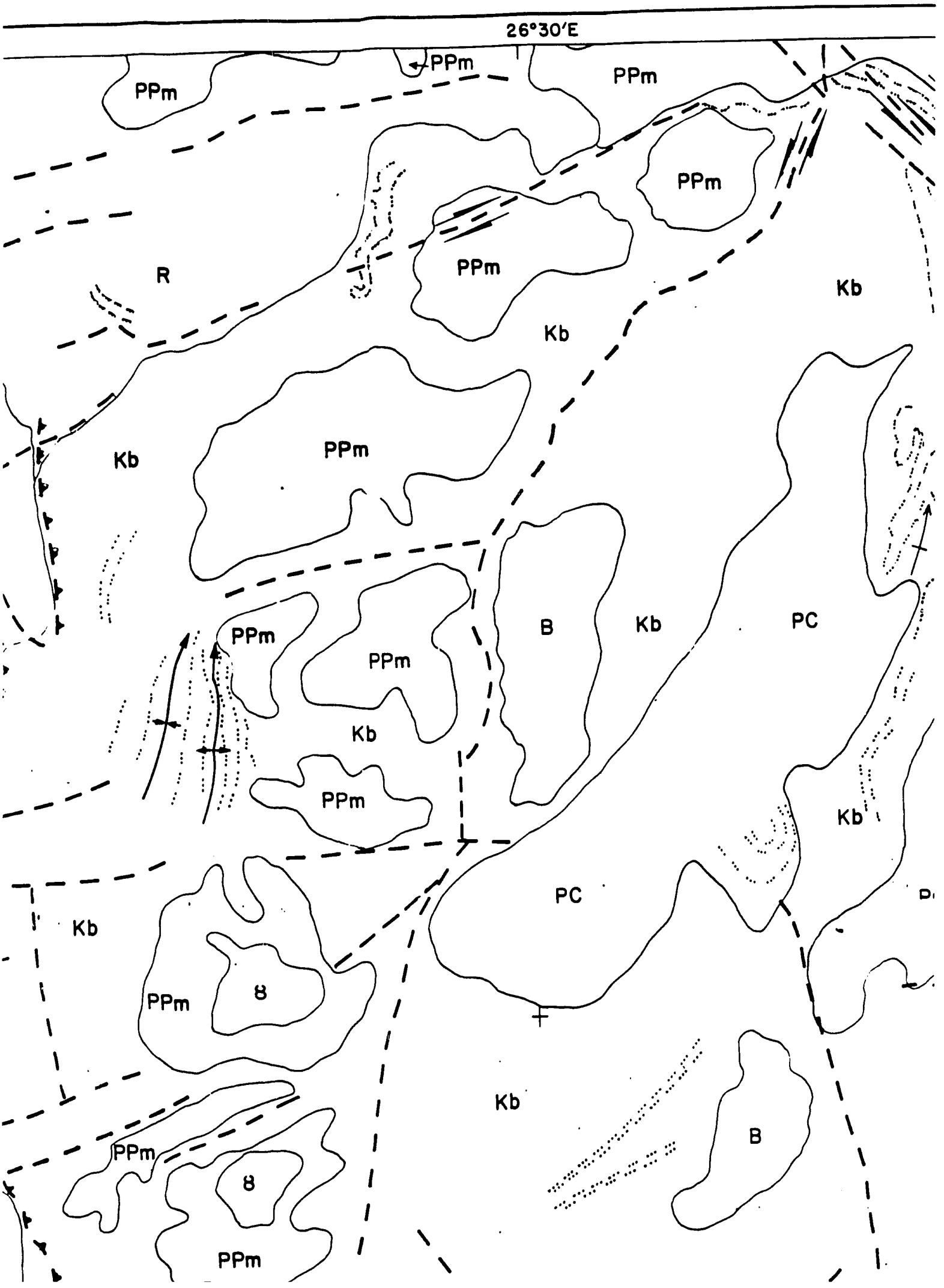
série

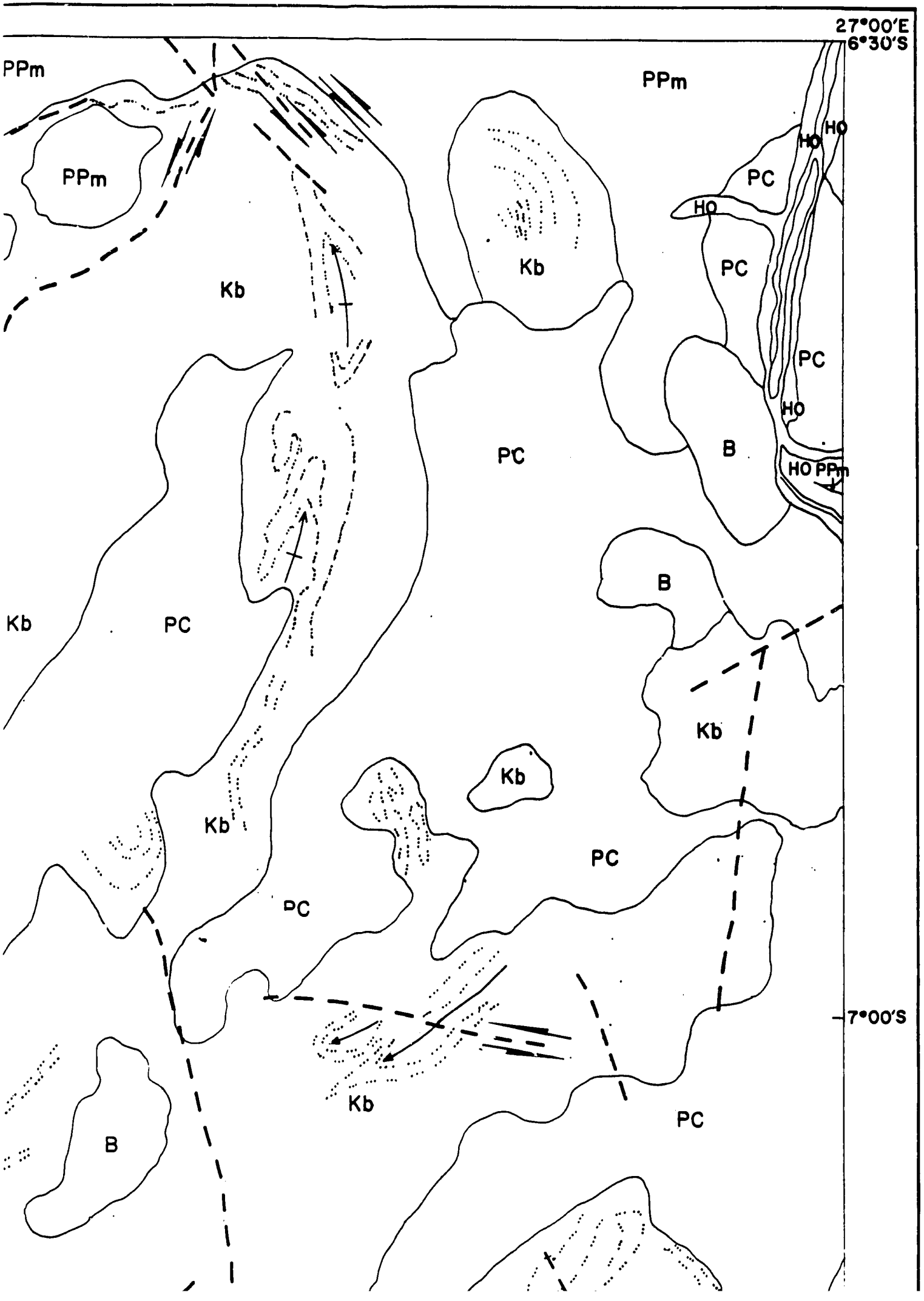
ur:

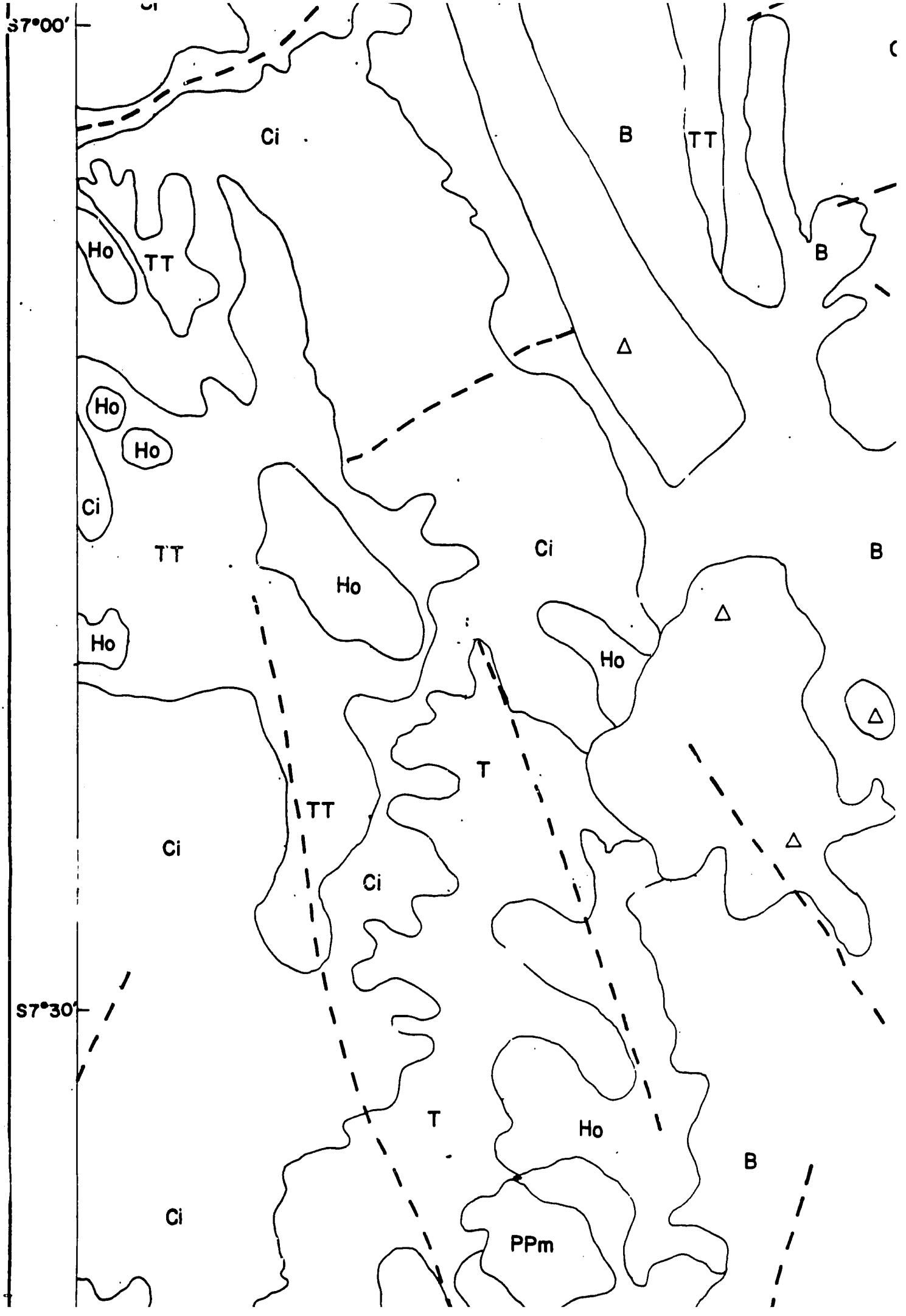
DESSINATEUR LUMBU


25°30'E
S6°30'
S7°00'
TT
B
TT
B
R
Ci
Ci
B
R
B
Ci
Ci
R
Ci
TT
H
B
B
Ci
B
H
B
B
TT
Ci
Ci
B
TT
Ho
TT
B
C

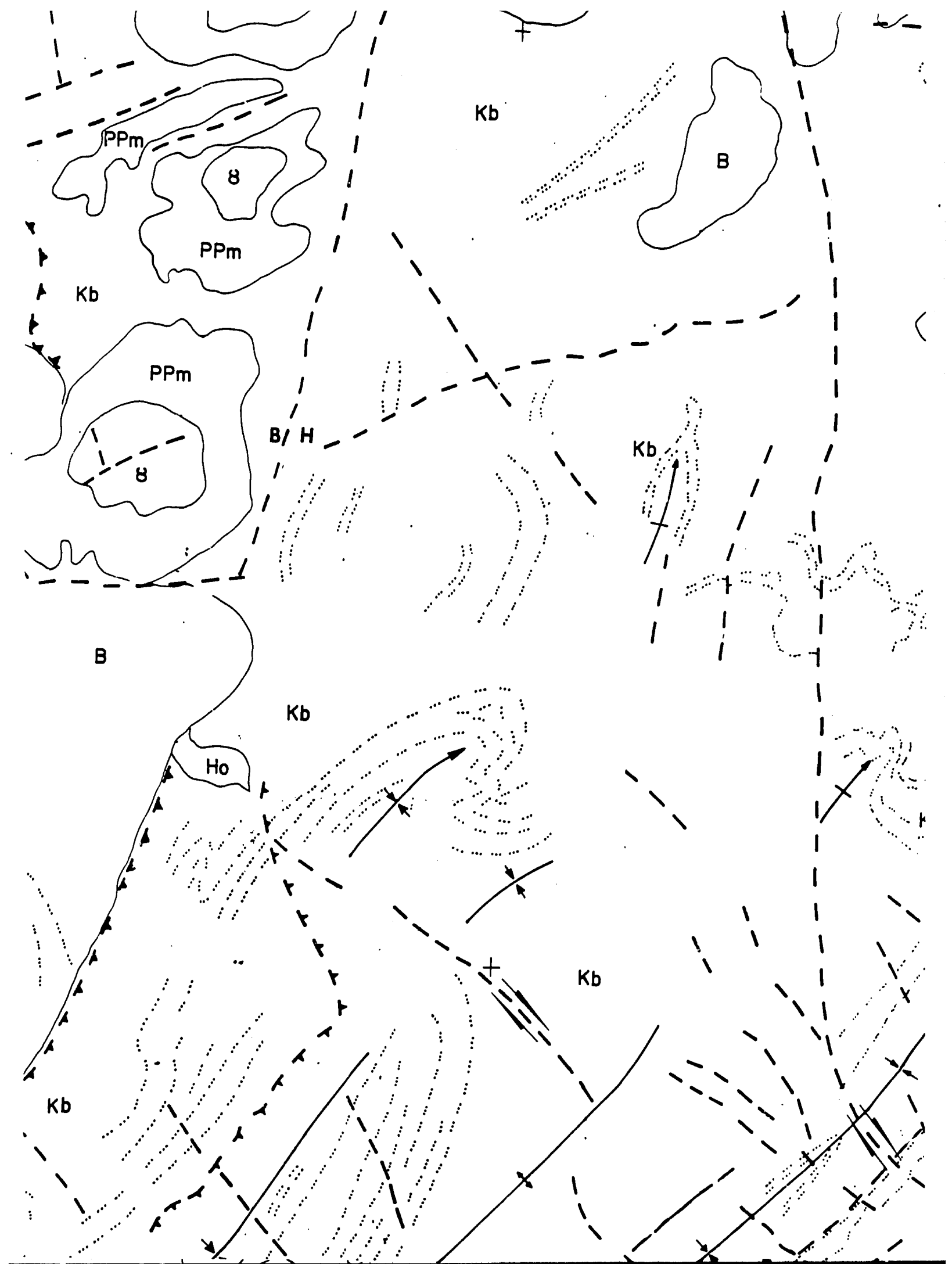

26°00'E
Ci
PPm
PC
R
PPr
T
R
Ci
R
R
R
Ci
T
Kb
R
B
Ci
T
B
TT
B
Kb
PPm
Ci
T
TT
PPm
B
TT

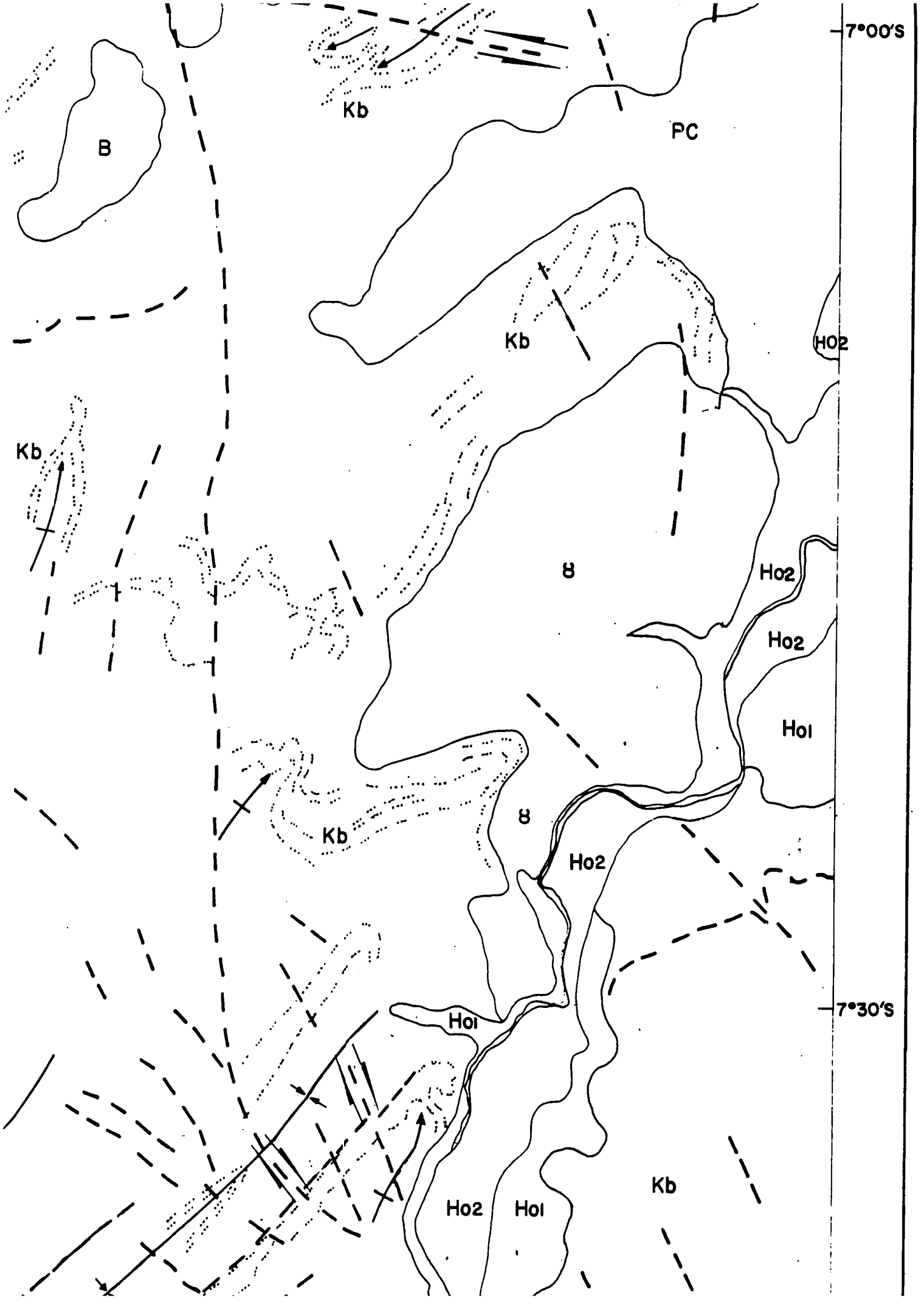

26°30′E
PPm
PPm
PPm
PPm
PPm
R
Kb
Kb
Kb
PPm
PPm
PPm
PPm
Kb
B
Kb
PC
Kb
PC
Kb
PPm
8
Kb
B
PPm
8
PPm

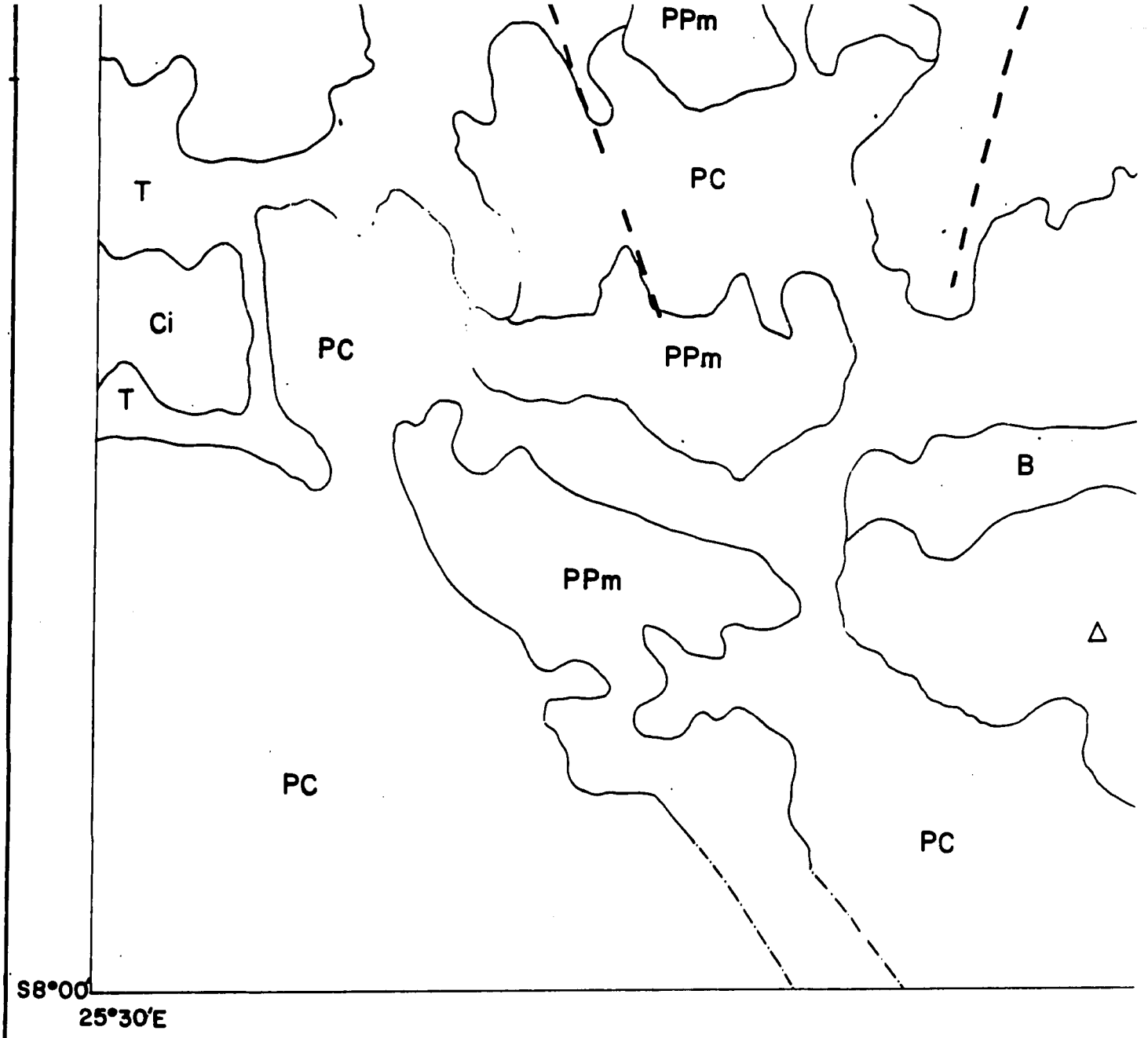

27°00'E
6°30'S
PPm
PPm
PPm
Kb
Kb
PC
HO
HO
HO
PC
PC
PC
HO
B
HO
PPm
PC
B
Kb
PC
Kb
Kb
Kb
PC
PC
7°00'S
Kb
PC
B


S7°00'
S7°30'
Ci
B
TT
Ho
TT
B
Δ
Ho
Ho
Ci
TT
Ci
B
Ho
Ho
Ho
Δ
Δ
T
TT
Ci
Ci
Δ
T
Ho
B
Ci
PPm

Ci
T
B
TT
B
TT
B
Kb
Cl
B
T
B
B
Kb


Kb
PPm
8
PPm
B
Kb
PPm
8
B/ H
Kb
B
Kb
Ho
Kb
Kb


7°00'S
7°30'S
Kb
B
PC
Kb
Ho2
Kb
8
Ho2
Ho2
Ho1
8
Kb
Ho2
Ho1
Ho2
Ho1
Kb



Limite lithologique séparant les systèmes

Limite lithologique douteuse separant les systèmes

Limite lithologique à l'interieur d'un système

Limite lithologique douteuse à l'interieur d'un système

Axe anticlinal

Axe synclinal

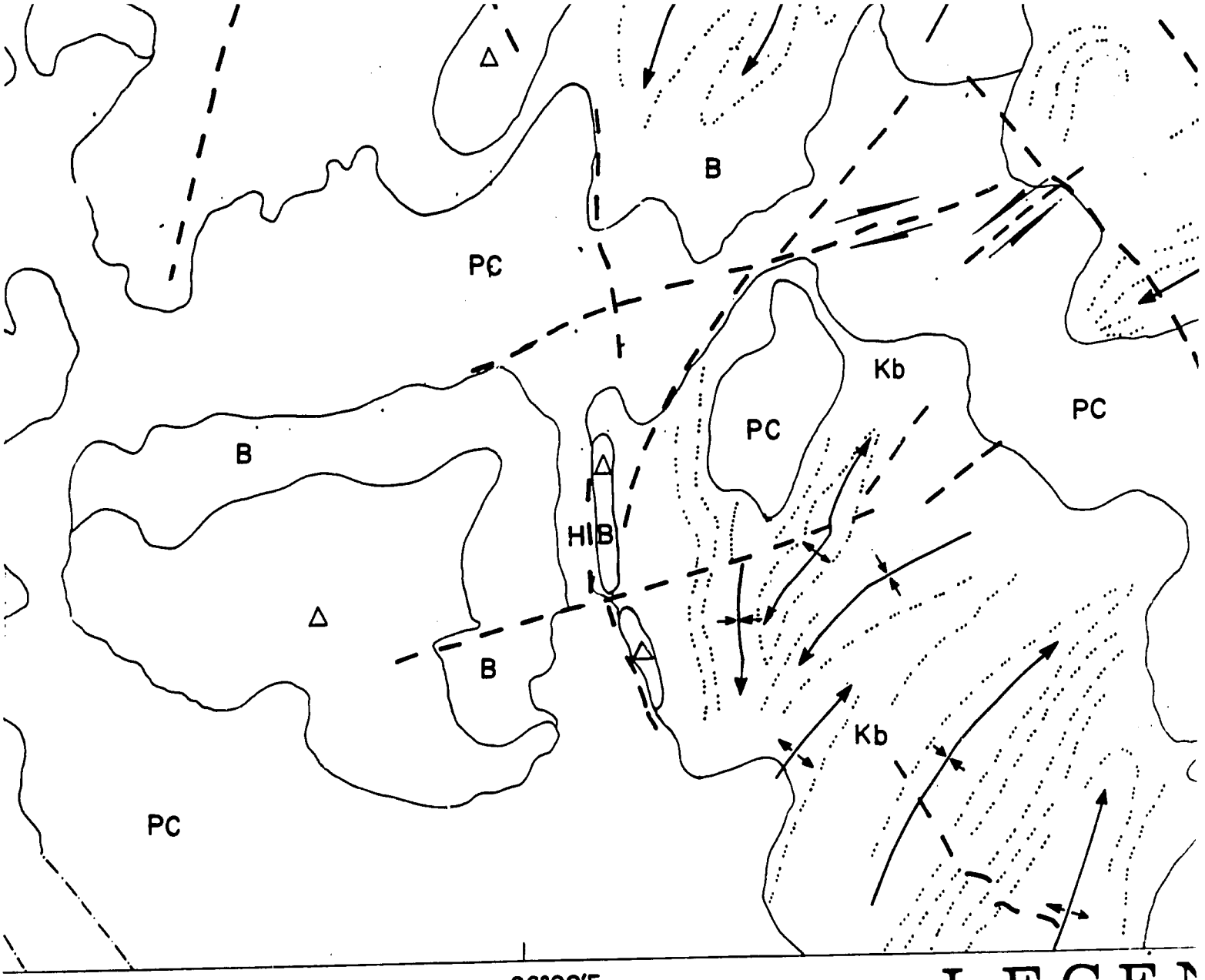
Plissement à pendage indéterminé

Ho =

Ho1 =

Ho2 =

PLANCHE N° II INTERPPETATION GEOLOGIQUE ET STRUCTURALE.



LEGEN

systèmes

ne

d'un système

Faille

Faille de cisaillement

H
B
Faille avec affaissement (H=Haut , B=Bas)

Faille de chevauchement

TERRAINS PHANEROZOIQUES

Ho =Holocène , Alluvions modernes

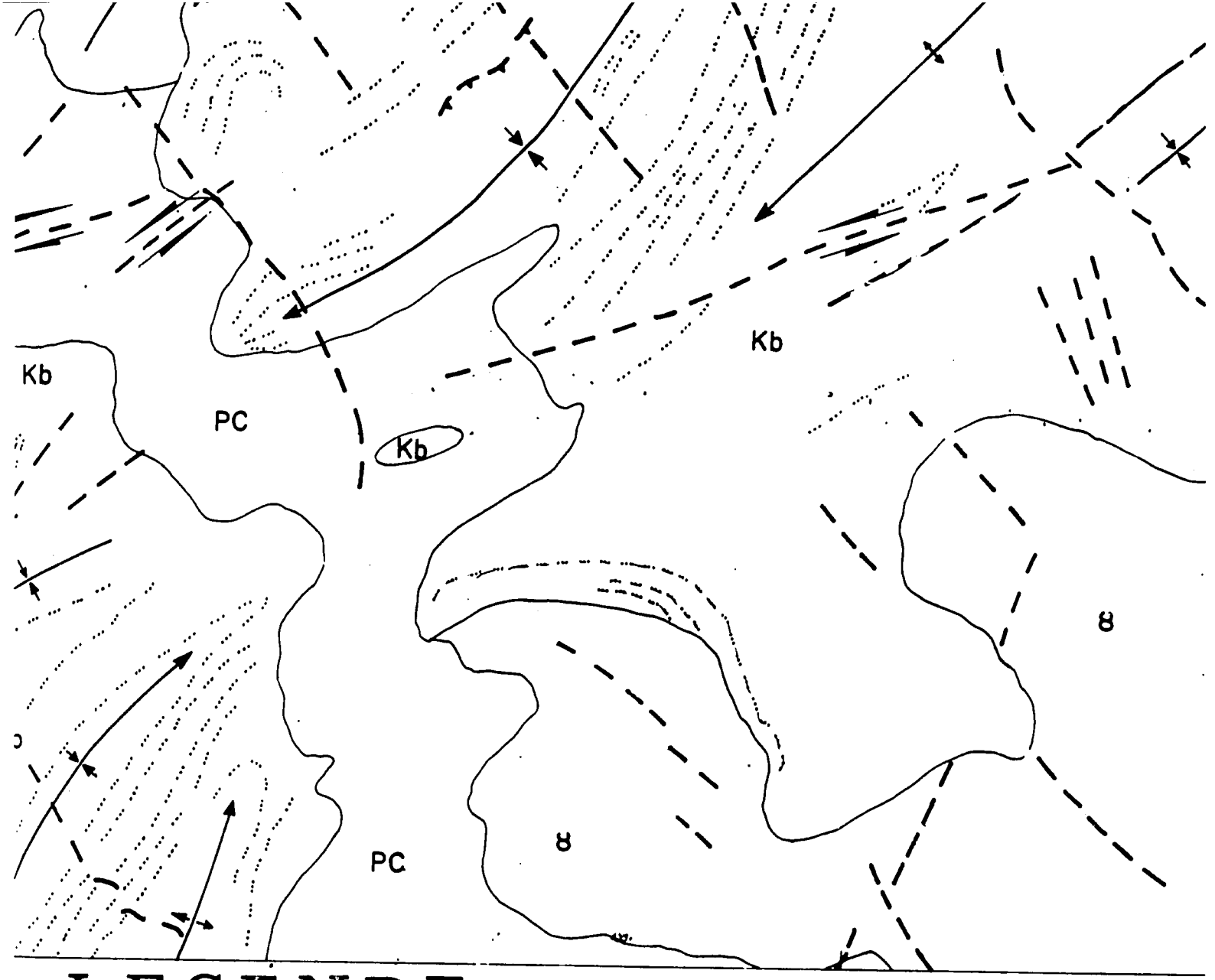
Ho1 = " relativement ancien

Ho2 = " " jeune

Echelle 1/

5 0 5

GIQUE ET STRUCTURALE. D Scène Landsat de MWANZA & KABONGO



LEGENDE

as)

PPm = Pleistocène , Pliocène et Miocène supérieur " Série des cirques " Quelo

T = Triasique et Liasique série de la haute série des " roches rouges "

TT = Néogène série des sables ocre

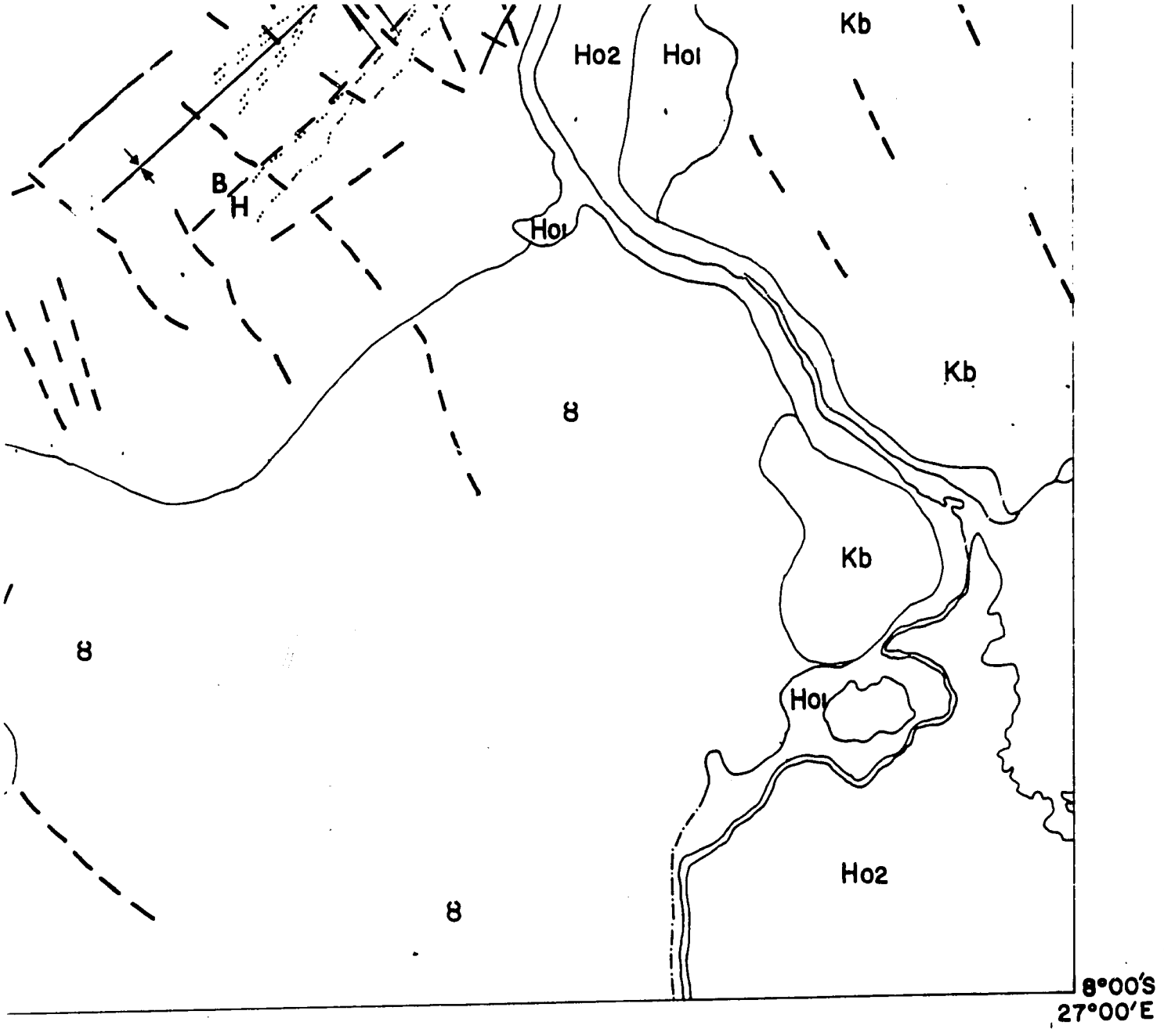
PC = Permien inférieur ; Carboniferien supérieur, série de la Lukuga

Ci = Wealdien, série de la Loia

Echelle : 1/200.000

5 0 5 10 15

DESSINATEURS LUMBU ET PAMBU



irques "Quelo

s rouges "

.ukuga

TERRAINS PRECAMBRIENS

B = Bushimay indifférencié

Kb = Kibarien

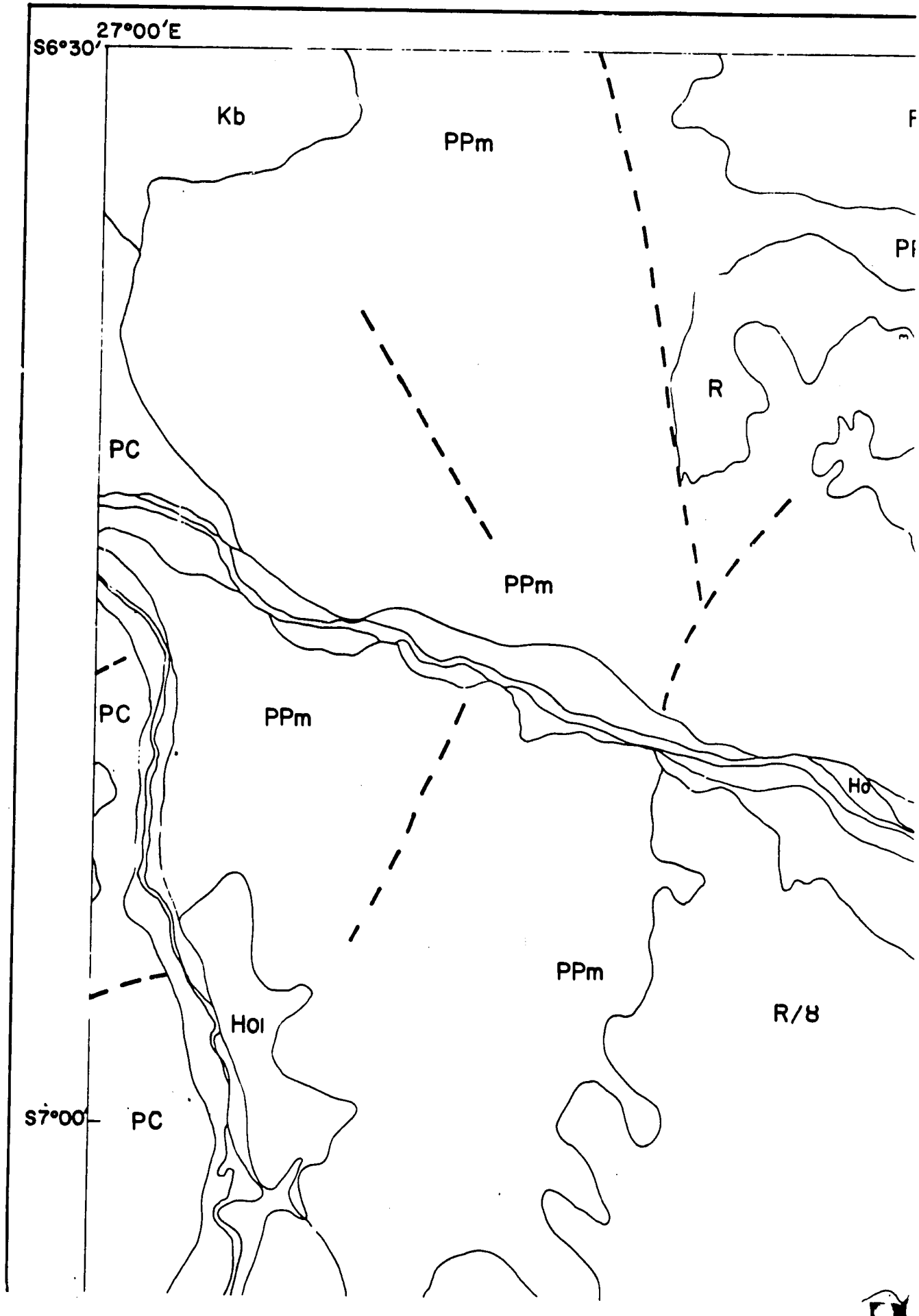
R = Rusizien

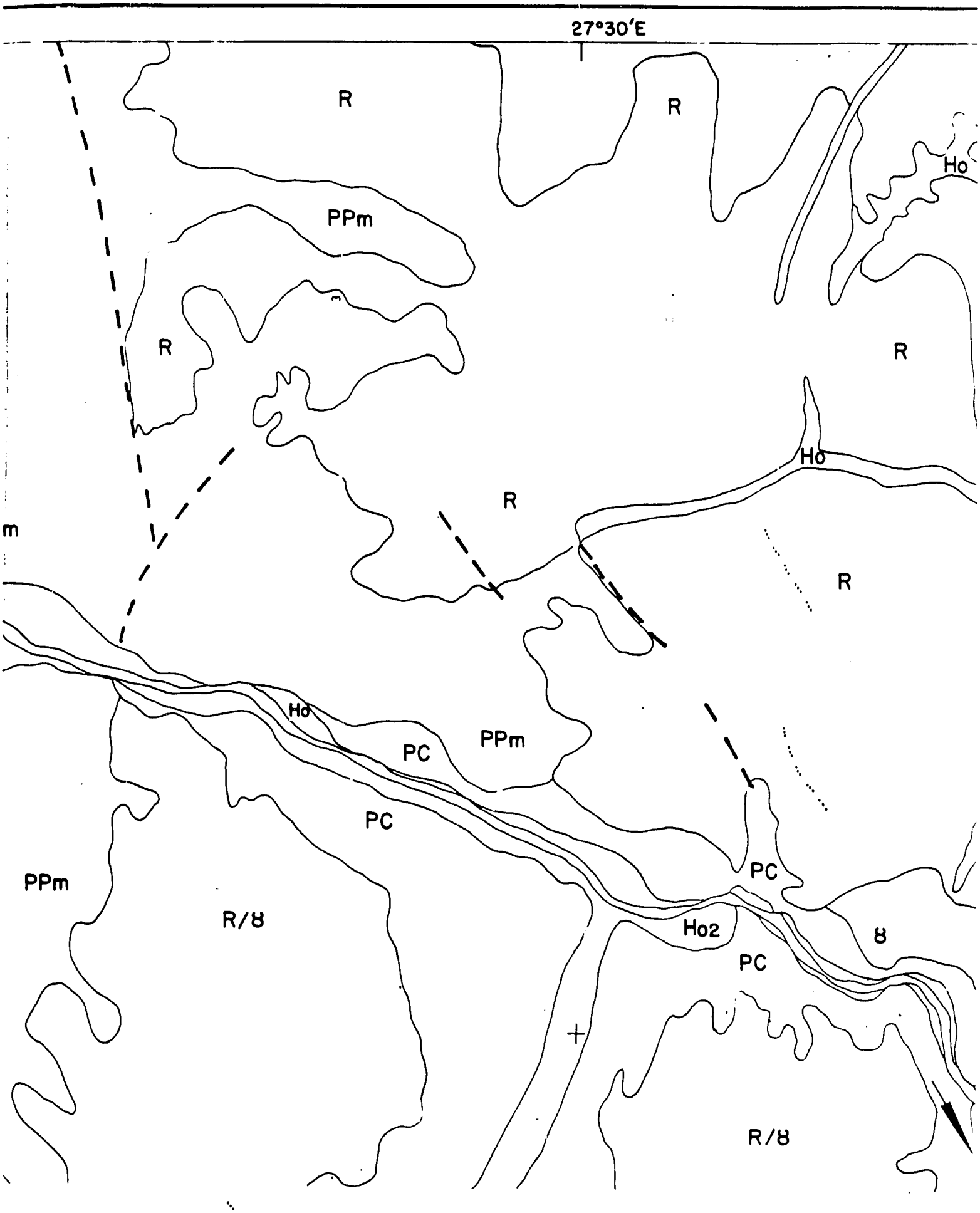
8 = Roche granitique

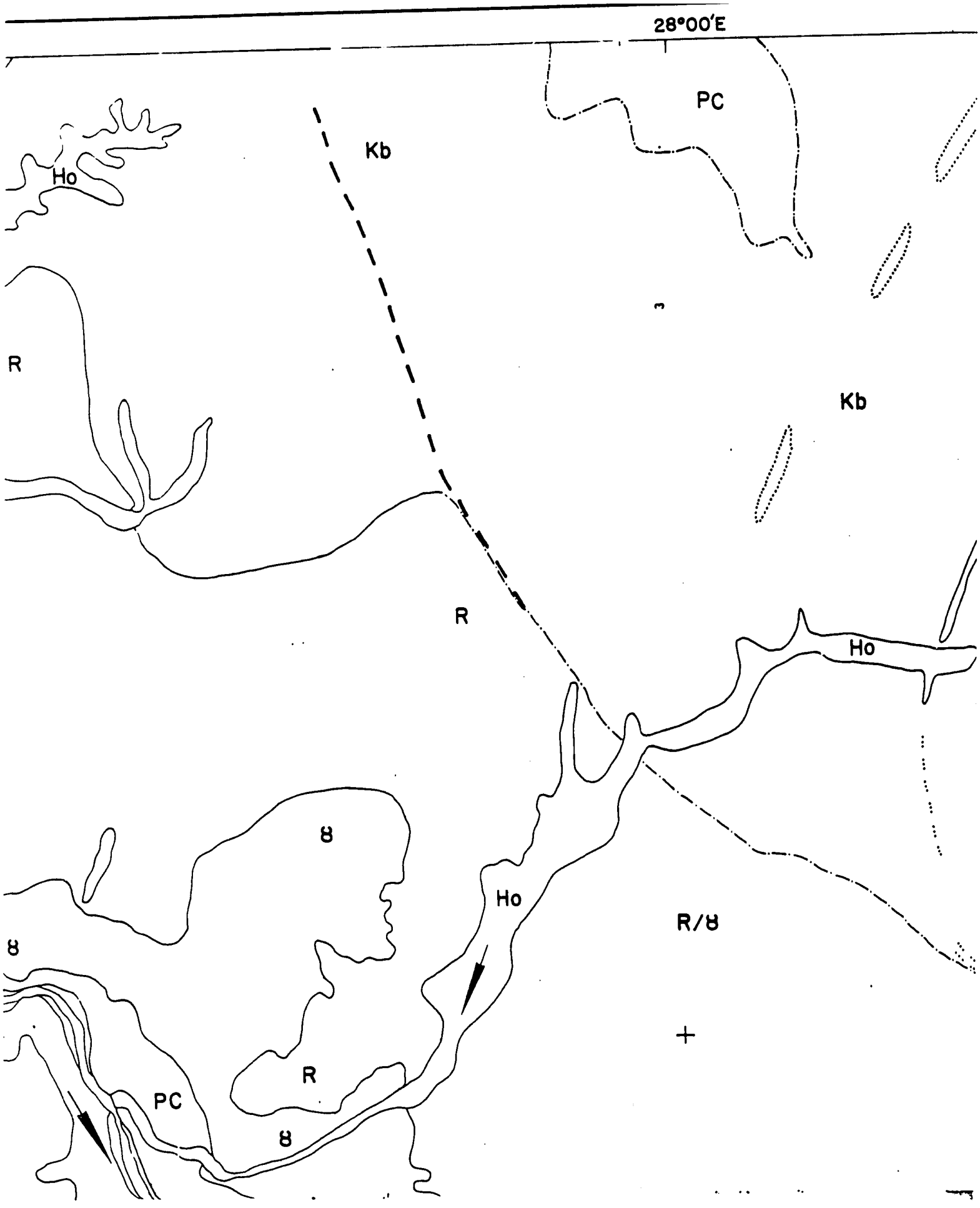
△ = Laves et intrusions doléritiques

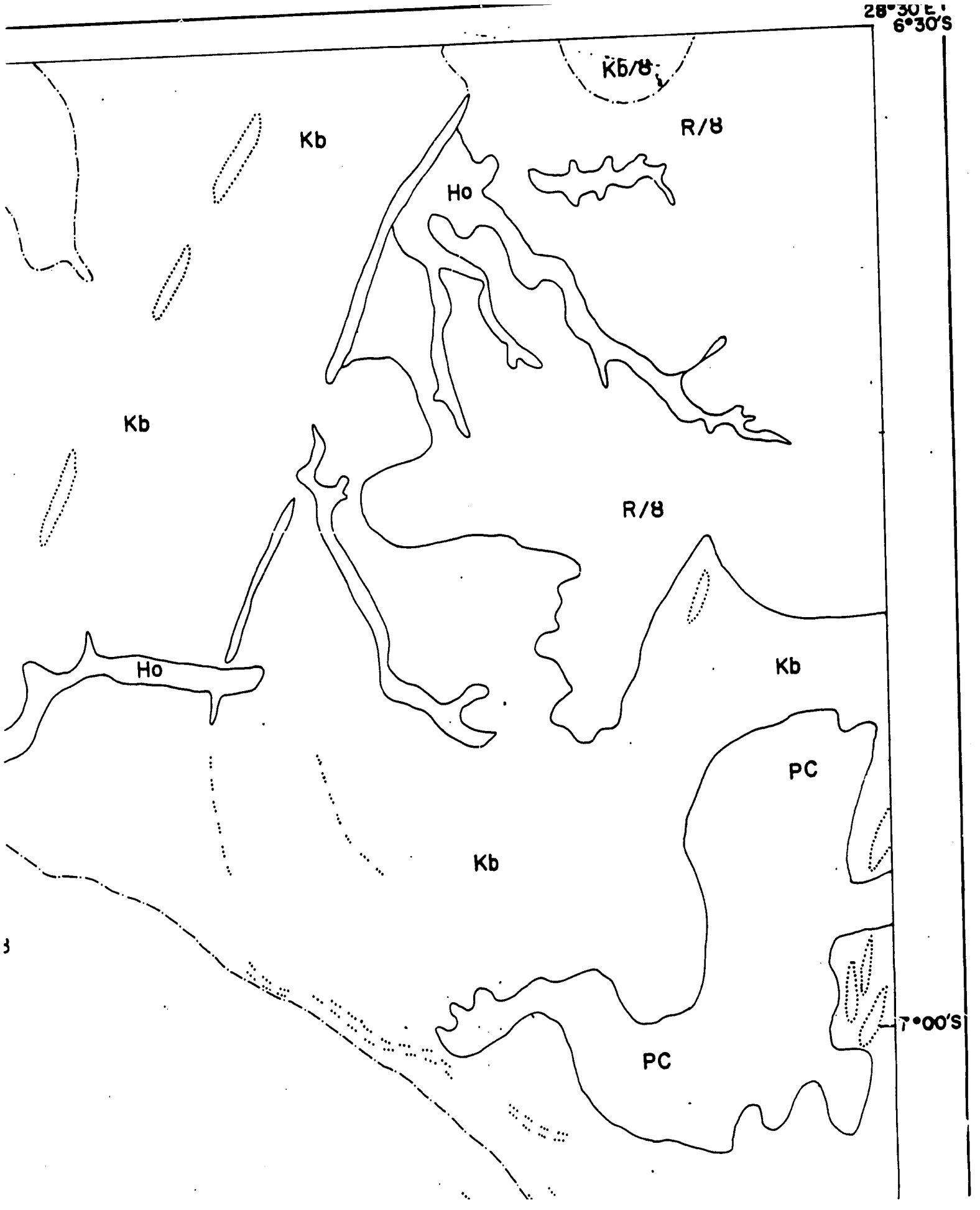
⬭ = Anomalie geométrique - Intrusion de Kimberlite supposée

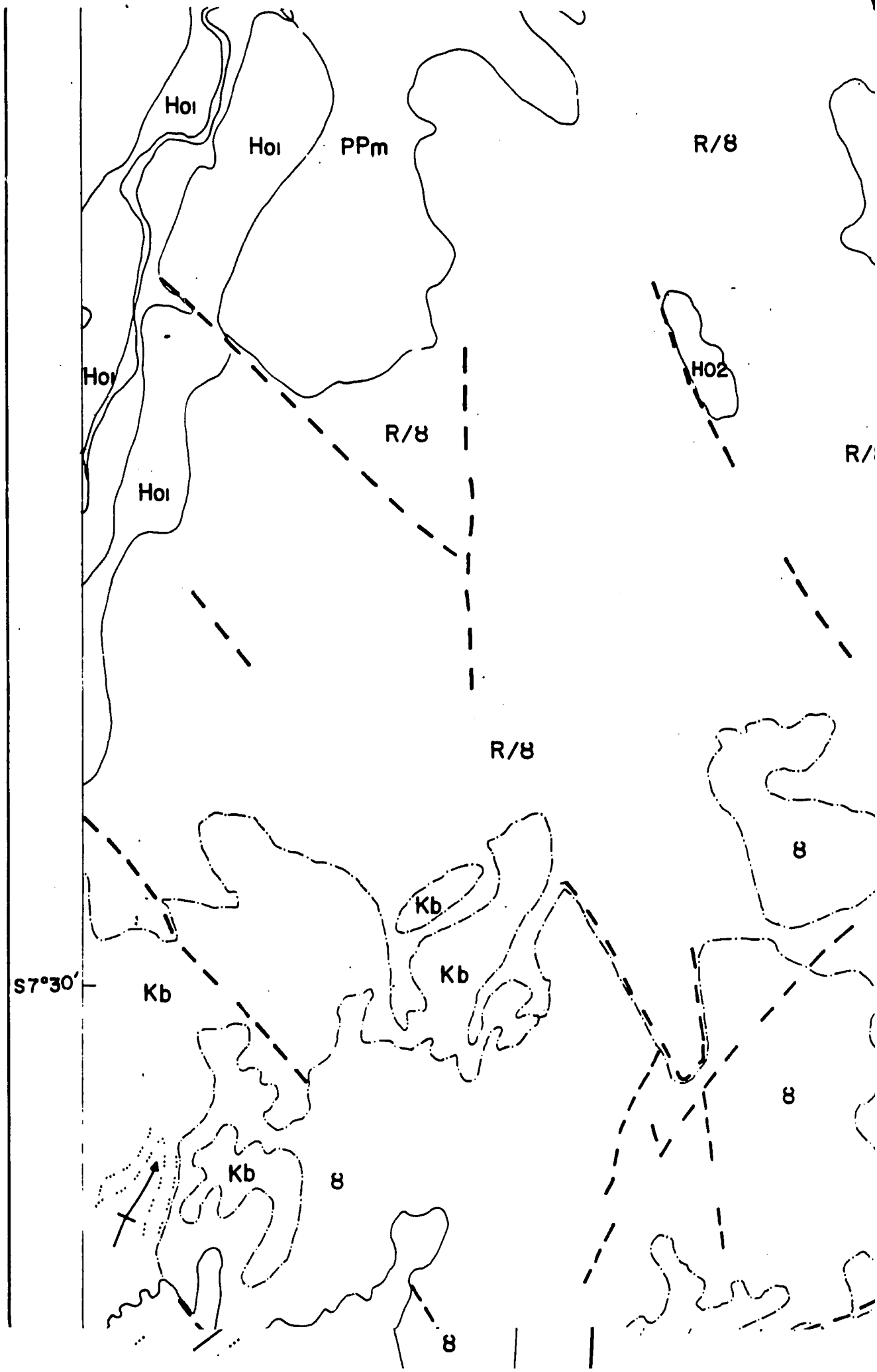
ET PAMBU

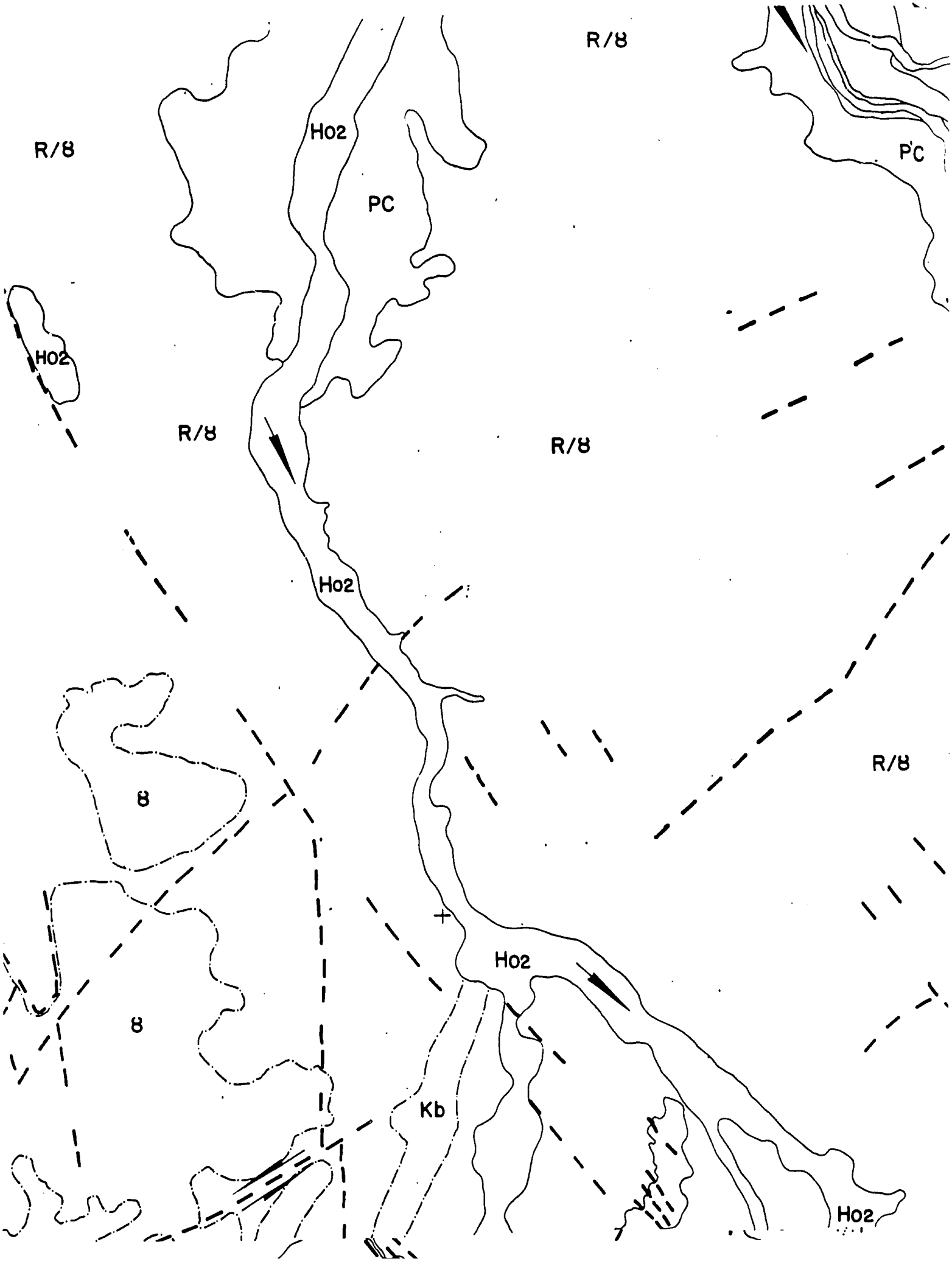

27°00'E
S6°30'
Kb
PPm
R
PC
PPm
PC
PPm
Hd
PPm
R/8
Hol
S7°00'
PC

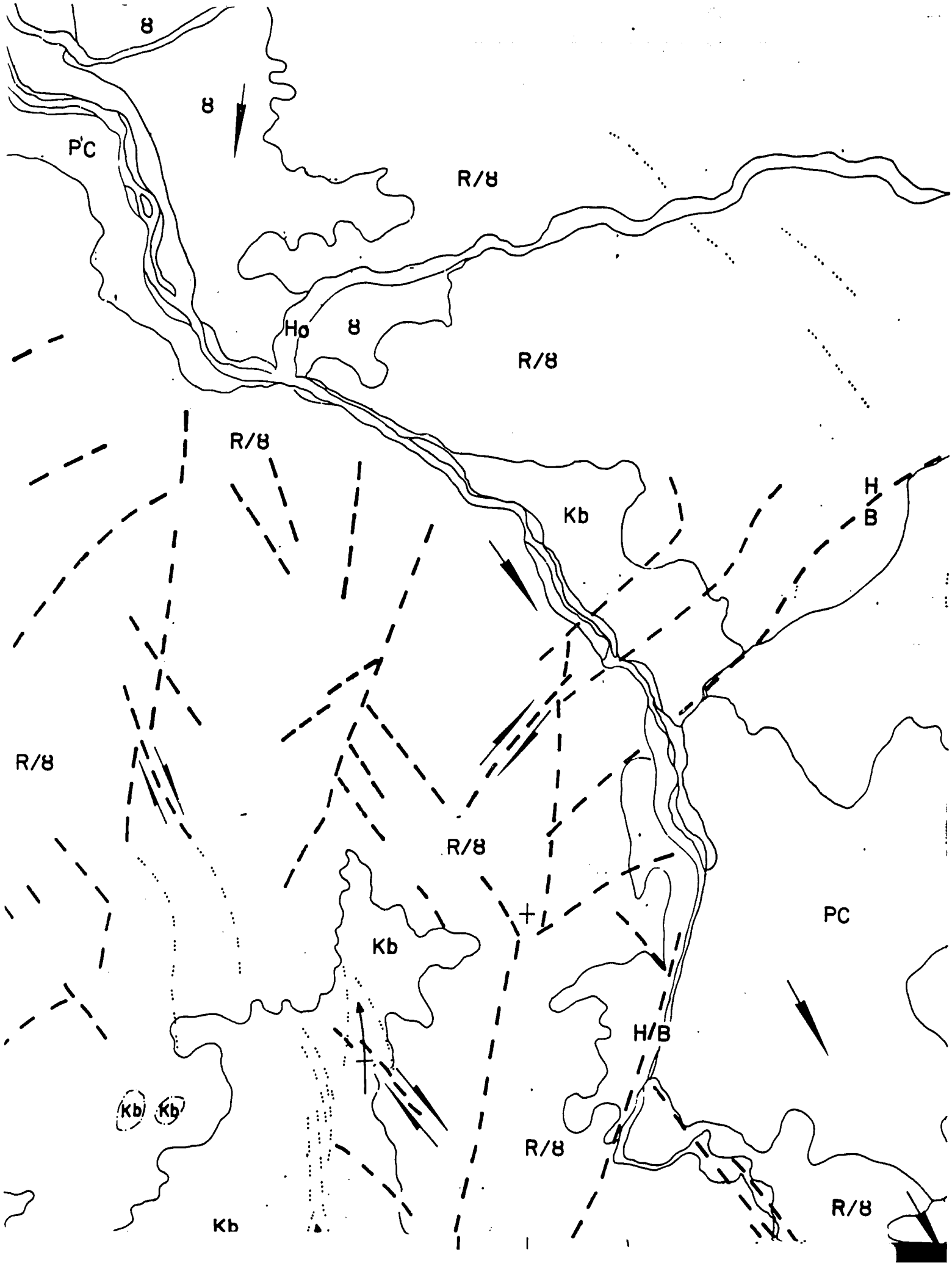

27°30′E
R
R
Ho
PPm
R
R
Ho
R
m
R
Ho
PC
PPm
PC
PPm
R/8
PC
Ho2
8
PC
R/8

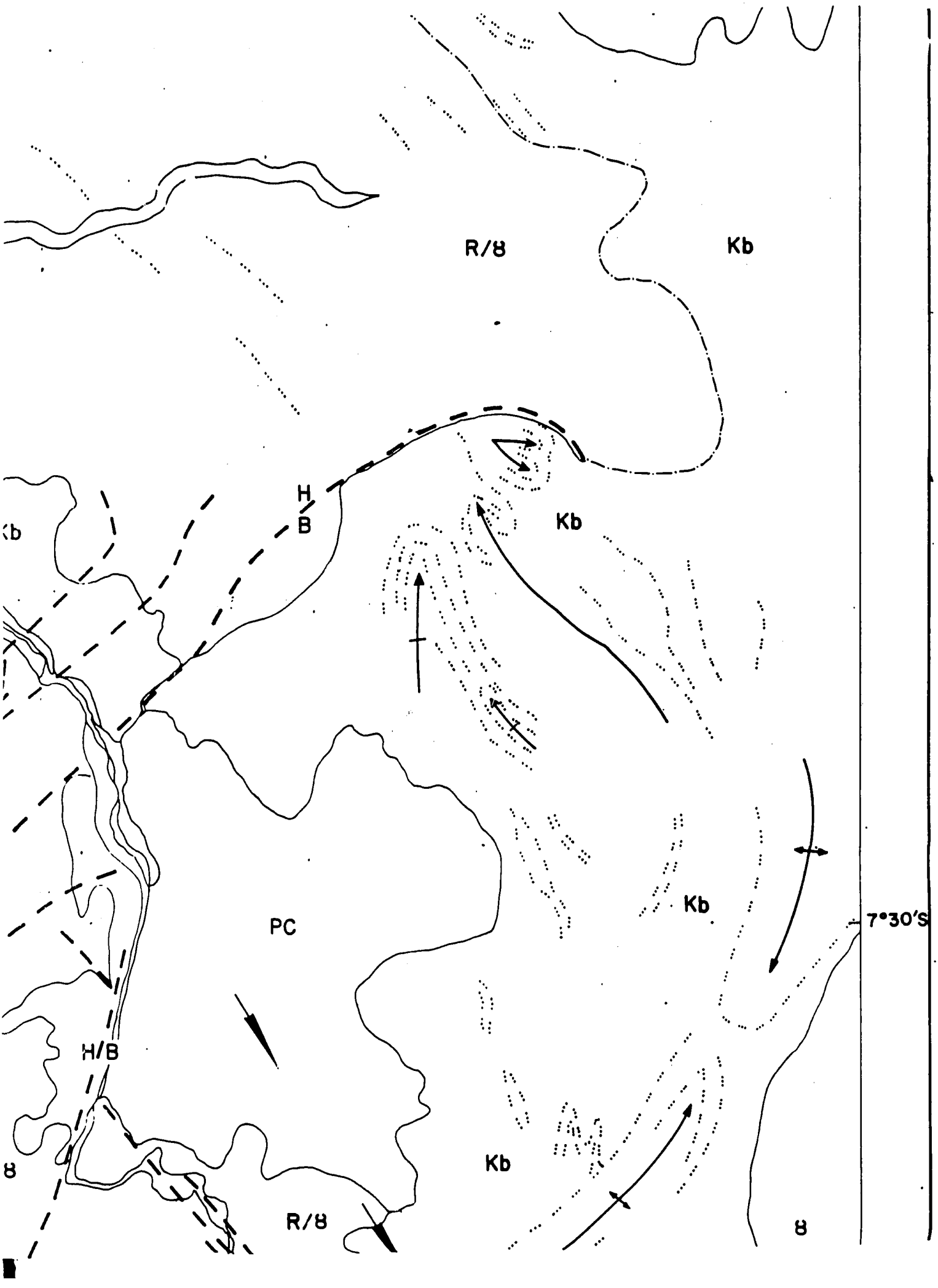

28°00'E
PC
Kb
Ho
R
Kb
R
Ho
ȣ
Ho
R/ȣ
ȣ
R
PC
ȣ

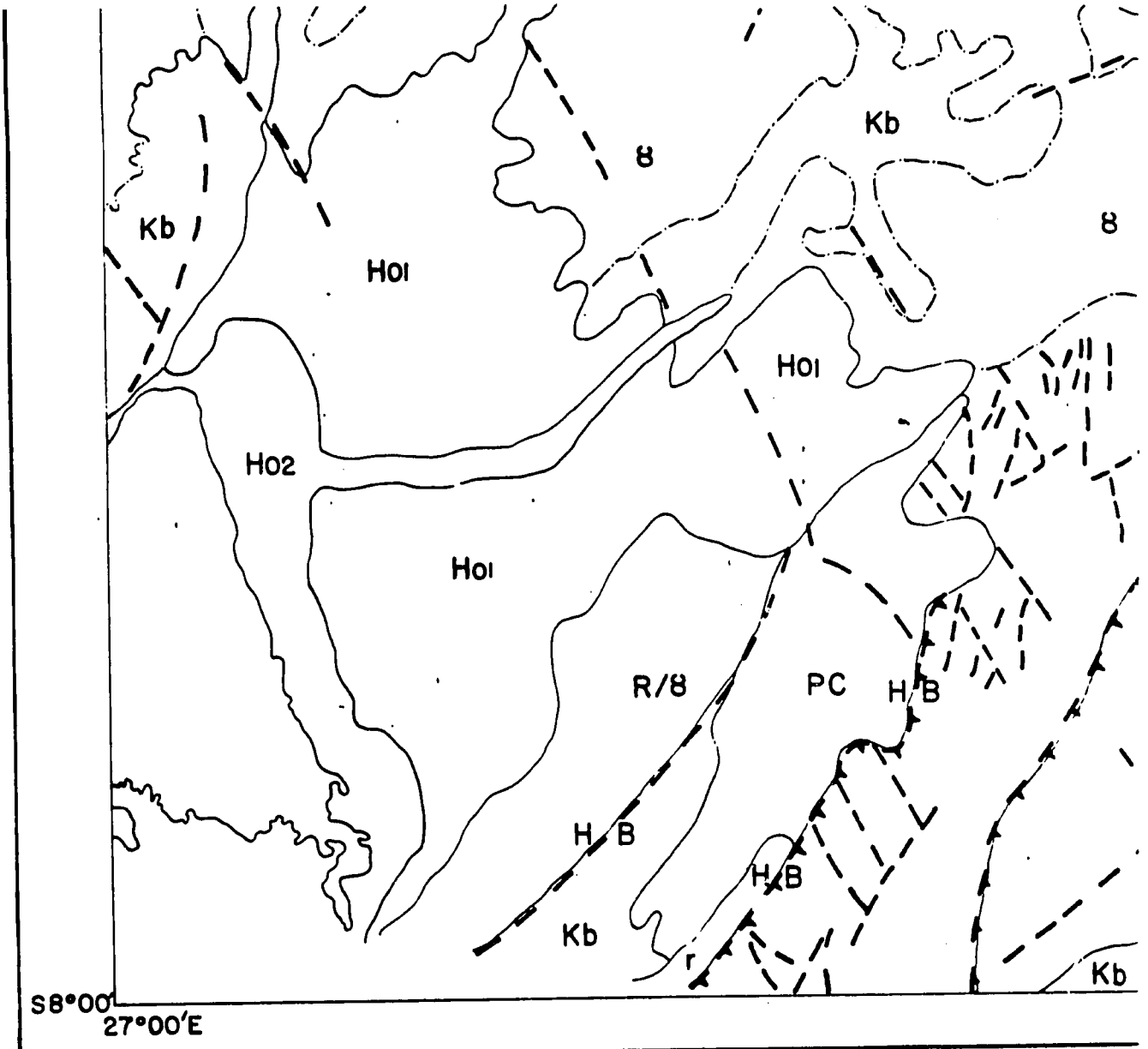

28°30'E
6°30'S
Kb/8
R/8
Kb
Ho
Kb
R/8
Ho
Kb
PC
Kb
7°00'S
PC


Ho1
Ho1
PPm
R/8
Ho1
Ho2
R/8
Ho1
R/8
8
Kb
Kb
S7°30′
Kb
8
Kb
8
8


R/8
R/8
Ho2
PC
PC
Ho2
R/8
R/8
Ho2
R/8
8
8
Ho2
Kb
Ho2


8
8
PC
R/8
Ho
8
R/8
R/8
Kb
H
B
R/8
R/8
Kb
PC
H/B
Kb
Kb
R/8
R/8
Kb


R/8
Kb
H
B
Kb
Kb
PC
Kb
7°30'S
H/B
Kb
R/8
8



Limite lithologique séparant les systèmes

" " douteuse séparant les systemes

" " à l'interieur d'un système

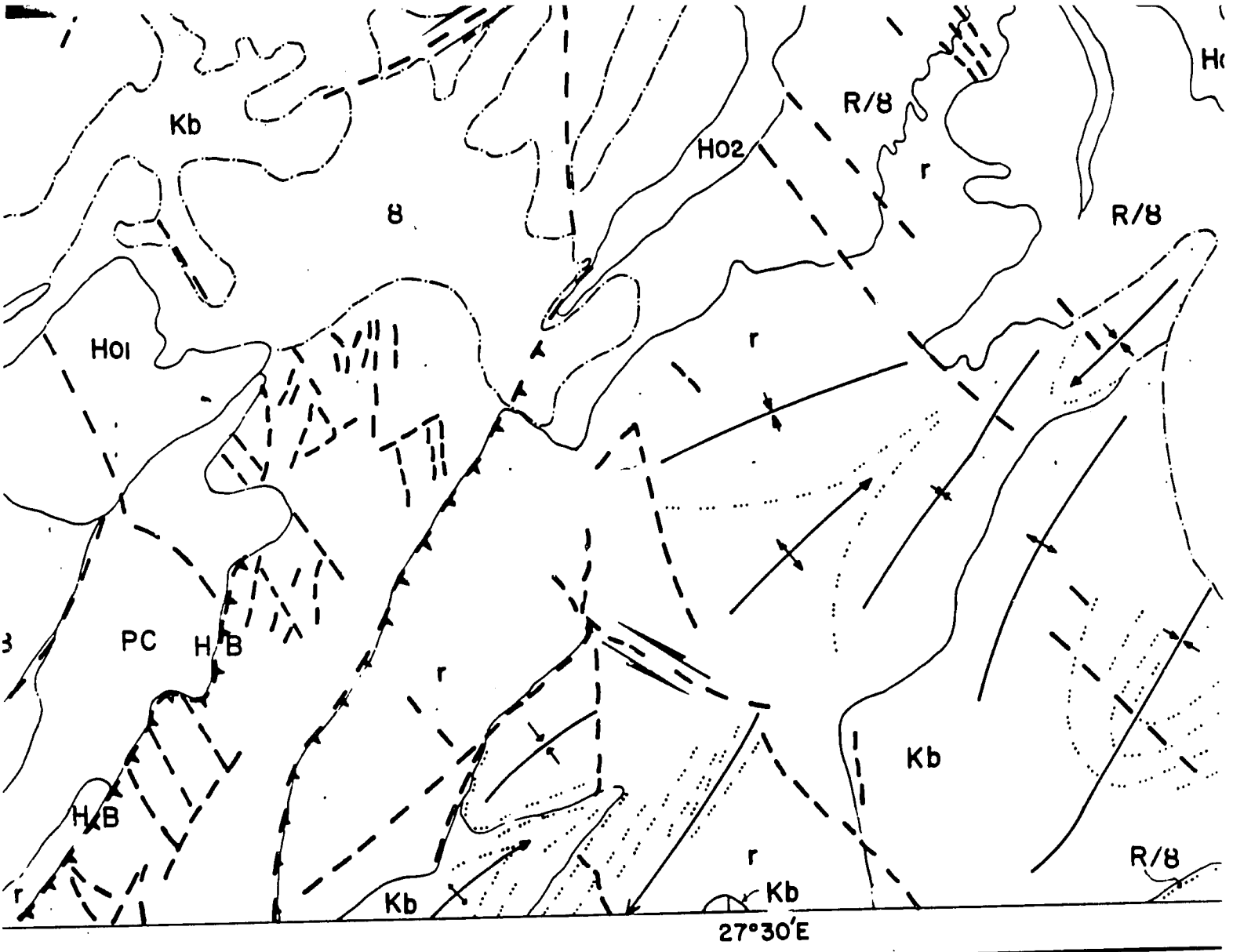
" " douteuse à l'interieur d'un système

Axe anticlinal

Axe synclinal

Plissement à pendage indeterminé

PLANCHE N°II: INTERPRETATION GEOLOGIQUE ET STRUCTU



L E

ant les systèmes

use séparant les systemes

nterieur d'un système

nuse à l'interieur d'un système

ndeterminé

Faille

Faille de cisaillement

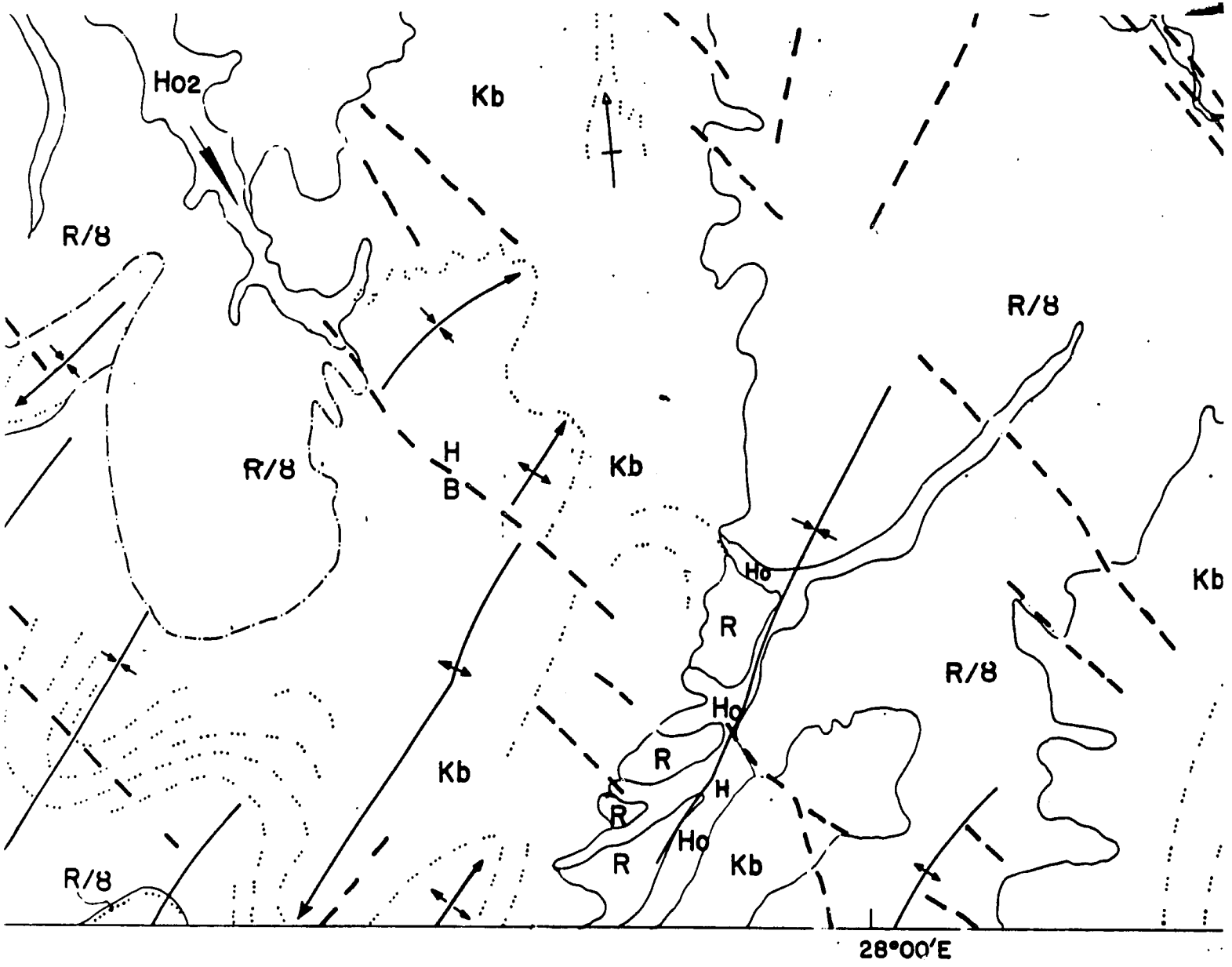
Faille avec affaissement (H=Haut, B= Bas)

Faille de chevauchement

Direction et position propable des fleuves au Tertiaire (Anté Rift)

5 0

ON GEOLOGIQUE ET STRUCTURALE . C Scène Landsat de MANONO



L E G E N D E

TERRAINS PHANEROZOIQUE

Ho = Holocène, Alluvions modernes

Ho1 = " relativement ancien

Ho2 = " " jeune

PPm = Pleistocène, Pliocène et Miocène superieur "Série des cirques Quelo "

PC = Permien inférieur, Carboniferien supérieur, série de la Lukuga

r =

Kb =

Kb/8 =

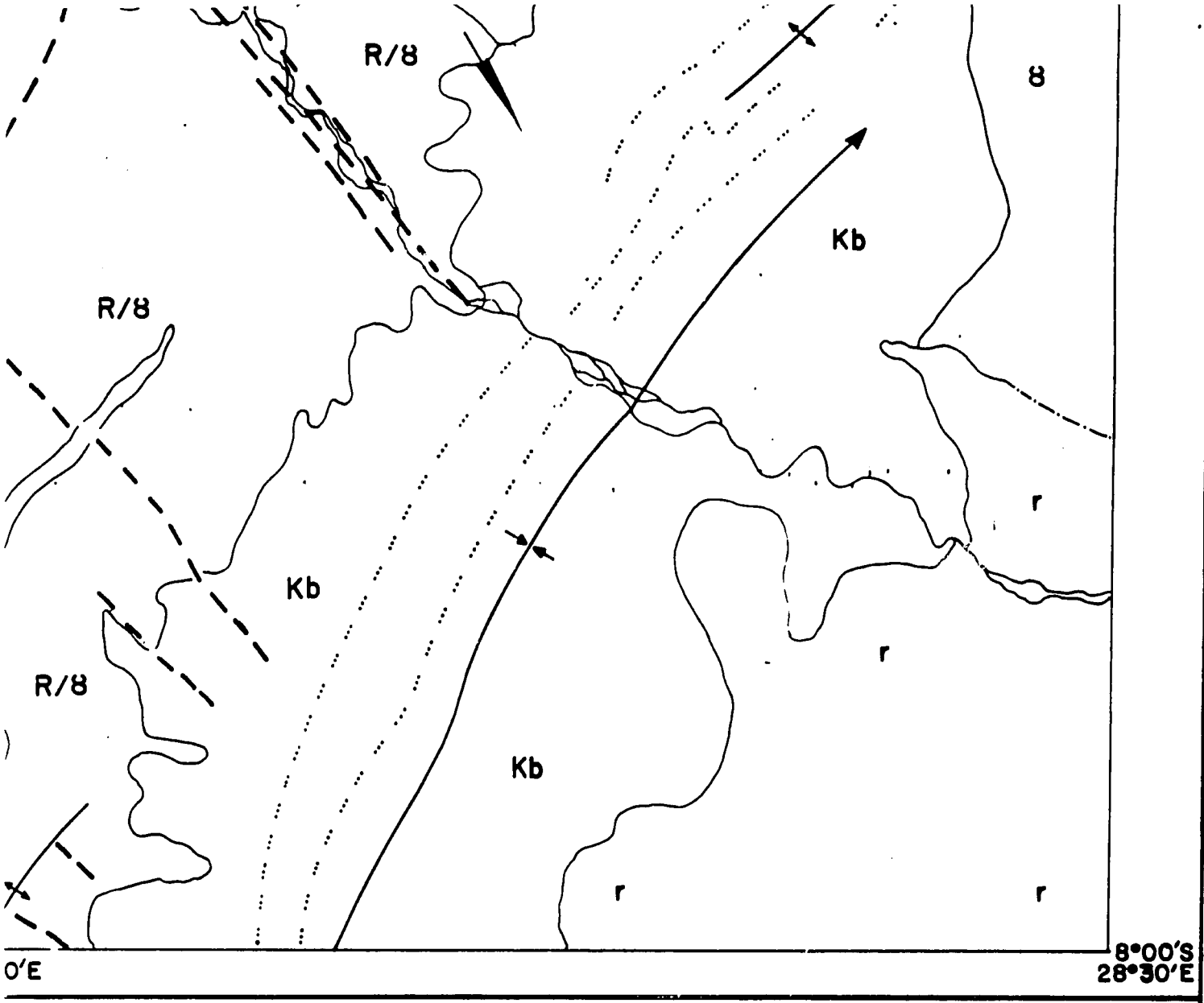
R =

R/8 =

8 =

Echelle : 1/200.000

0 5 10 15



des cirques

de la

TERRAINS PRECAMBRIENS

r = Mwashya - Roan

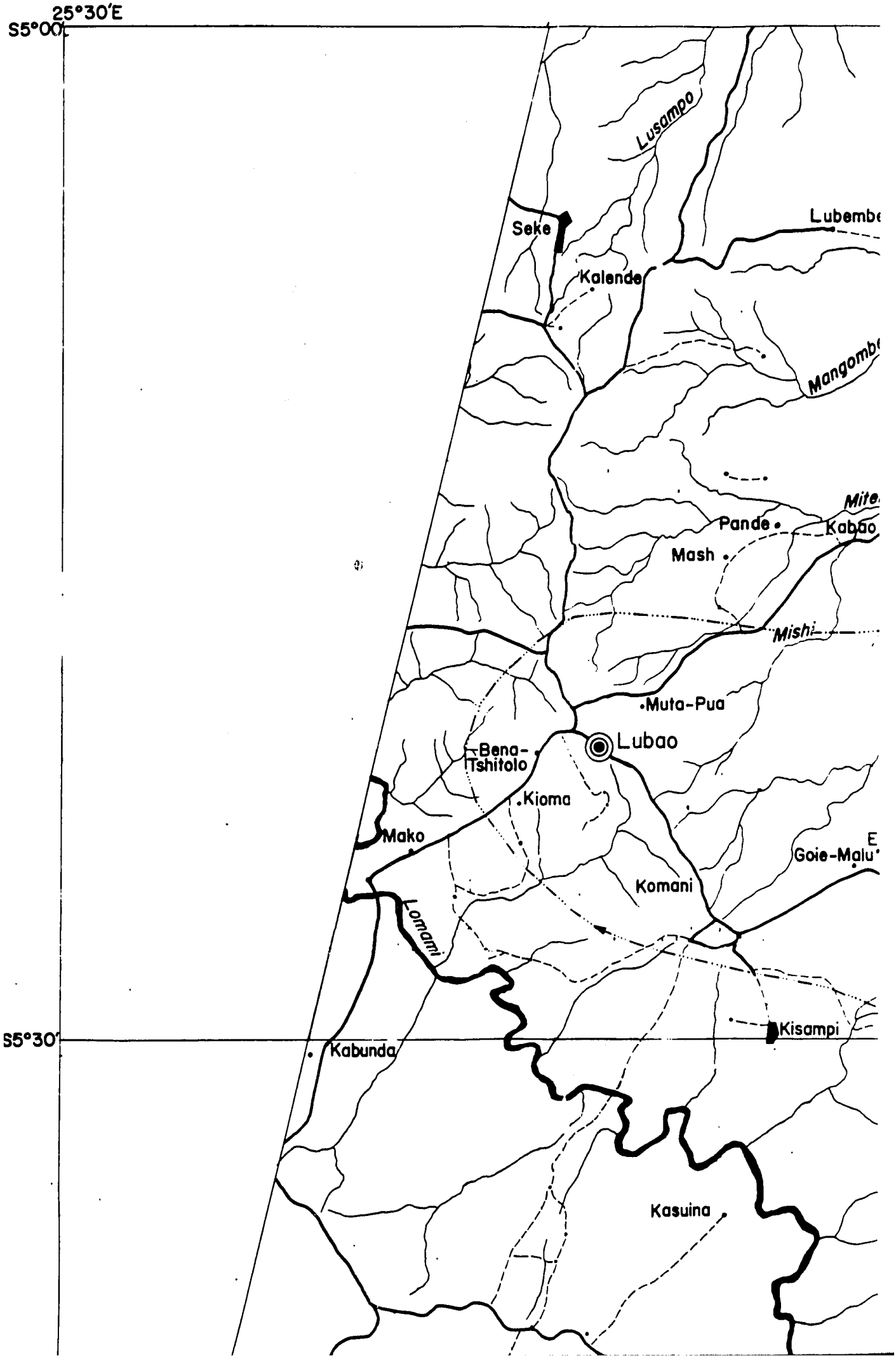
Kb = Kibarien

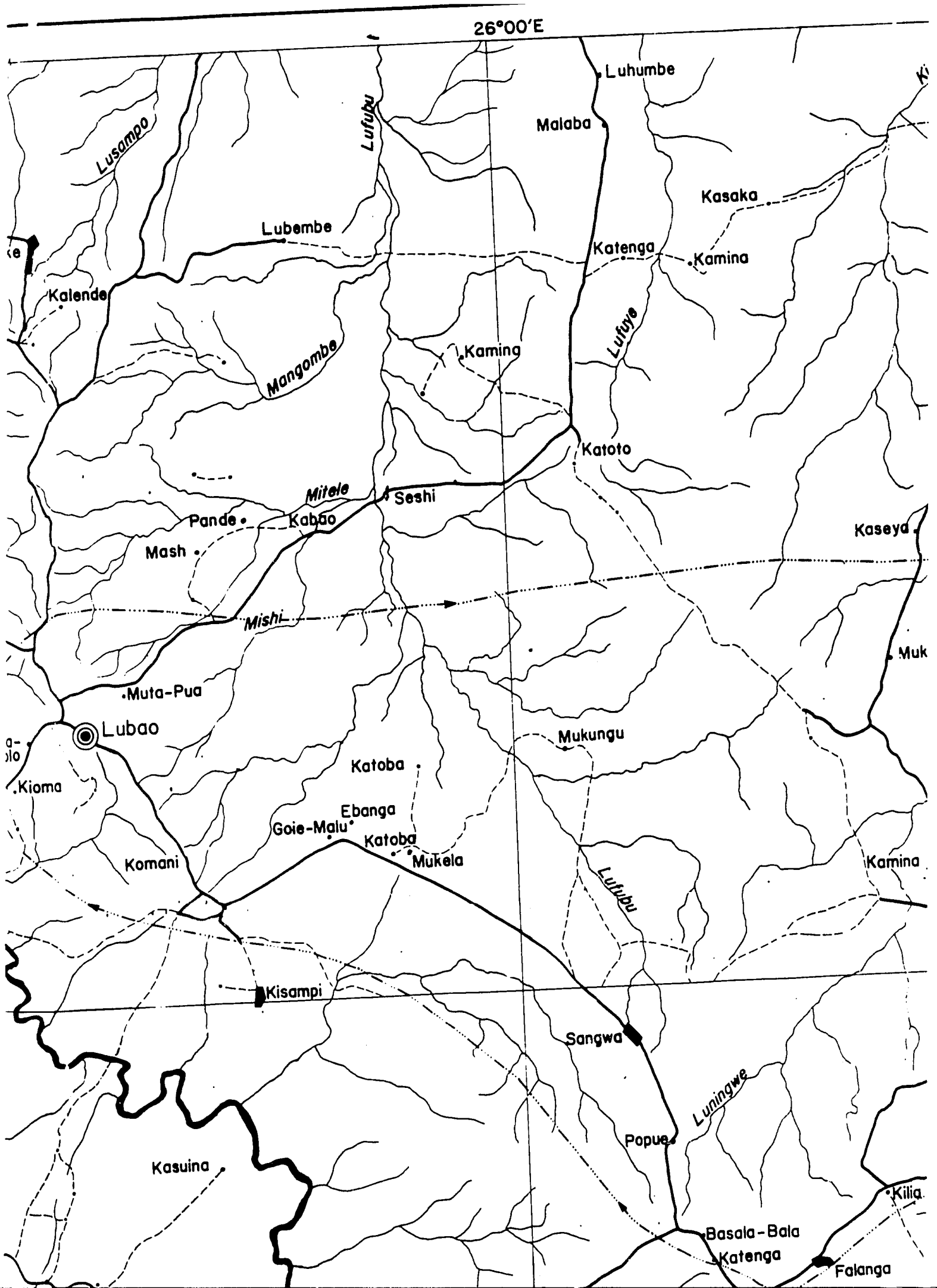
Kb/ϑ = Kibarien et/ou Roche granitisée

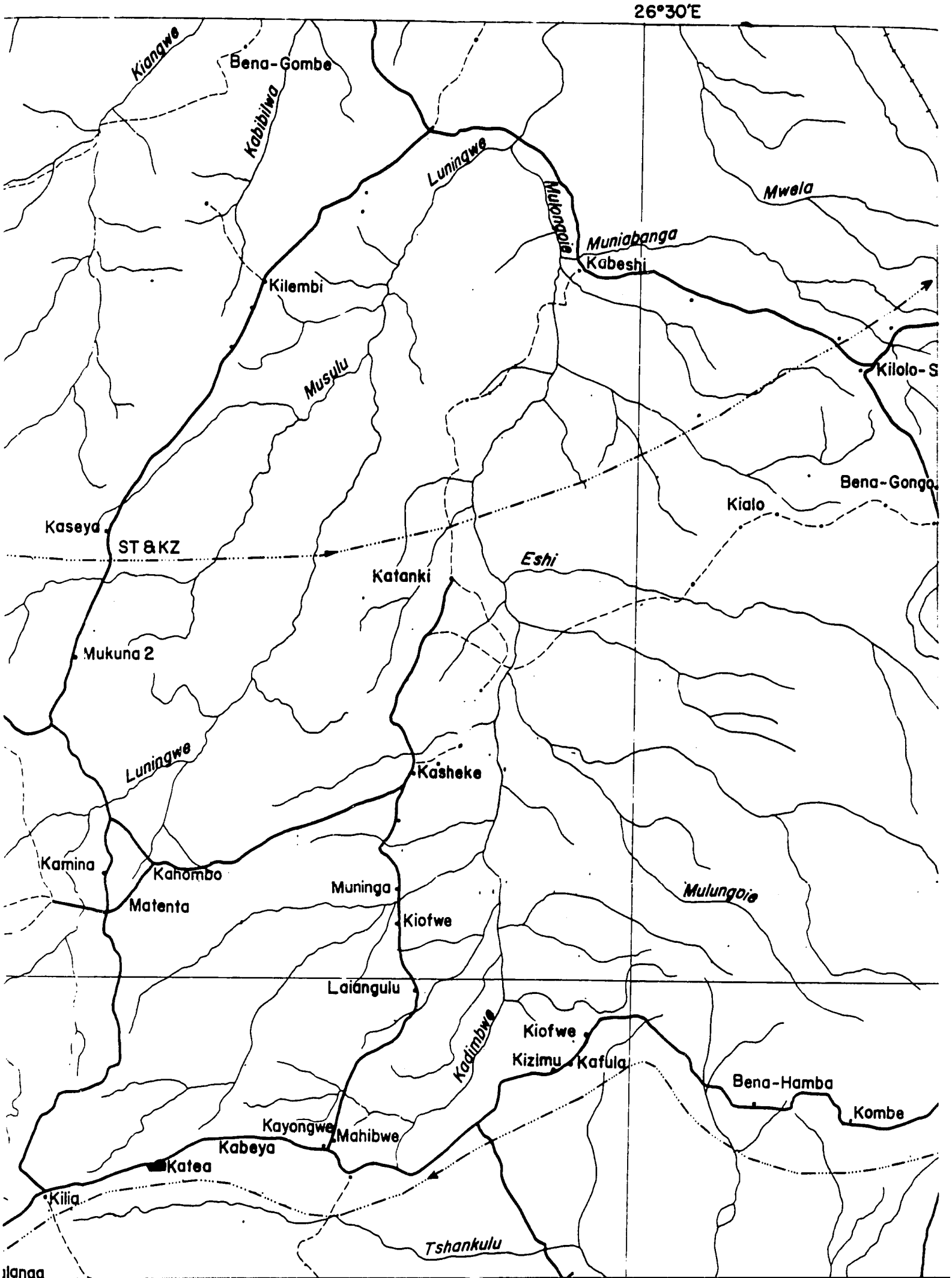
R = Rusizien

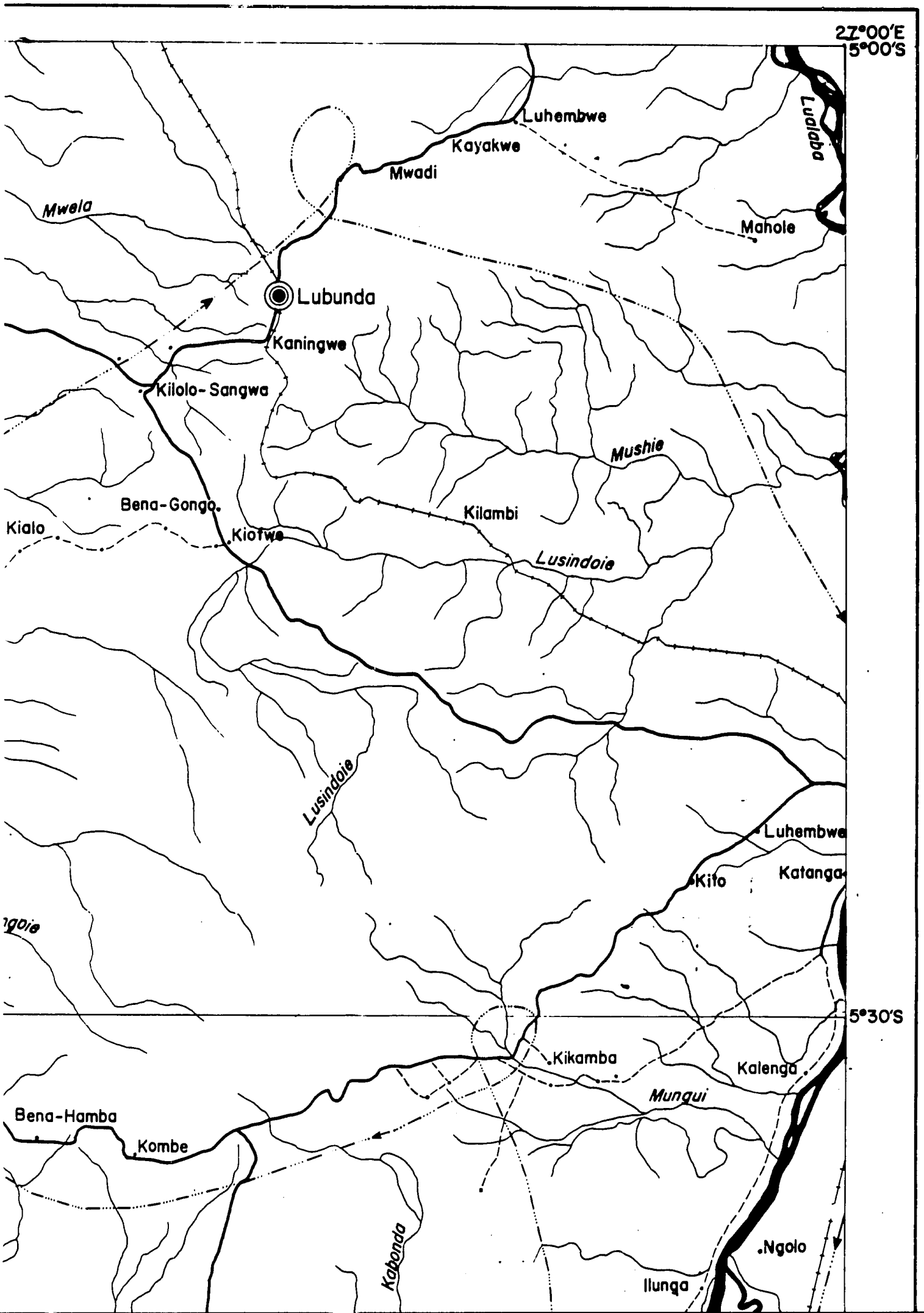
R/ϑ = Rusizien et/ou Roche granitisée

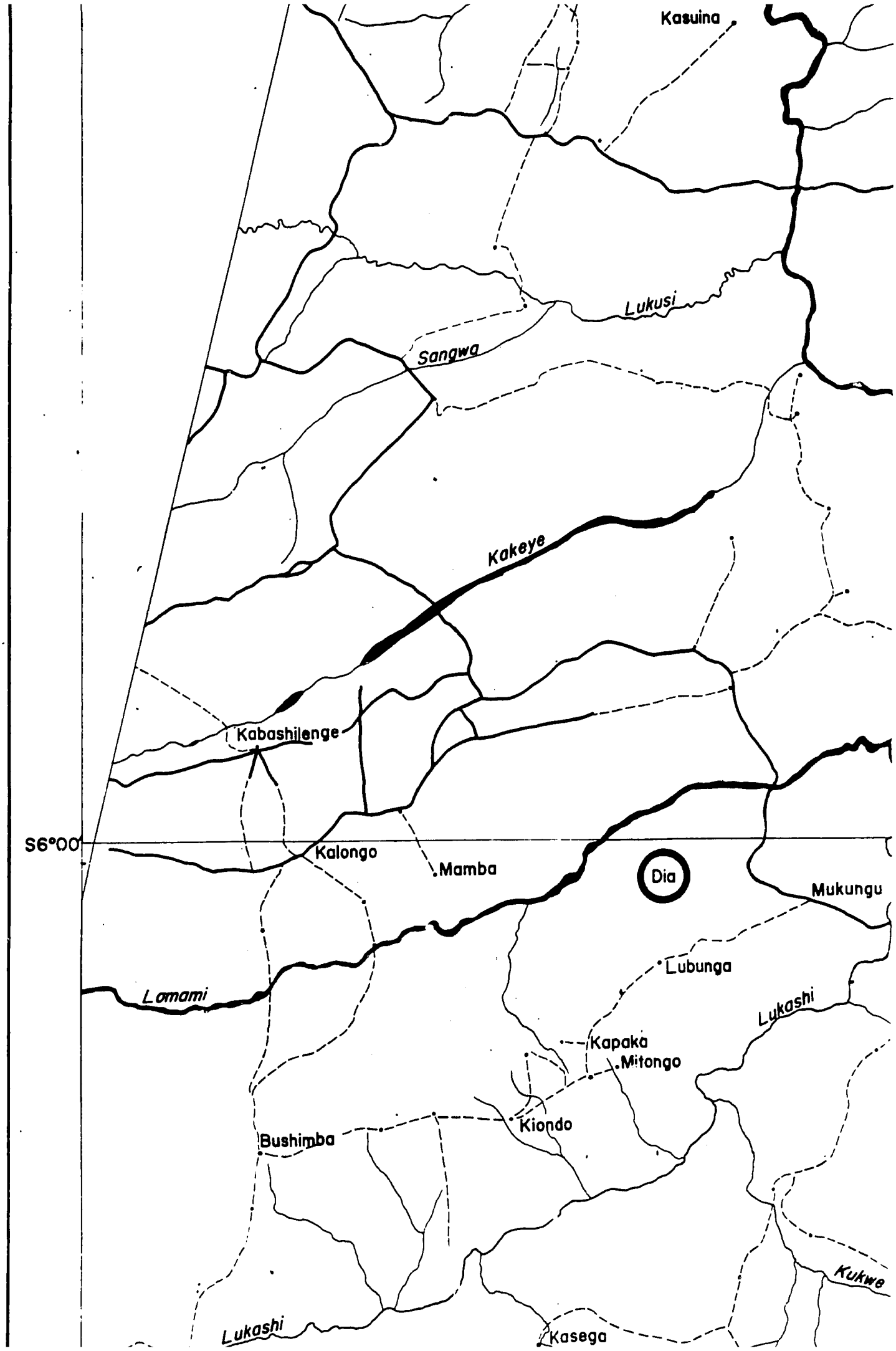
ϑ = Roche granitique

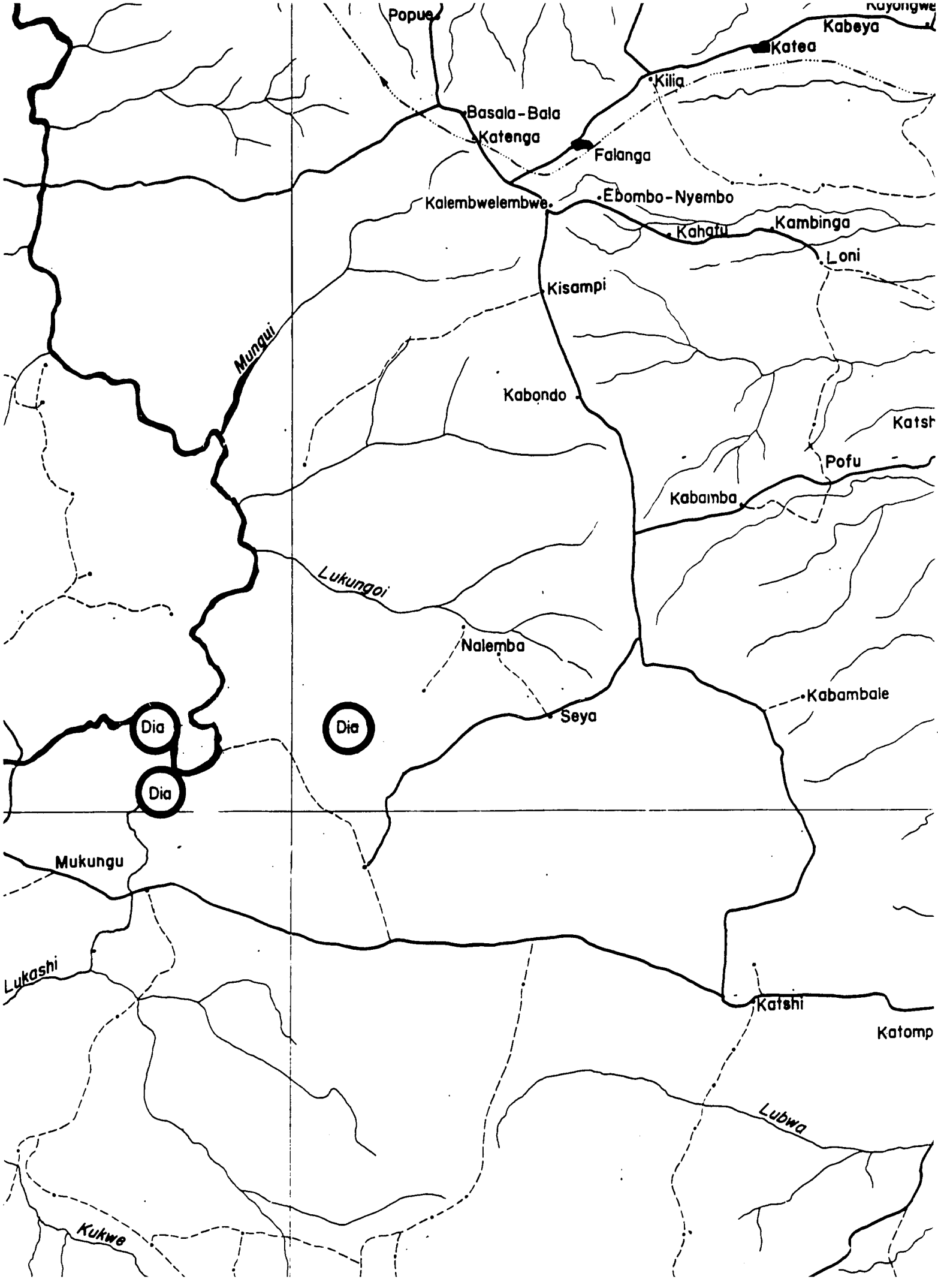

25°30'E
S5°00'
S5°30'
Lusampo
Seke
Kalende
Lubemb
Mangomb
Mite
Pande
Kabao
Mash
Mishi
Muta-Pua
Lubao
Bena-Tshitolo
Kioma
Mako
Goie-Malu
E
Komani
Lomami
Kisampi
Kabunda
Kasuina

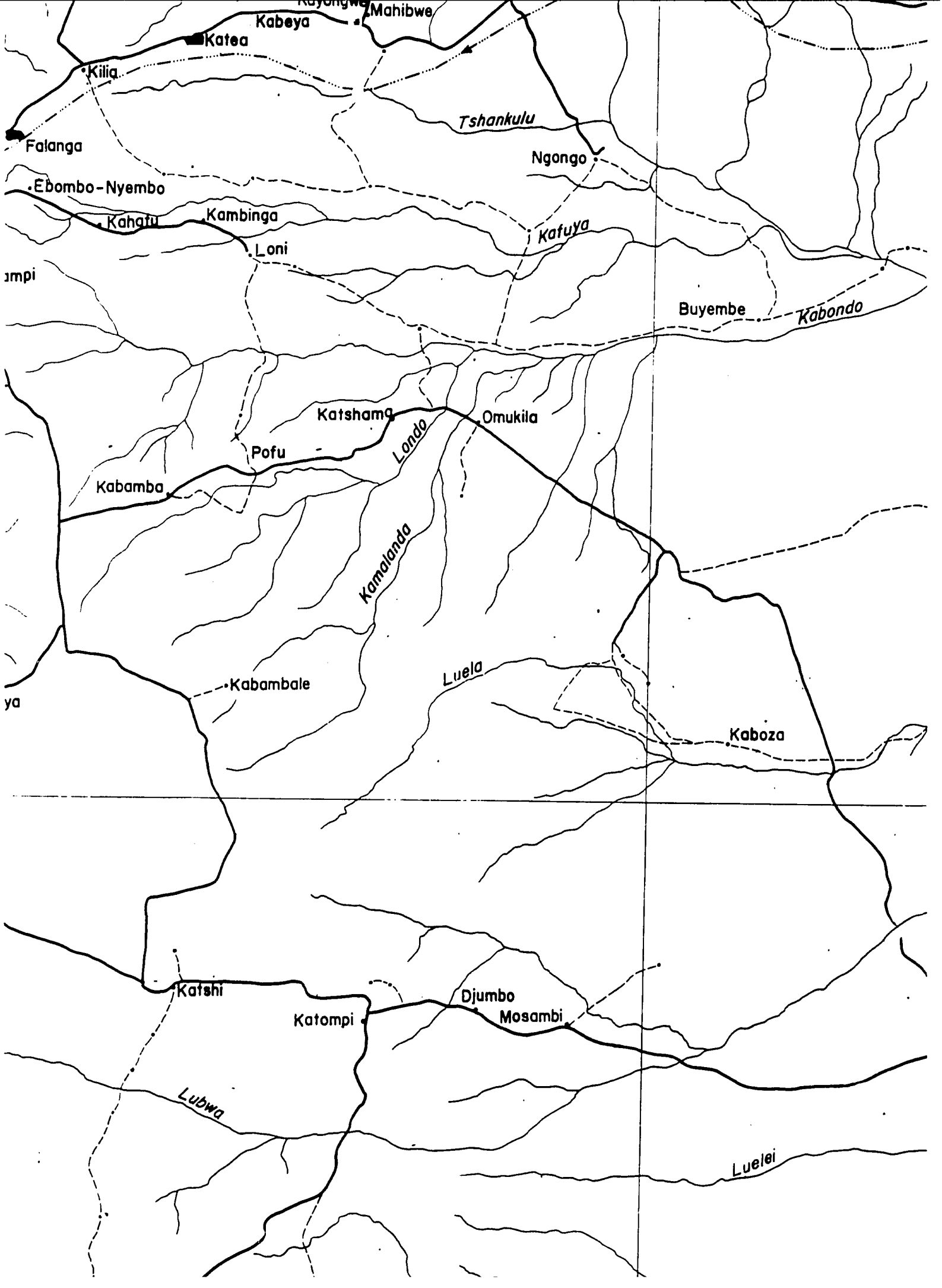

26°00'E
Luhumbe
Malaba
Lufubu
Lusampo
Kasaka
Lubembe
Katenga
Kamina
Kalende
Lufuye
Kaming
Mangombe
Katoto
Mitele
Seshi
Pande
Kabao
Kaseya
Mash
Mishi
Muta-Pua
Lubao
Mukungu
Katoba
Kioma
Ebanga
Goie-Malu
Katoba
Mukela
Komani
Kamina
Lufubu
Kisampi
Sangwa
Luningwe
Popue
Kasuina
Kilia
Basala-Bala
Katenga
Falanga

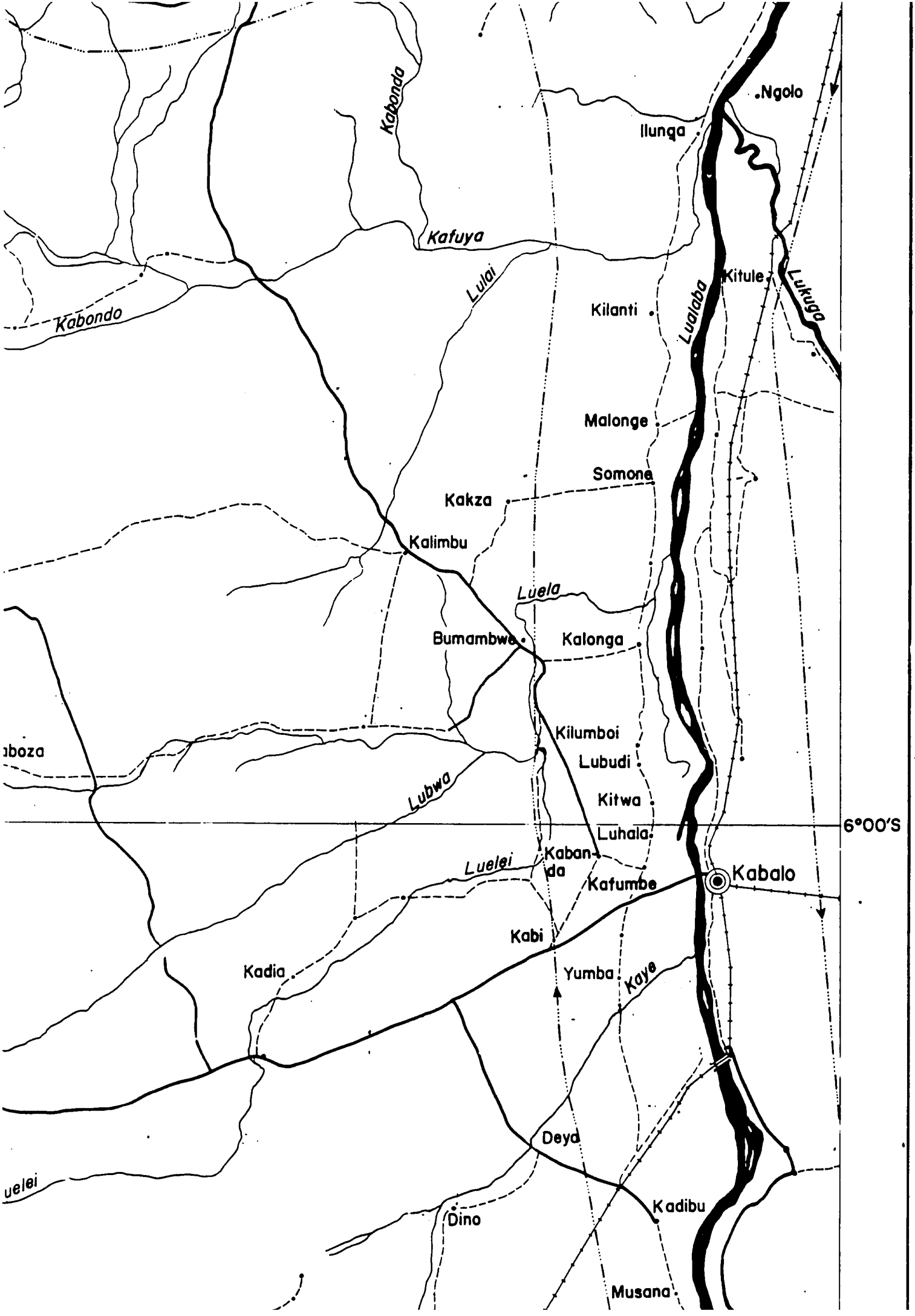

26°30'E
Kiangwe
Bena-Gombe
Kabibilwa
Luningwe
Mukongoie
Mwela
Muniabanga
Kabeshi
Kilembi
Musulu
Kilolo-S
Bena-Gongo
Kialo
Kaseya
ST & KZ
Eshi
Katanki
Mukuna 2
Luningwe
Kasheke
Kamina
Kahombo
Matenta
Muninga
Kiofwe
Mulungoie
Laiangulu
Kiofwe
Kadimbwe
Kizimu
Kafula
Bena-Hamba
Kombe
Kayongwe
Mahibwe
Kabeya
Katea
Kilia
Tshankulu

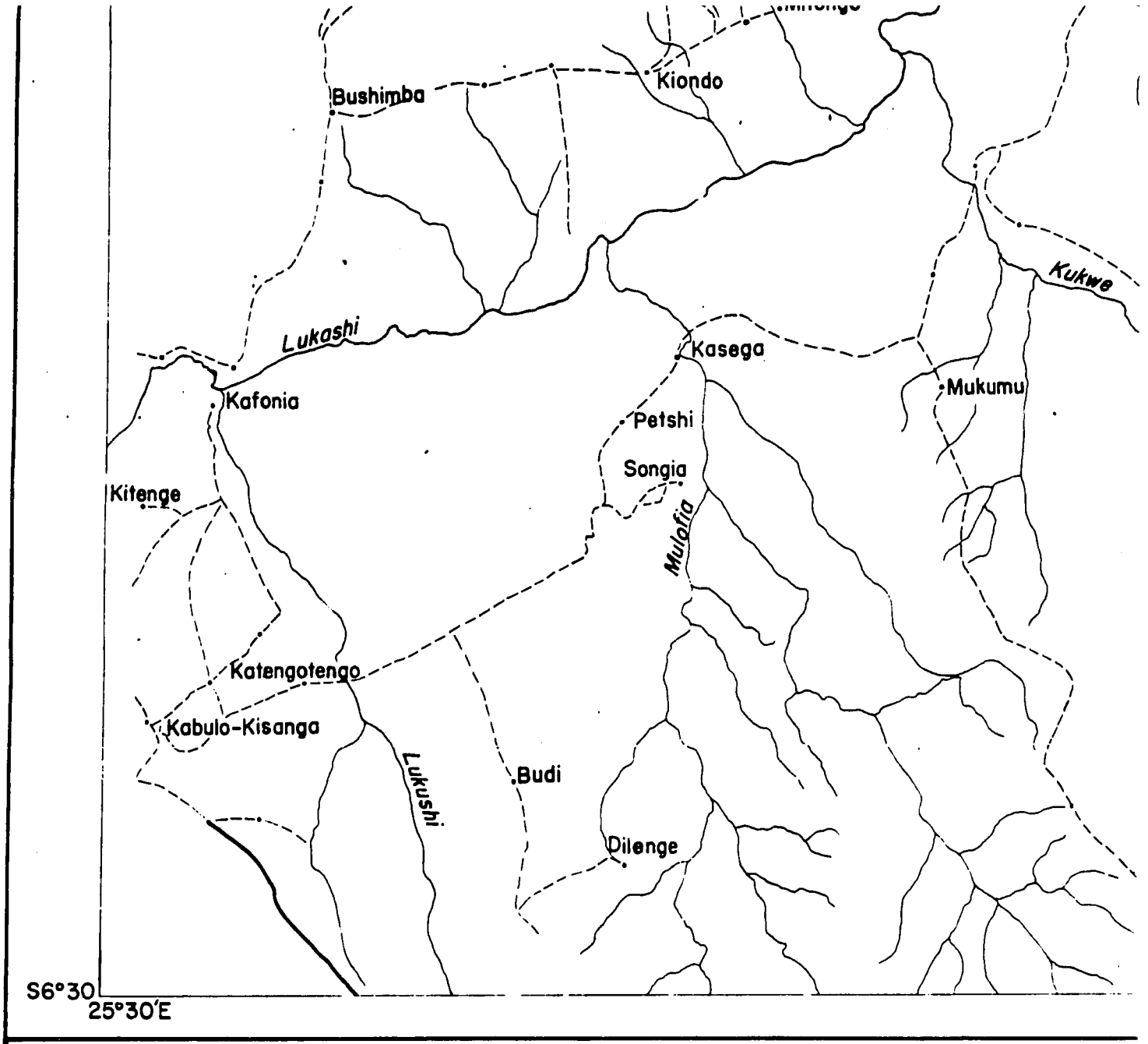

27°00'E
5°00'S
Luhembwe
Kayakwe
Mwadi
Lualaba
Mwela
Mahole
Lubunda
Kaningwe
Kilolo-Sangwa
Mushie
Bena-Gongo
Kialo
Kiotwe
Kilambi
Lusindoie
Lusindoie
Luhembwe
Kito
Katanga
5°30'S
Kikamba
Kalenga
Mungui
Bena-Hamba
Kombe
Kabonda
Ngolo
Ilunga


Kasuina
Lukusi
Sangwa
Kakeye
Kabashilenge
S6°00'
Kalongo
Mamba
Dia
Mukungu
Lubunga
Lomami
Lukashi
Kapaka
Mitongo
Kiondo
Bushimba
Kukwe
Lukashi
Kasega


Popue
Kayongwe
Kabeya
Katea
Kilia
Basala-Bala
Katenga
Falanga
Kalembwelembwe
Ebombo-Nyembo
Kahafu
Kambinga
Loni
Kisampi
Mungui
Kabondo
Katsh
Pofu
Kabainba
Lukungoi
Nalemba
Kabambale
Seya
Dia
Dia
Dia
Mukungu
Lukashi
Katshi
Katomp
Lubwa
Kukwe


Mahibwe
Kabeya
Katea
Kilia
Tshankulu
Falanga
Ngongo
Ebombo-Nyembo
Kahatu
Kambinga
Katuya
Loni
ampi
Buyembe
Kabondo
Katshama
Omukila
Londo
Pofu
Kabamba
Kamalanda
Luela
Kabambale
ya
Kaboza
Katshi
Djumbo
Mosambi
Katompi
Lubwa
Luelei


Kabonda
Ngolo
Ilunga
Kafuya
Lulai
Kitule
Lukuga
Lualaba
Kabondo
Kilanti
Malonge
Somone
Kakza
Kalimbu
Luela
Bumambwe
Kalonga
Kilumboi
Lubudi
Kitwa
Lubwa
6°00'S
Luhala
Kaban-
da
Luelei
Kabalo
Kafumbe
Kabi
Kadia
Yumba
Kaye
Deya
Kadibu
Dino
Musana



Route

Sentier

Chemin de fer

Ligne de vol ISTANCIOFF et KAZADI Fevrier 1980

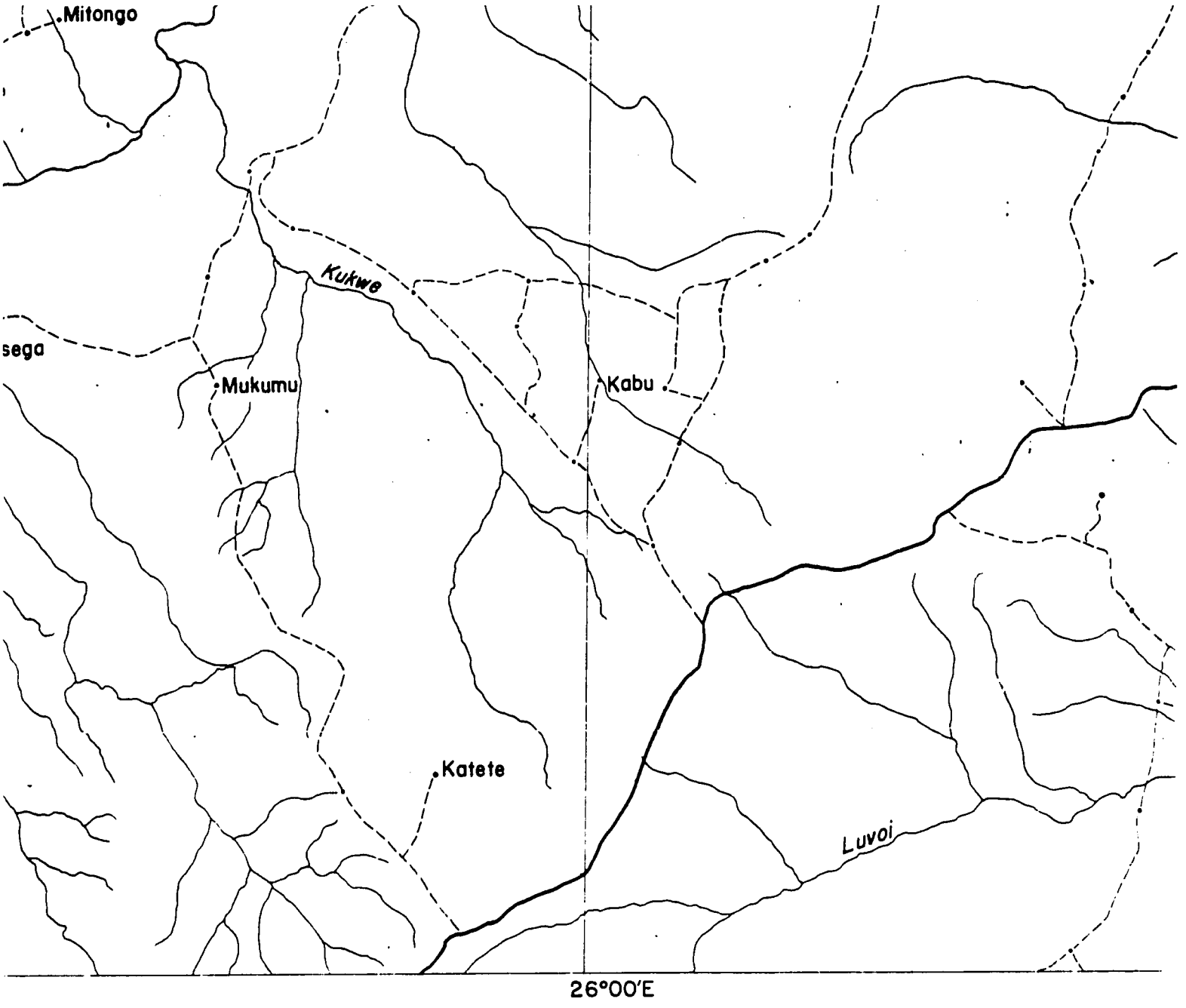
Chef-lieu de Zone

Localité

Centre important

Dia

PLANCHE N°12 : CARTE D'ITINERAIRES, PLAN DE VOL, ECHANTILL



LEGI

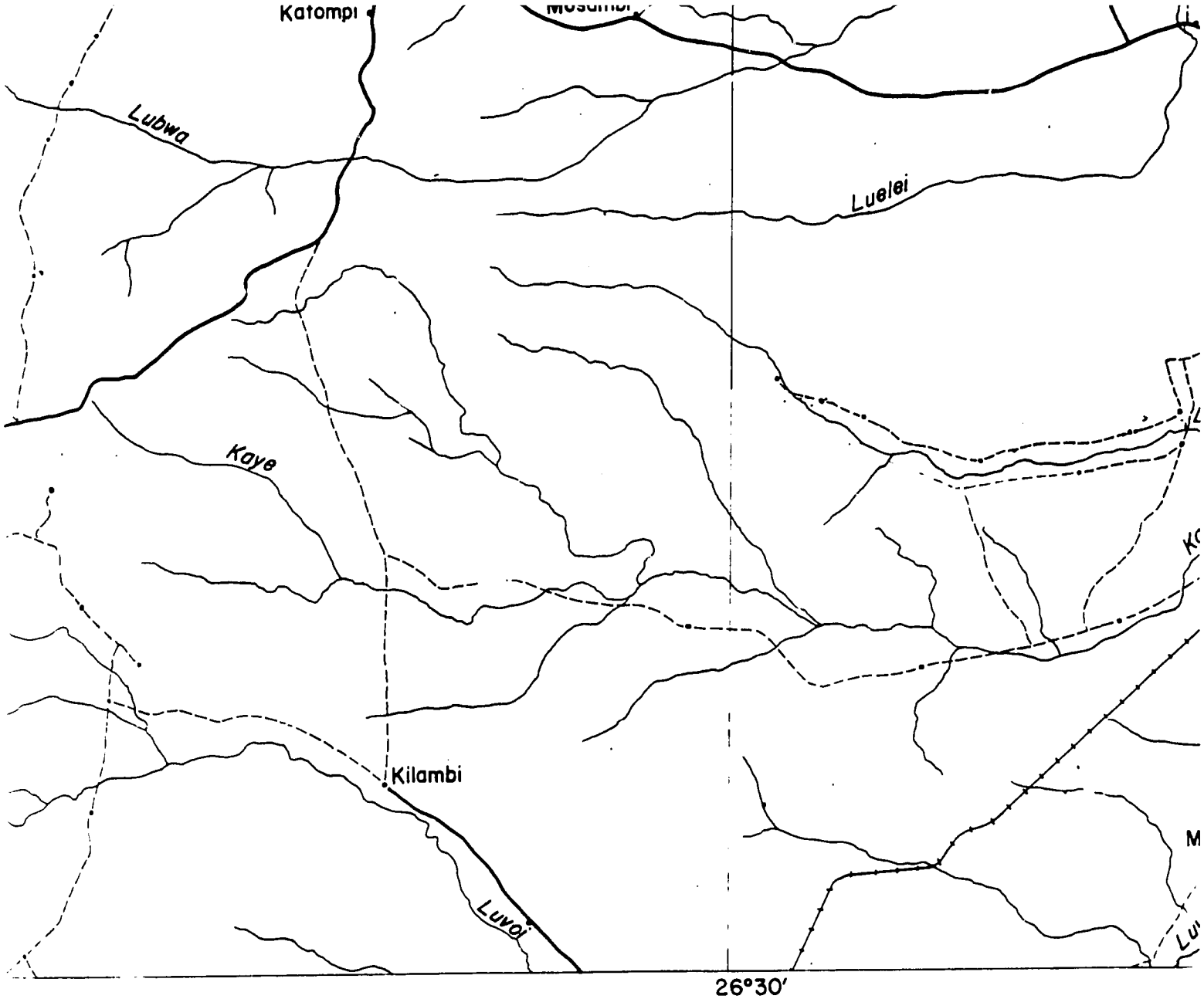
Dia Indice de diamant (d'après la carte de gîtes minéraux du Zaïre)

1980

Echelle

5 0 5

RES, PLAN DE VOL, ECHANTILLONAGE. A Scène Landsat de LUBUNDA

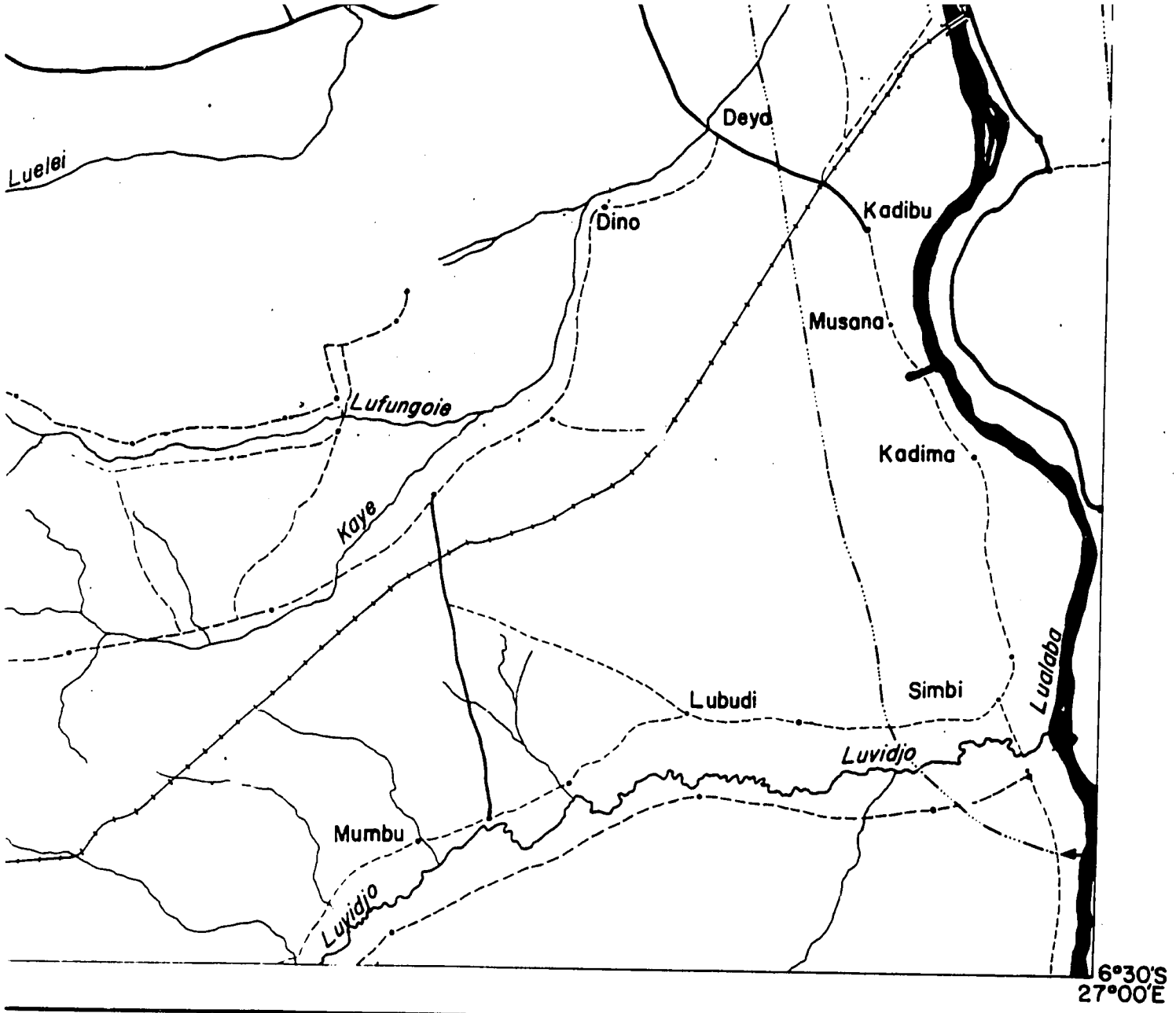


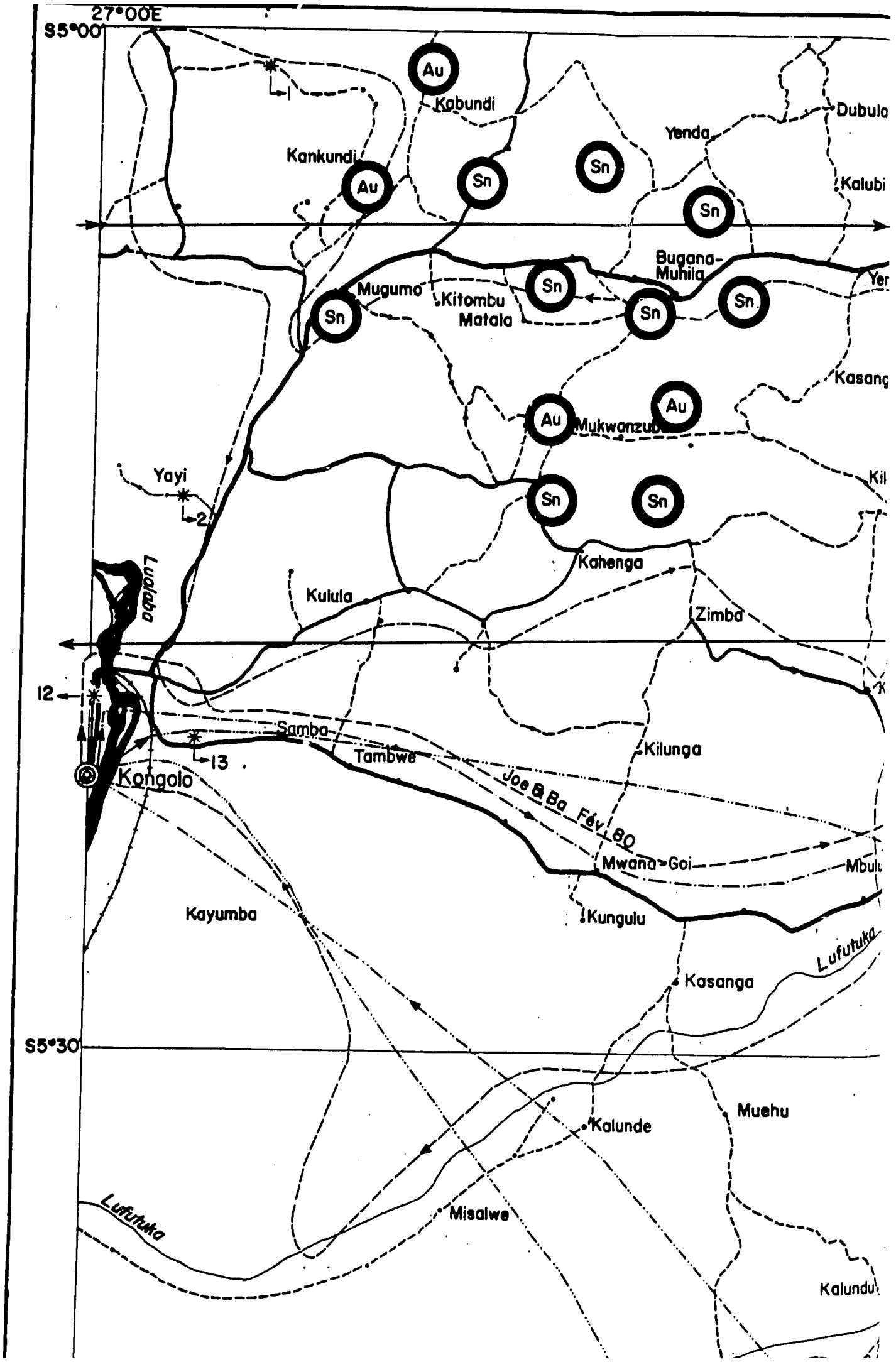
EGENDE

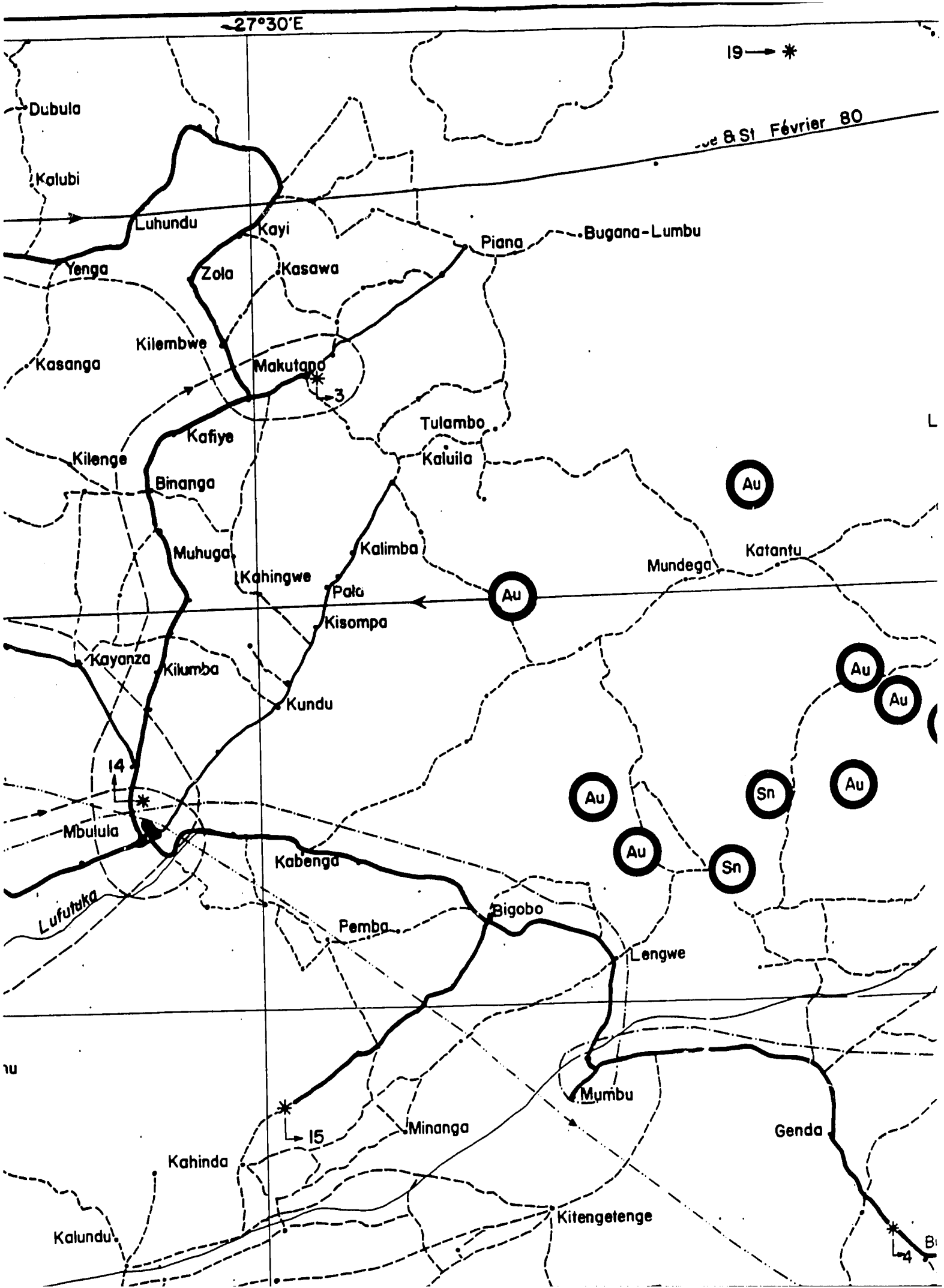
Echelle 1/200.000

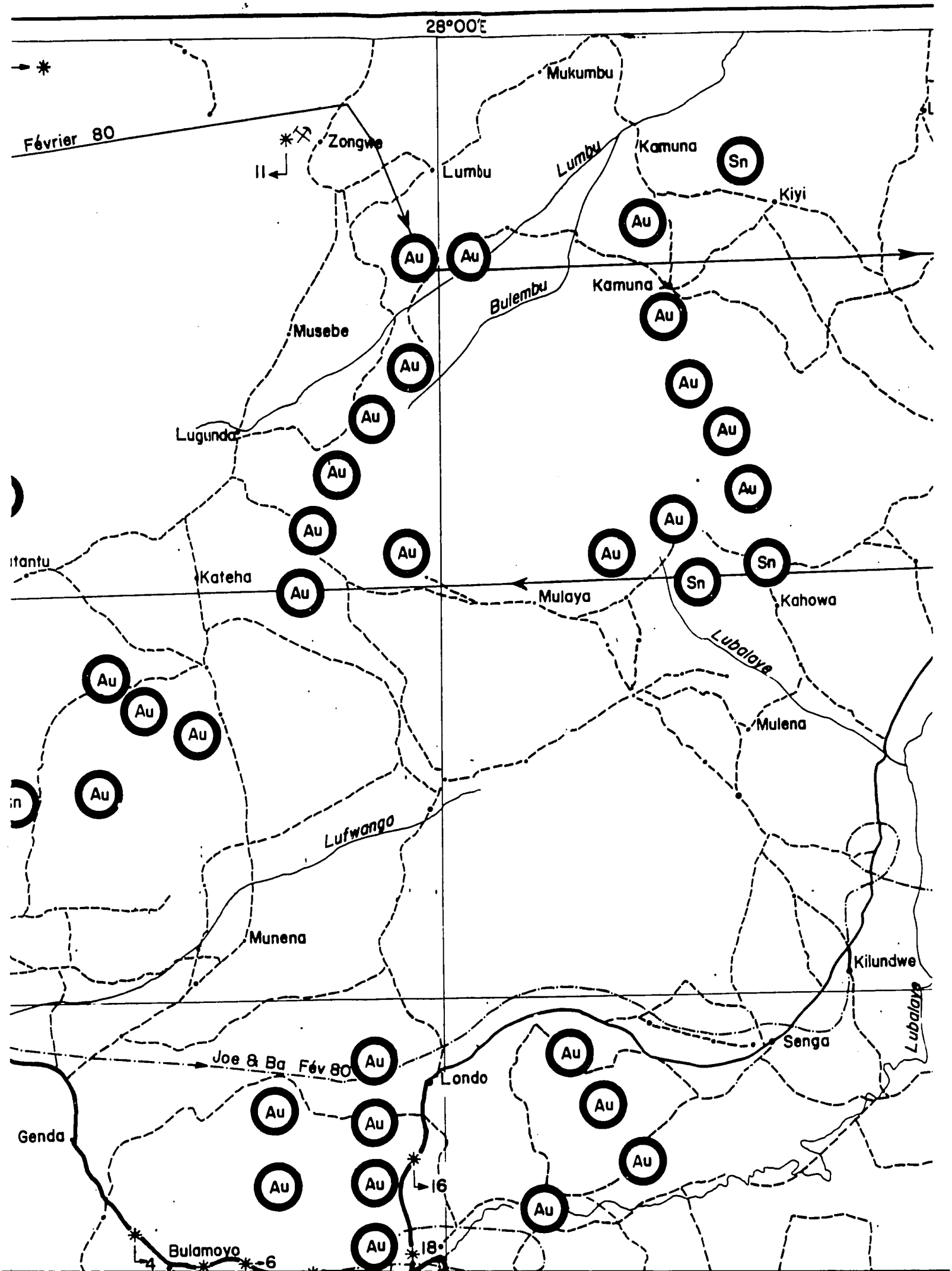
0 5 10 15

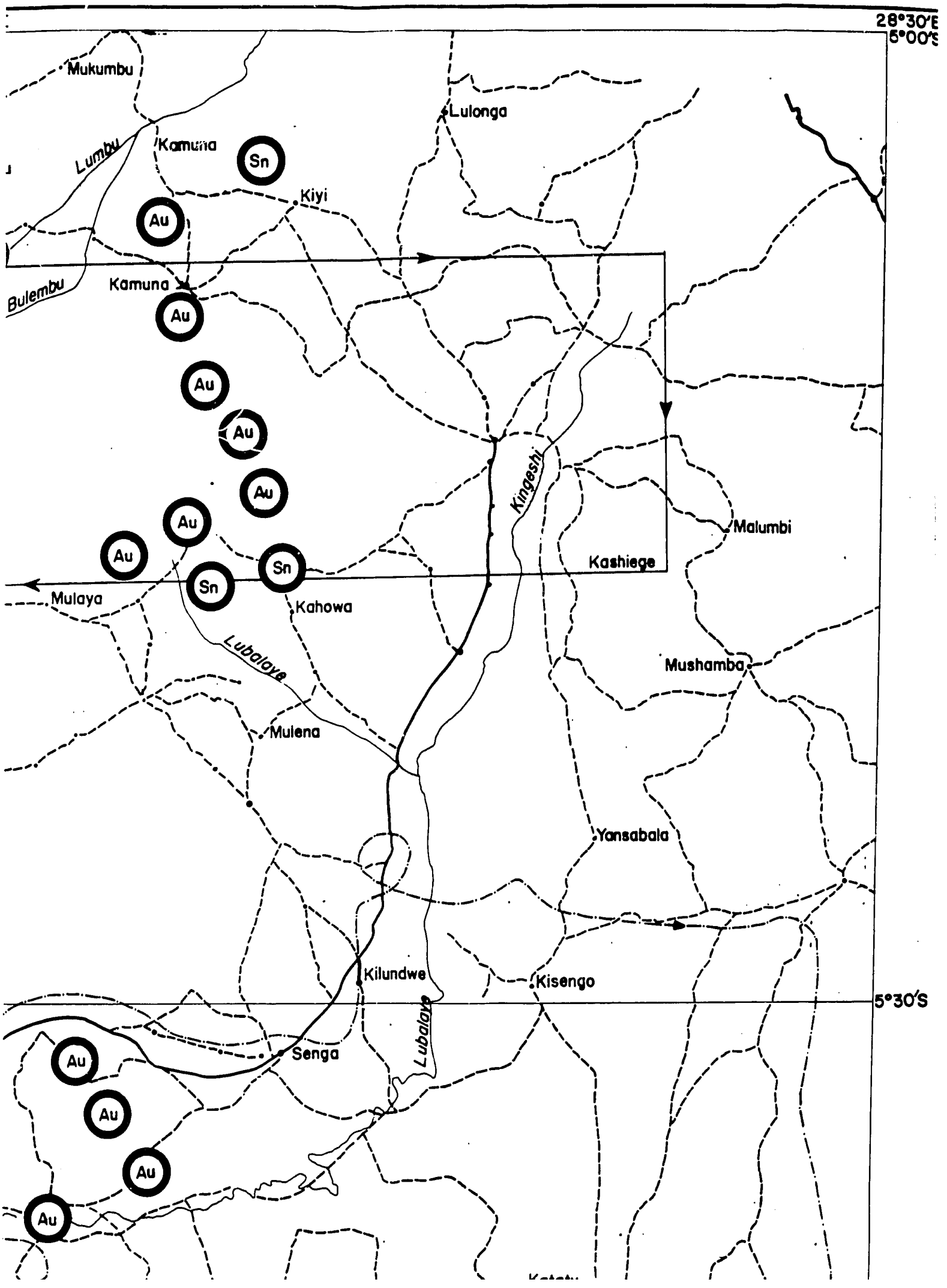
DESSINATEUR LUMBU

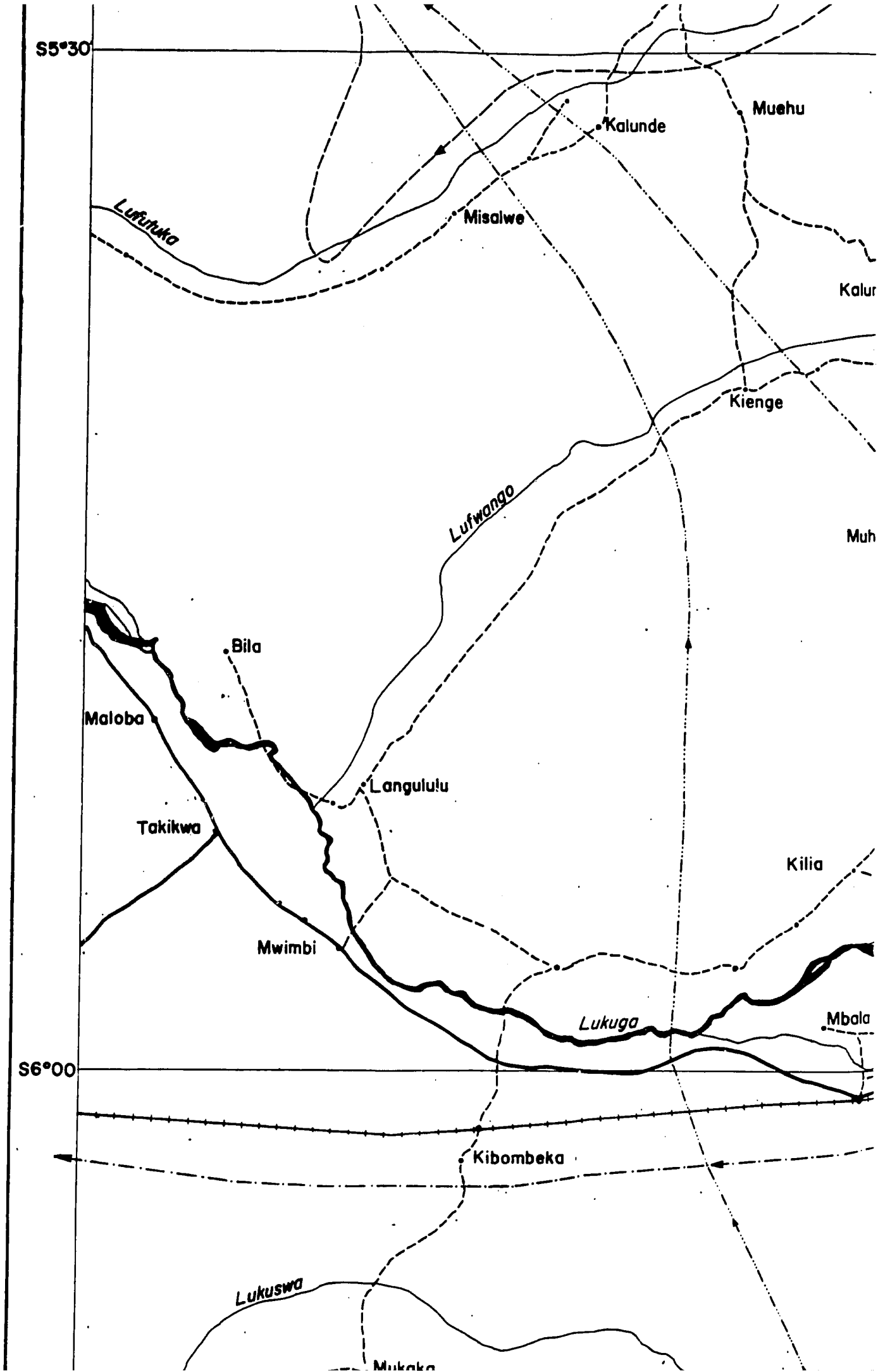

Luelei
Deya
Dino
Kadibu
Musana
Lufungoie
Kadima
Kaye
Lualaba
Simbi
Lubudi
Luvidjo
Mumbu
Luvidjo
6°30'S
27°00'E

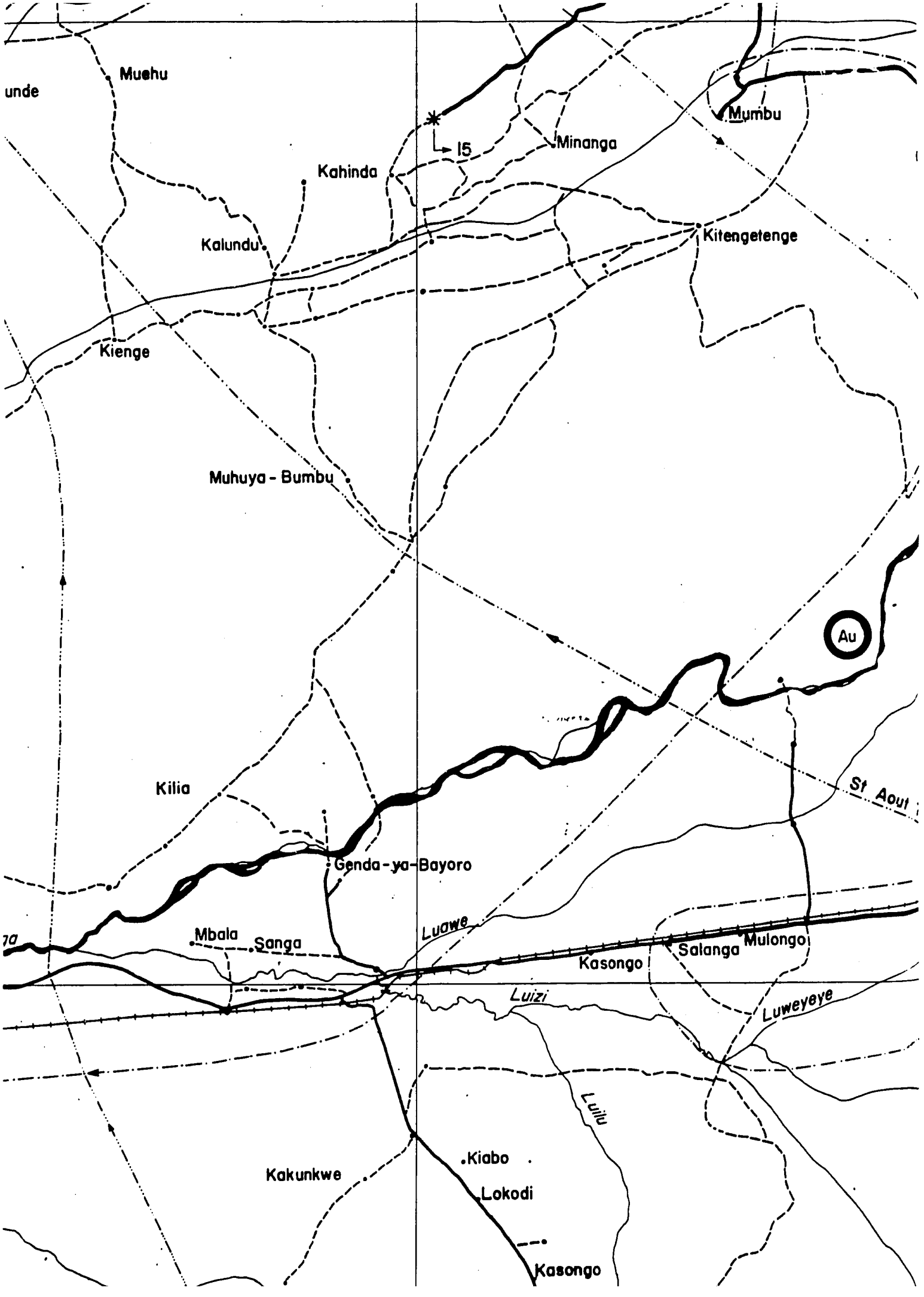

27°00E
S5°00
Au
Kabundi
Dubula
Yenda
Kankundi
Au
Sn
Sn
Sn
Kalubi
Sn
Bugana-
Muhila
Mugumo
Kitombu
Matala
Sn
Sn
Sn
Sn
Kasang
Au
Au
Mukwanzub
Yayi
Sn
Sn
Kahenga
Lualaba
Kulula
Zimba
12
Samba
13
Tambwe
Kilunga
Kongolo
Joe & Ba Fév 80
Mwana-Goi
Kayumba
Kungulu
Lufufuka
Kasanga
S5°30
Muehu
Kalunde
Lufufuka
Misalwe
Kalundu

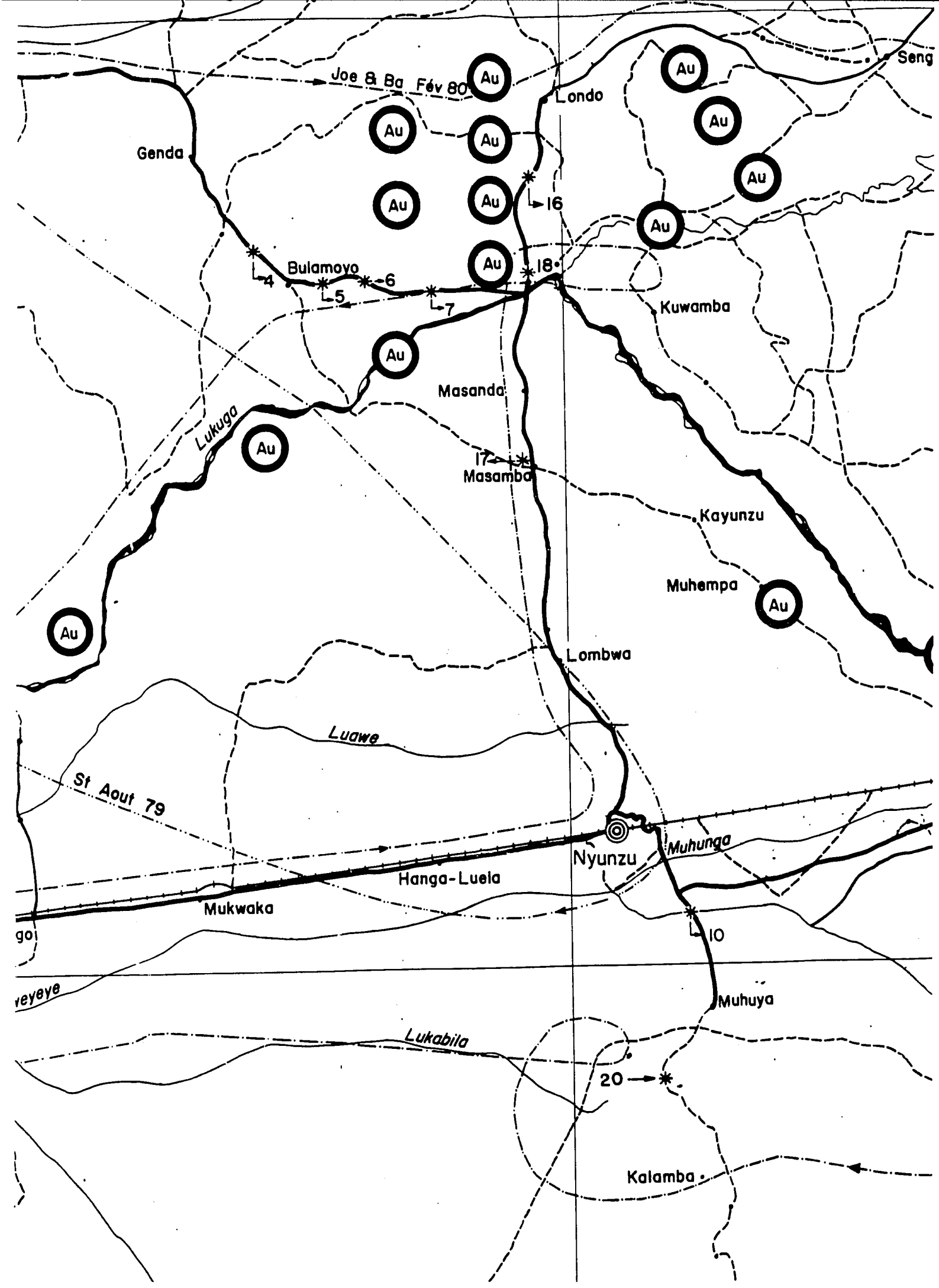

27°30'E
19
Dubula
Kalubi
Luhundu
Kayi
Yenga
Zola
Kasawa
Piana
Bugana-Lumbu
Kasanga
Kilembwe
Makutano
3
Tulambo
Kafiye
Kilenge
Kaluila
Binanga
Au
Muhuga
Kalimba
Katantu
Mundega
Kahingwe
Pala
Kisompa
Kayanza
Kilumba
Kundu
14
Sn
Mbulula
Kabenga
Lufuluka
Bigobo
Pemba
Lengwe
Mumbu
15
Minanga
Genda
Kahinda
Kitengetenge
Kalundu
4

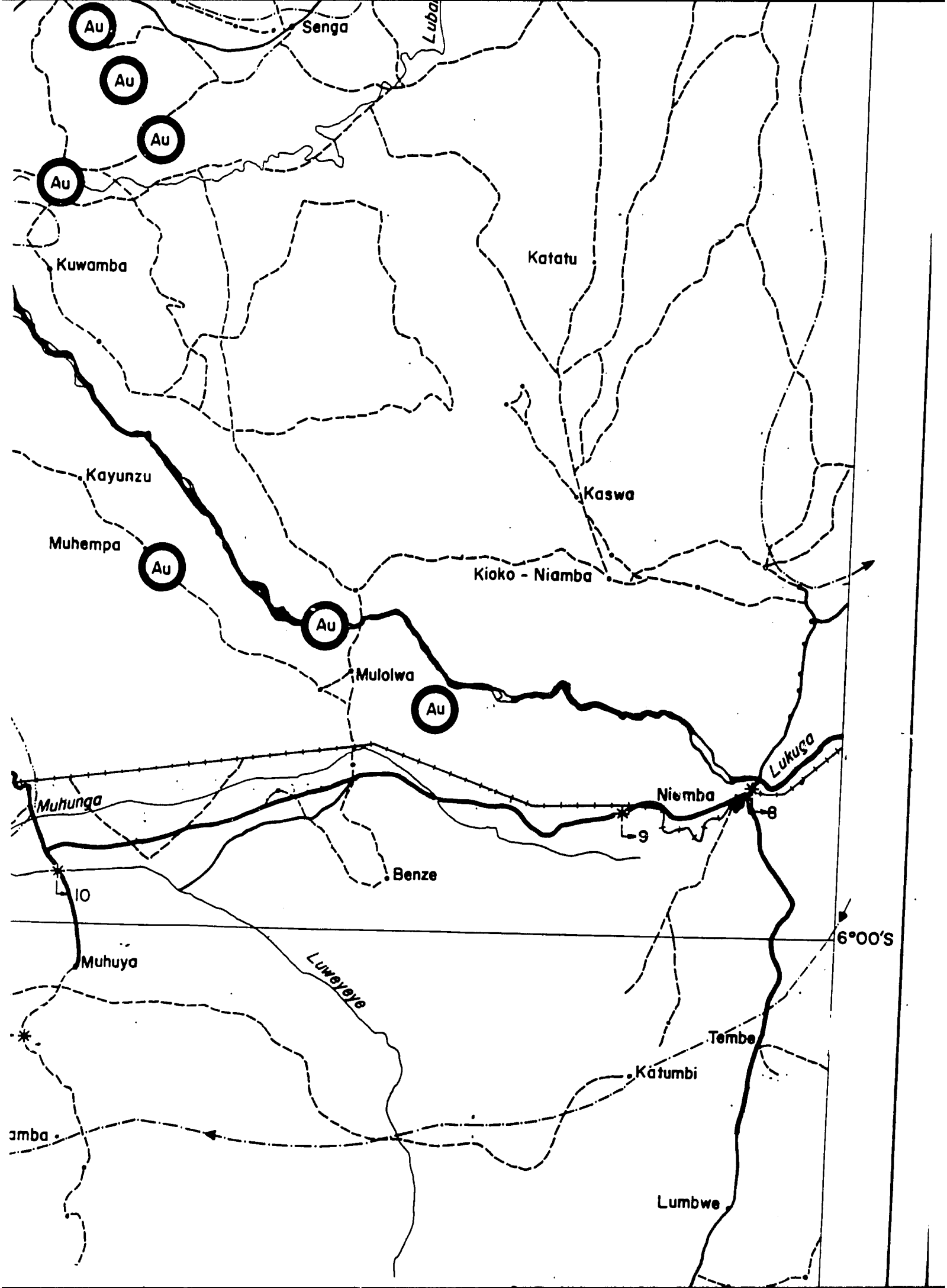

28°00'E
Février 80
Mukumbu
Zongwe
Lumbu
Lumbu
Kamuna
Kiyi
Kamuna
Bulembu
Musebe
Lugunda
Kateha
Mulaya
Kahowa
Lubalaye
Mulena
Lufwanga
Munena
Kilundwe
Lubalaye
Senga
Joe & Ba Fév 80
Londo
Genda
Bulamoyo
Au
Sn

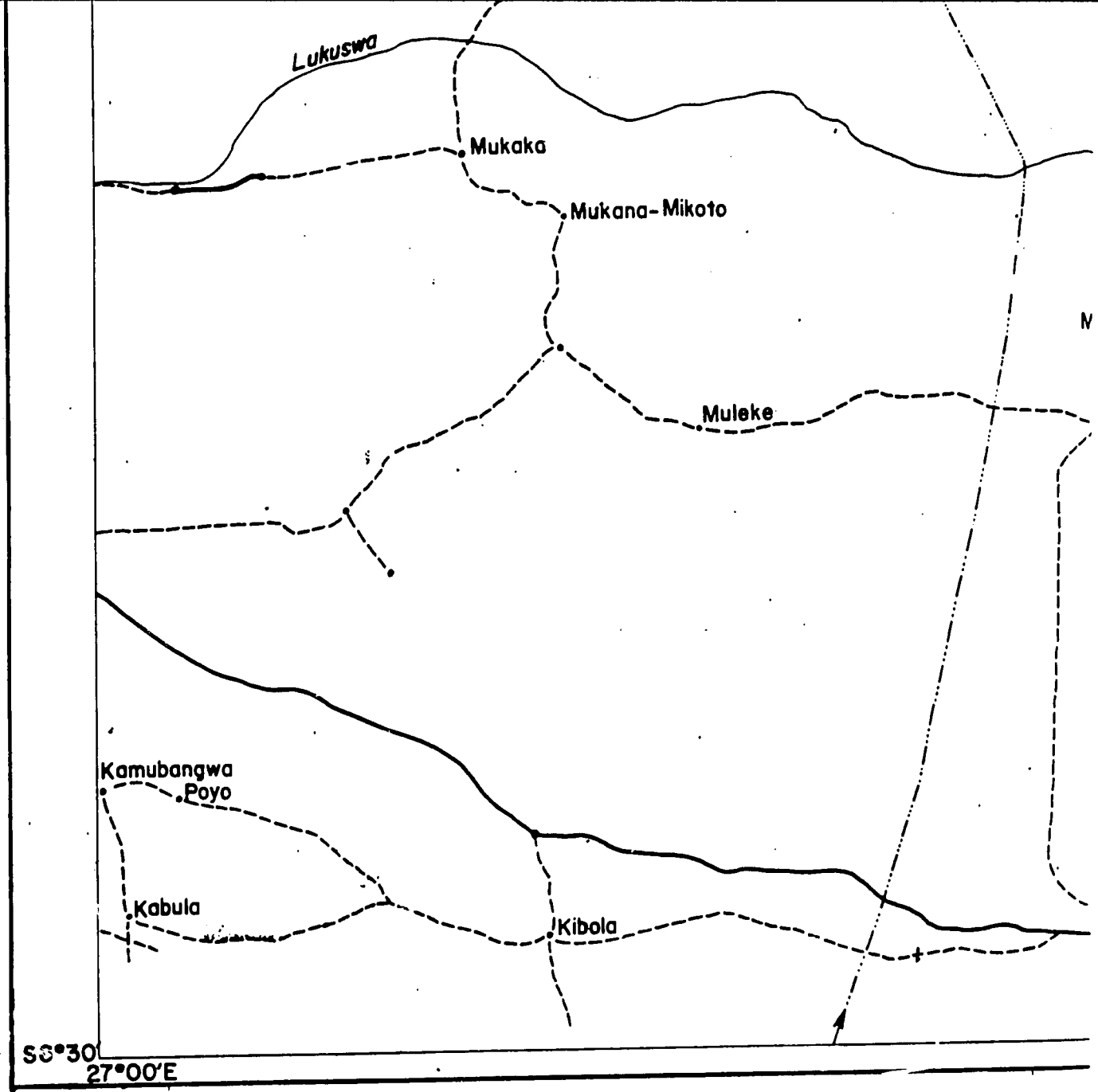

28°30'E
5°00'S
Mukumbu
Lulonga
Lumbu
Kamuna
Sn
Kiyi
Au
Bulembu
Kamuna
Au
Au
Au
Au
Au
Au
Sn
Sn
Kingeshi
Malumbi
Kashiege
Mulaya
Kahowa
Lubalaye
Mushamba
Mulena
Yansabala
Kilundwe
Kisengo
5°30'S
Lubalaye
Senga
Au
Au
Au
Au


S5°30'
Muehu
Kalunde
Lufuruka
Misalwe
Kalur
Kienge
Lufwanga
Muh
Bila
Maloba
Langululu
Takikwa
Kilia
Mwimbi
Lukuga
Mbala
S6°00
Kibombeka
Lukuswa
Mukaka


Muehu
unde
Mumbu
15
Minanga
Kahinda
Kitengetenge
Kalundu
Kienge
Muhuya - Bumbu
Au
Kilia
St Aout
Genda-ya-Bayoro
Luawe
Mbala
Sanga
Salanga
Mulongo
Kasongo
Luizi
Luweyeye
Luilu
Kakunkwe
Kiabo
Lokodi
Kasongo


Joe 8 Ba Fév 80
Au
Londo
Seng
Genda
16
Bulamoyo
4
5
6
7
18
Kuwamba
Masanda
Lukuga
17
Masamba
Kayunzu
Muhempa
Lombwa
Luawe
St Aout 79
Nyunzu
Muhunga
Hanga-Luela
Mukwaka
10
Muhuya
Lukabila
20
Kalamba


Au
Au
Au
Au
Senga
Luba
Kuwamba
Katatu
Kayunzu
Kaswa
Muhempa
Au
Kioko - Niamba
Au
Mulolwa
Au
Lukuga
Muhunga
Niemba
8
9
Benze
10
6°00'S
Muhuya
Luweyeye
Tembe
Katumbi
amba
Lumbwe



Route

Sentier

Route parcourue par les chercheurs

Chemin de fer

Ligne de vol (Stancioff et Pessuti) Février 1980

" " "

Ligne de vol (Bakajika et Pessuti) Février 1980

Ligne de vol (Stancioff) Août 1979

Ligne de vol (Stancioff) Mars 1980

PLANCHE N°12 : CARTE D'ITINERAIRES, PLAN DE VOL, ECHANT

Kakunkwe
Lokodi
Kasongo
Mukana-Mikoto
Miemba
Manda
Muleke
Malo
Niemba
Luyebe
Kamisi
Ki
Longa
Mukondela
Lumbwe
Lukuswa
Konga
Luala
Lulenga
Kibola
Kahehu
27°30'E

L E

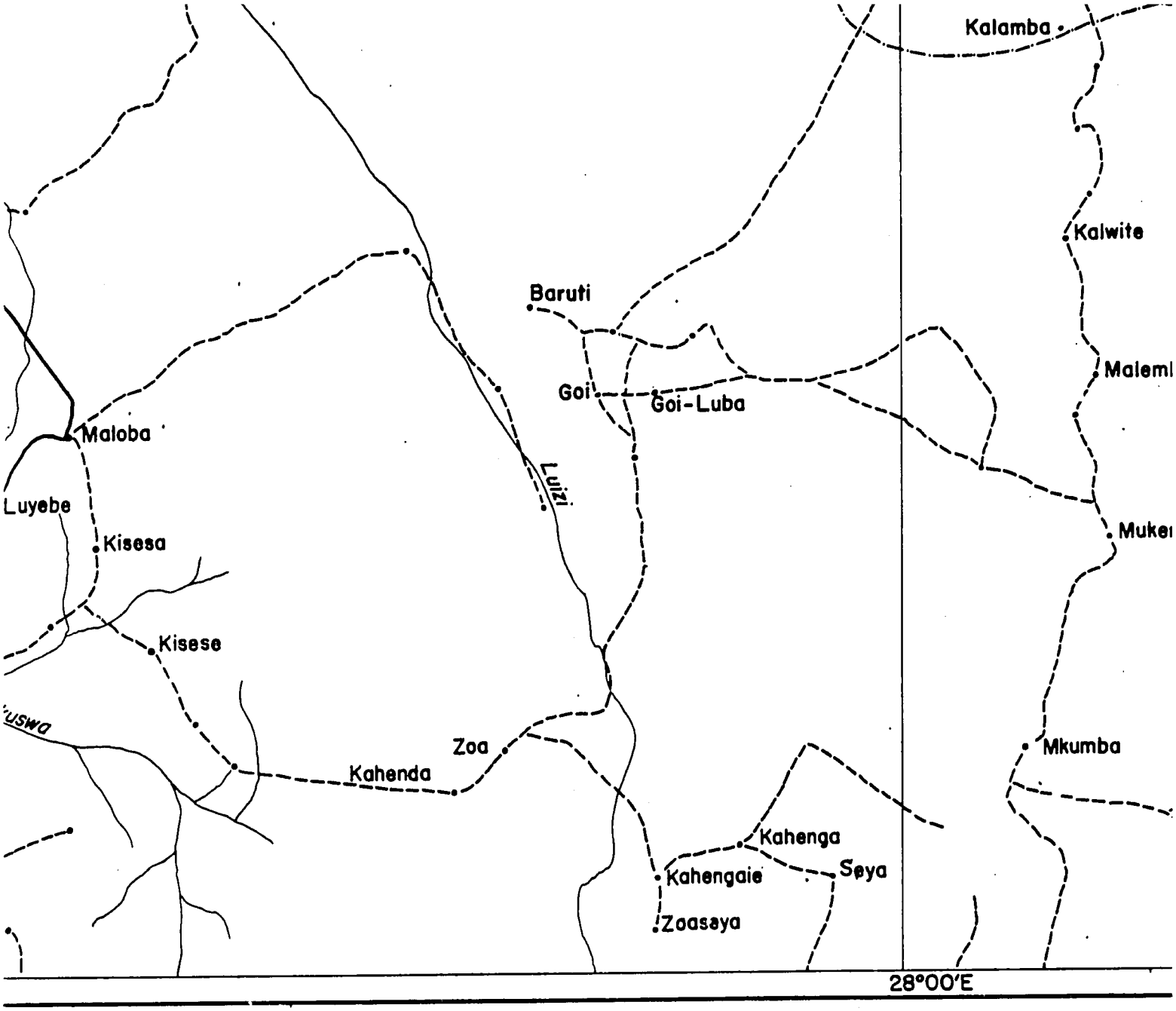
ar les chercheurs

cioff et Pessuti) Février 1980
" "
ajika et Pessuti) Février 1980
Stancioff) Août 1979
Stancioff) Mars 1980

Chef lieu de Zone
Localité
Centre important
Au Indice d'or d'après la carte des gites minéra
Sn Indice d'étain " " "
Au Mines ou anciennes mines d'or

D'ITINERAIRES, PLAN DE VOL, ECHANTILLONAGE. B Scène Landsat de NYUNZU KONGOLO

5



L E G E N D E

gites minéraux du Zaïre

,,

✱ Point de stationnement ou d'échantiollonnage par les chercheurs

1 → ✱ Kingulungu : échantillon d'or

2 → ✱ Yayi : affleurement de granite, Gneiss, veine de quartz

3 → ✱ Makutano : Indice d'or dans un ruisseau

4 → ✱ Près de Museka : phyllites , Schistes noirs

5 → ✱ Près de Bulamoyo : ,, ,, ,,

6 → ✱ Près de Bulamoyo : Schistes noirs

7 → ✱ Près de Niemba : phyllites , Schistes noirs , quartzite

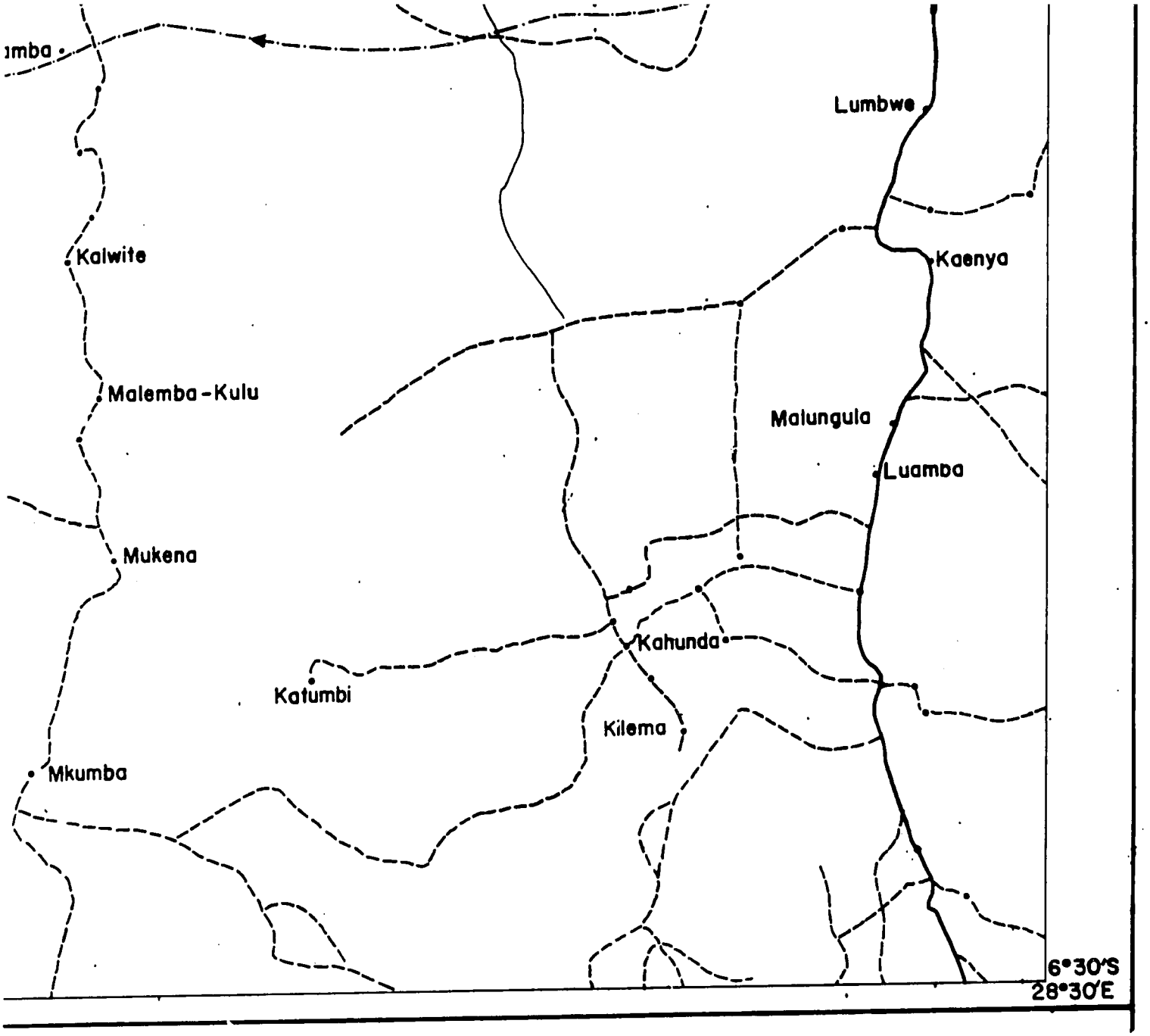
8 → ✱ Sur la rivière Niemba: tillite glaciaire , conglomérat de base de la Série de la Lukuga

9 → ✱ Kilima : gneiss , pegmatite , quartzite

Echelle : 1/200.000

5 0 5 10 15

DESSINATEUR LUMBU



s chercheurs

10 → ✱ Rivière Luweyeye : granite , pegmatite , cristal de cassiterite

11 → ✱ Rivière Kakala près de Zongwe : sable noir avec grains d'or

12 → ✱ Kongolo près du pont sur le Lualaba : granite , pegmatite , quartz

13 → ✱ Près de Samba : source hydrothermale

14 → ✱ Près de Mbulula : quartzite

15 → ✱ Biombo : indice d'or

16 → ✱ Maliangi : quartzite , schiste

17 → ✱ Masamba : quartzite massif

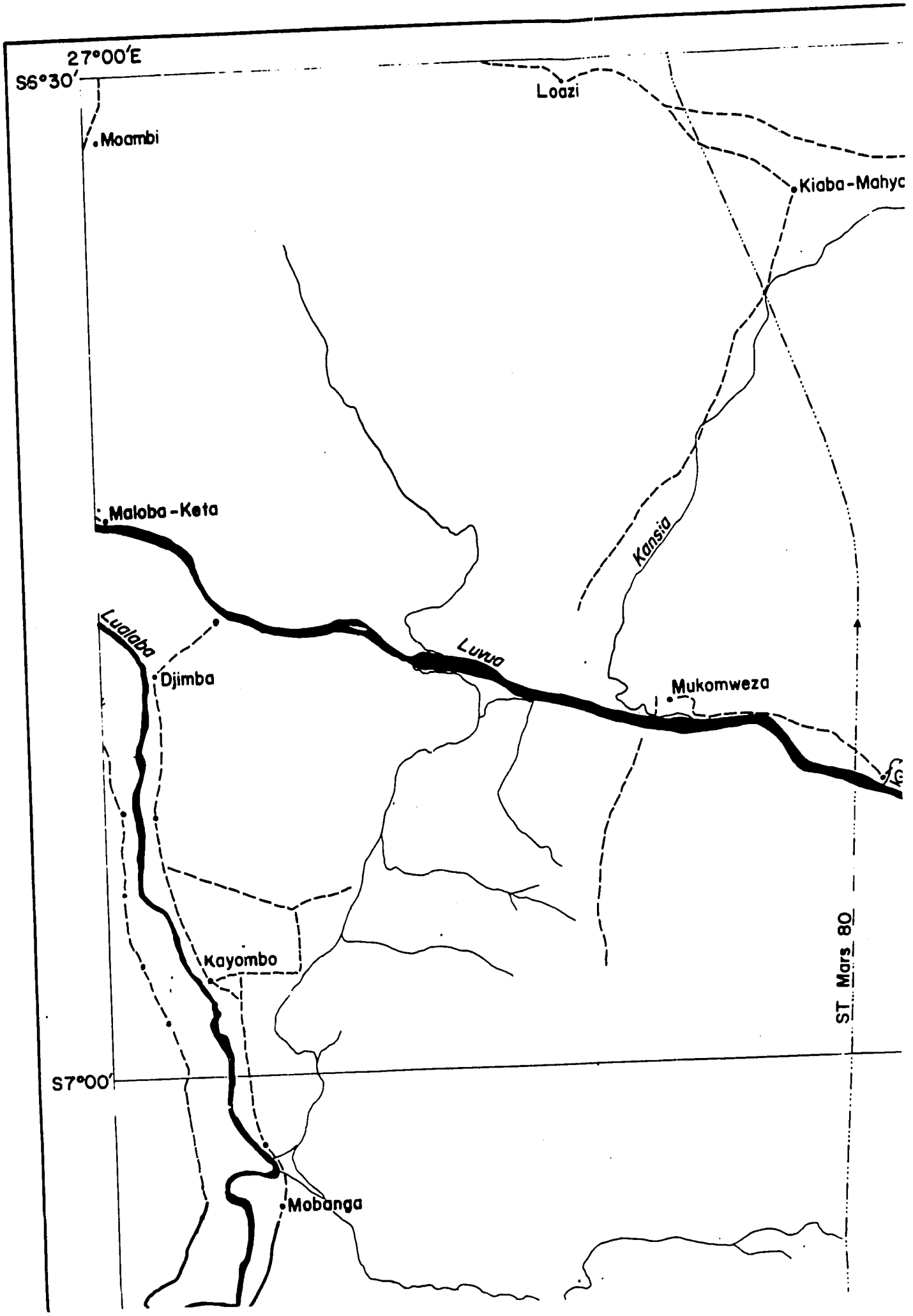
de base de

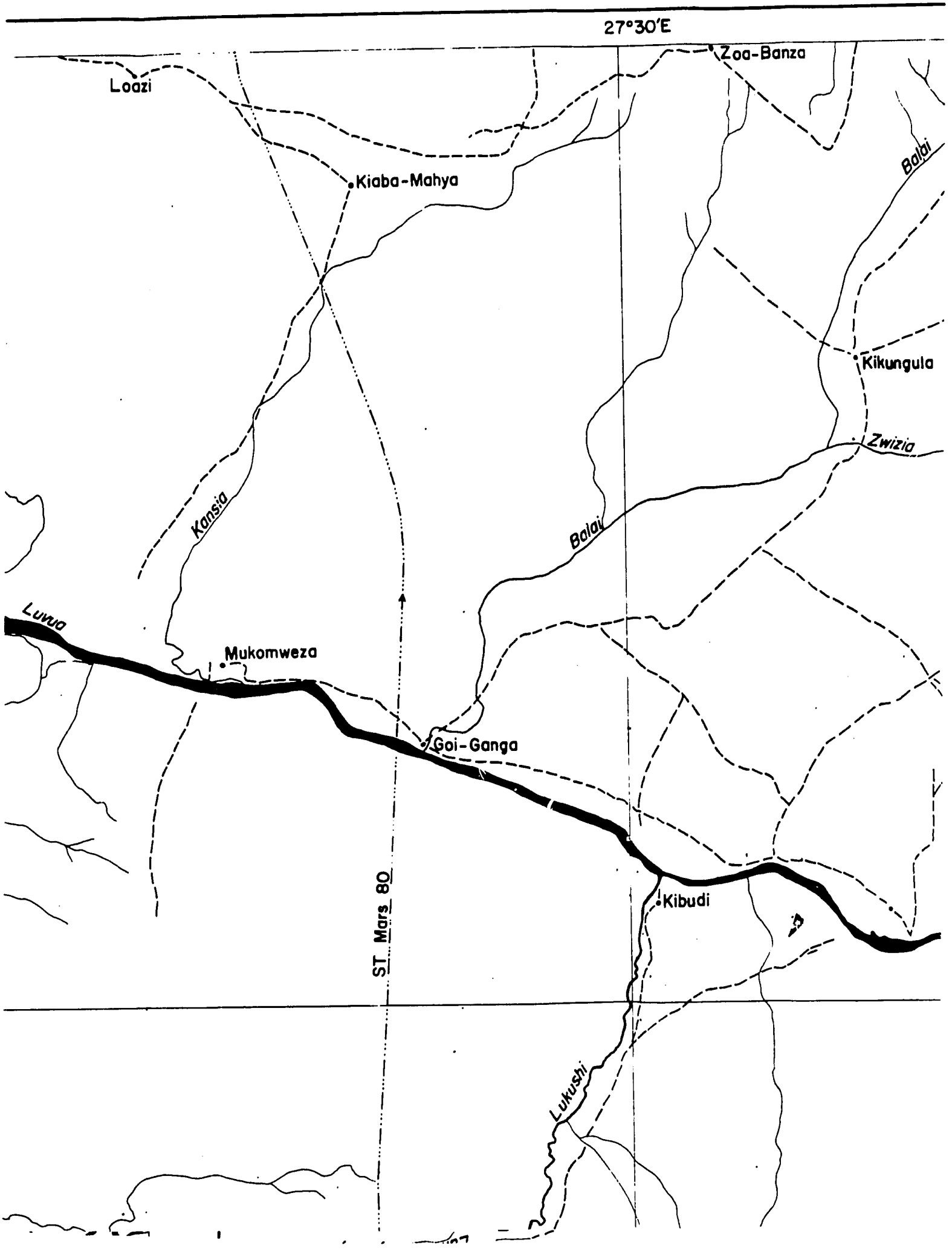
18 → ✱ Kabeya-Mayi : phillites , schistes , quartzite

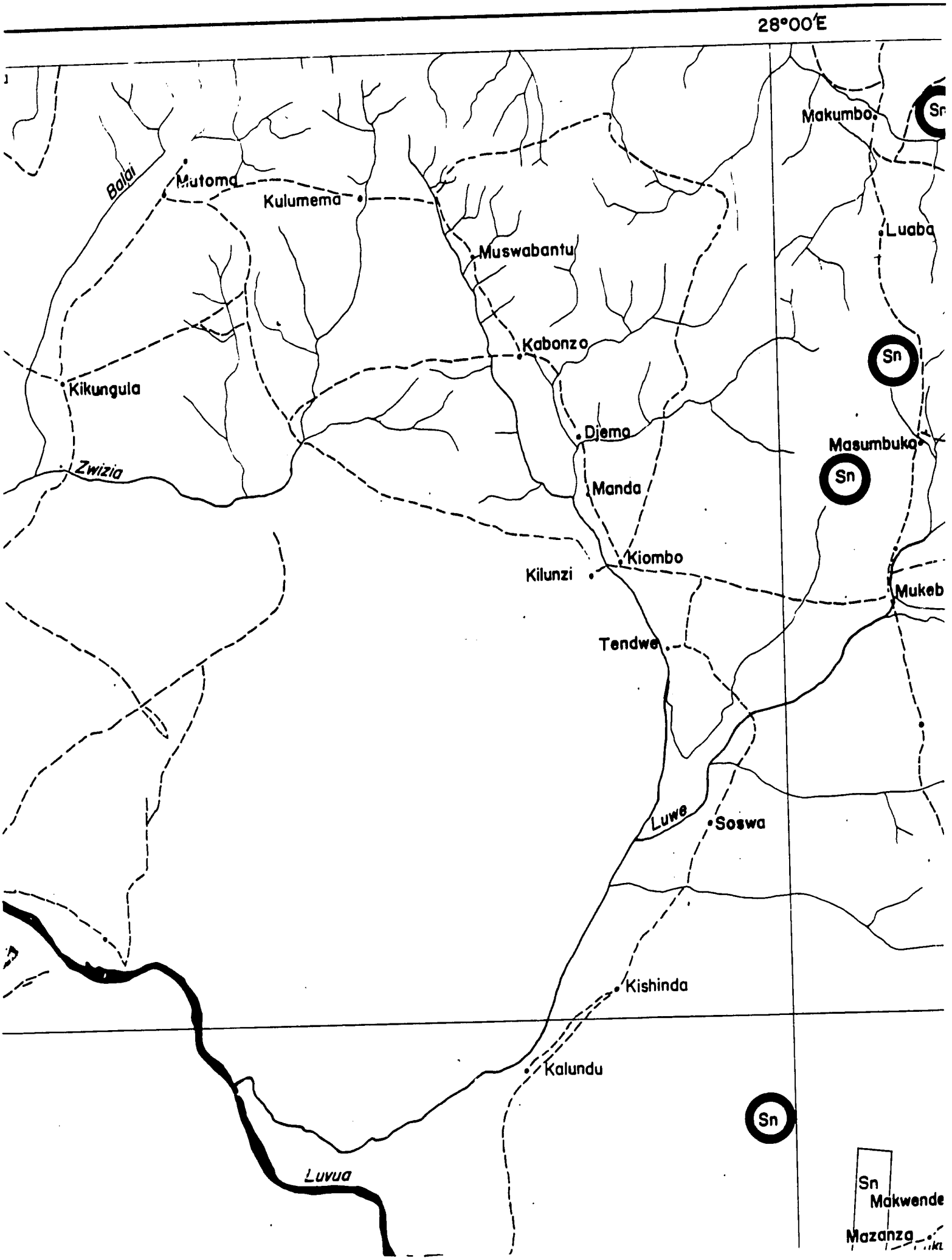
19 → ✱ Echantillon d'or de la rivière Luika

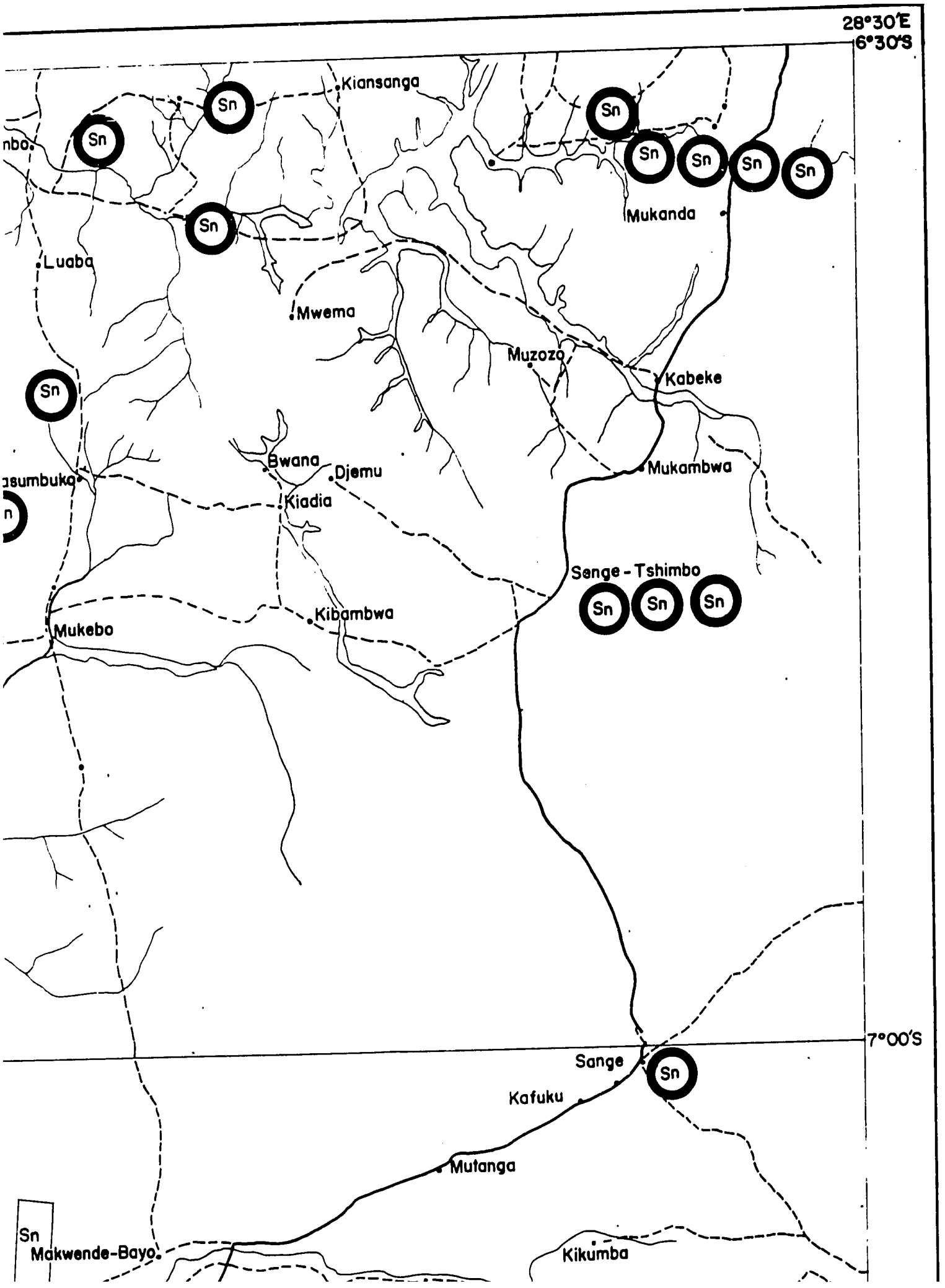
20 → ✱ Calcedoine de Mobanzo

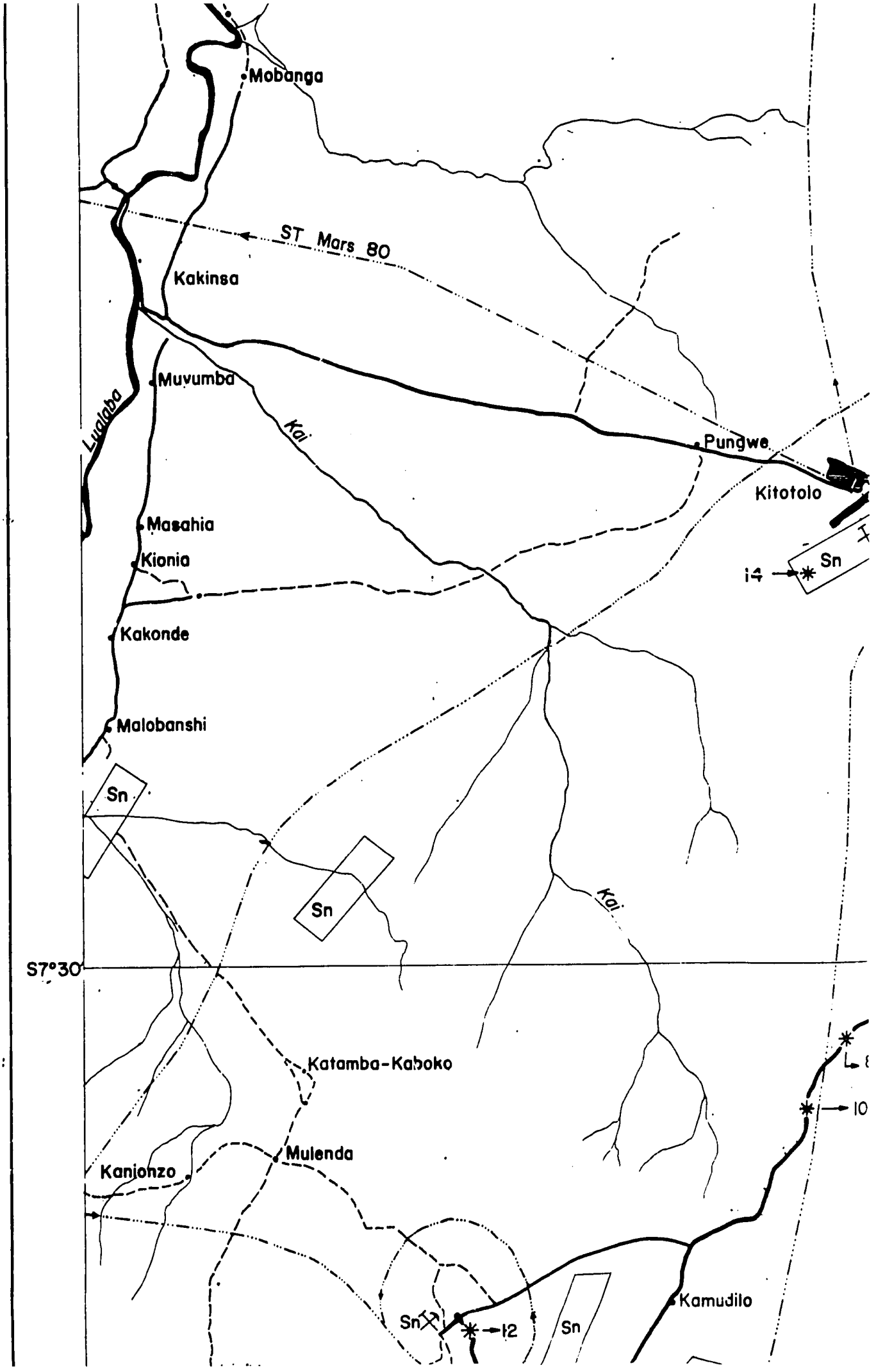
3U

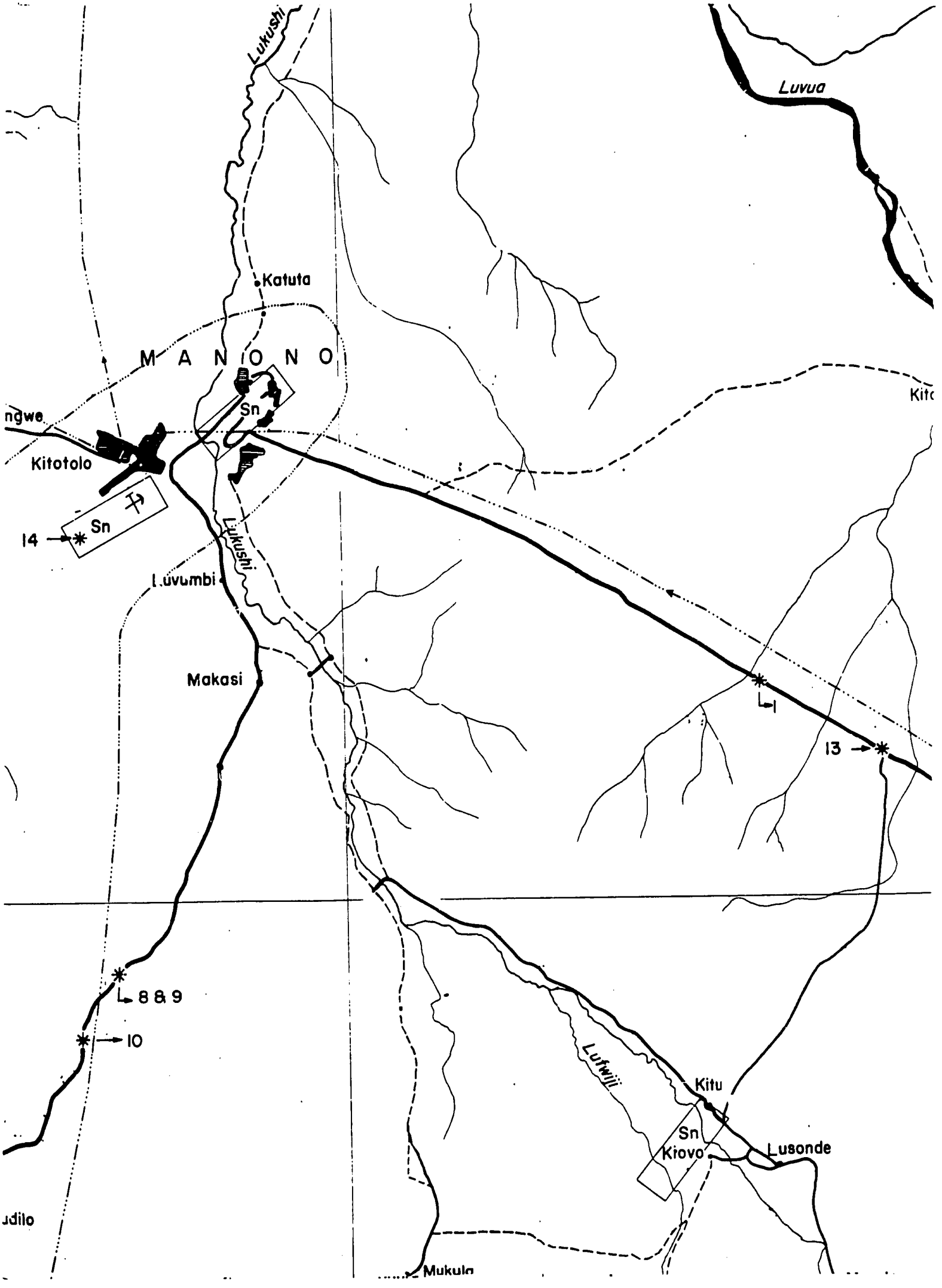

27°00'E
S6°30'
Loazi
Moambi
Kiaba-Mahyc
Maloba-Keta
Kansia
Lualaba
Luvua
Djimba
Mukomweza
Kayombo
ST Mars 80
S7°00'
Mobanga

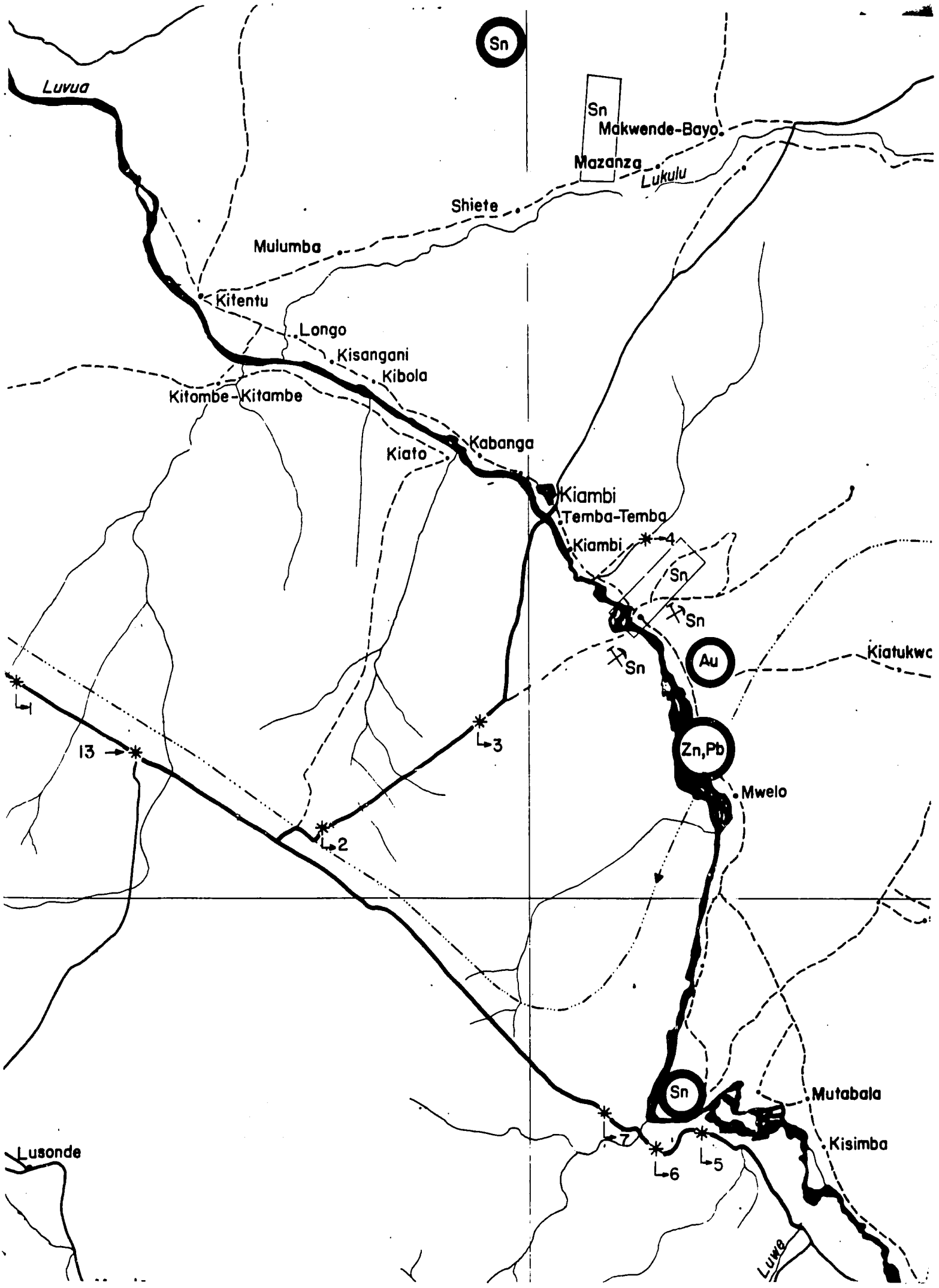

27°30'E
Zoa-Banza
Loazi
Kiaba-Mahya
Balai
Kikungula
Zwizia
Kansia
Balai
Luvua
Mukomweza
Goi-Ganga
Kibudi
ST Mars 80
Lukushi

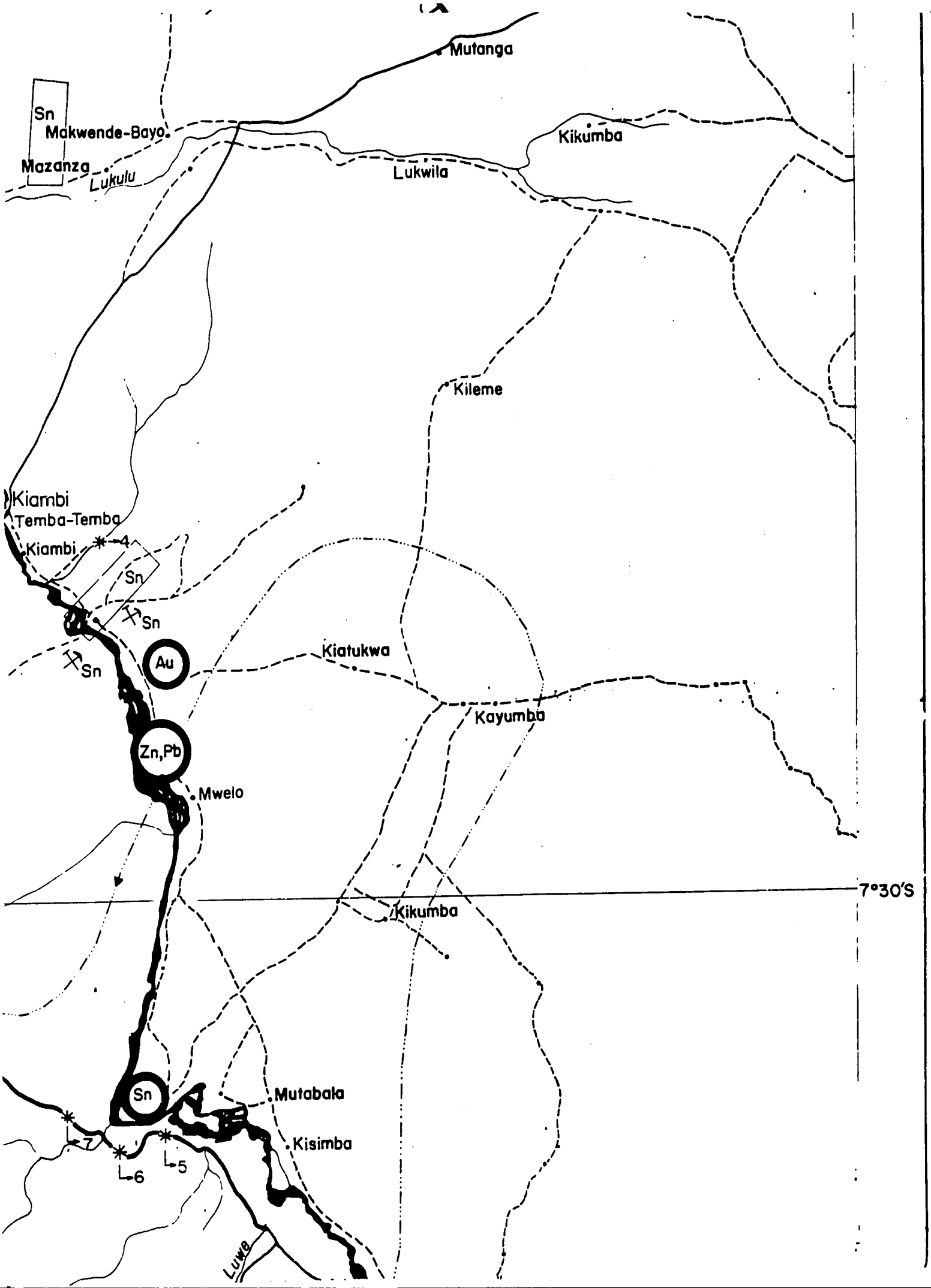

28°00'E
Makumbo
Sn
Balai
Mutoma
Kulumema
Luaba
Muswabantu
Kabonzo
Sn
Kikungula
Djema
Masumbuka
Zwizia
Sn
Manda
Kiombo
Kilunzi
Mukeb
Tendwe
Luwe
Soswa
Kishinda
Kalundu
Sn
Luvua
Sn
Makwende
Mazanza

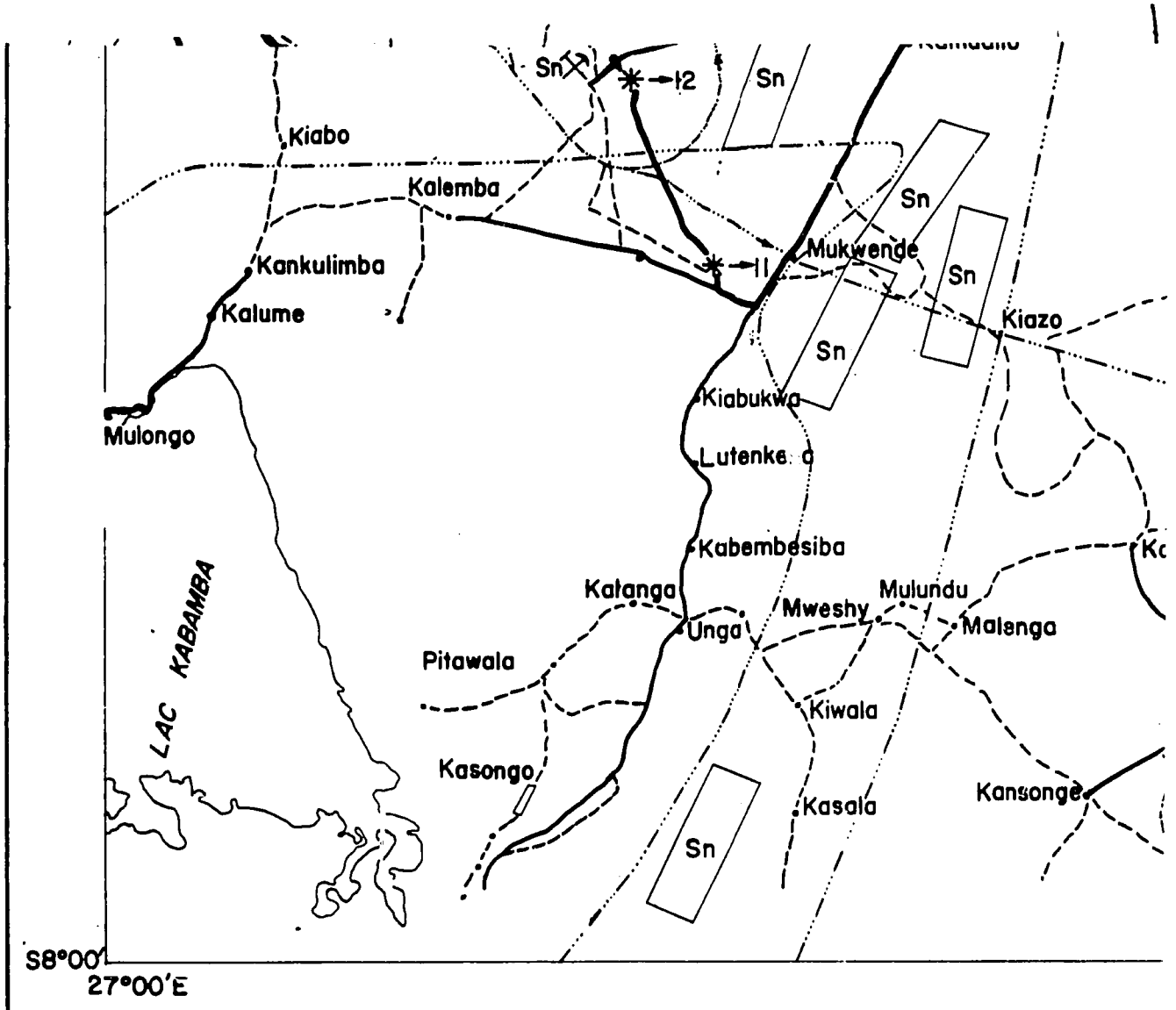

28°30'E
6°30'S
Kiansanga
Sn
Luaba
Mwema
Mukanda
Muzozo
Kabeke
Bwana
Djemu
Kiadia
Mukambwa
Senge - Tshimbo
Kibambwa
Mukebo
7°00'S
Sange
Kafuku
Mutanga
Makwende-Bayo
Kikumba


Mobanga
ST Mars 80
Kakinsa
Muvumba
Lualaba
Kai
Pungwe
Kitotolo
Masahia
Kionia
Sn
14
Kakonde
Malobanshi
Sn
Sn
Kai
S7°30
Katamba-Kaboko
10
Mulenda
Kanionzo
Kamudilo
Sn
12
Sn


Lukushi
Luvua
Katuta
M A N O N O
ngwe
Sn
Kitotolo
Sn
14
Lukushi
Luvumbi
Makasi
1
13
8 & 9
10
Lufwili
Kitu
Sn
Kiovo
Lusonde
udilo
Mukula


Sn
Luvua
Sn
Makwende-Bayo
Mazanza
Lukulu
Shiete
Mulumba
Kitentu
Longo
Kisangani
Kibola
Kitombe-Kitambe
Kabanga
Kiato
Kiambi
Temba-Temba
Kiambi
4
Sn
Sn
Sn
Au
Kiatukwc
1
13
3
Zn,Pb
Mwelo
2
Sn
Mutabala
Kisimba
7
6
5
Lusonde
Luwa


Mutanga
Sn
Makwende-Bayo
Mazanza
Lukulu
Lukwila
Kikumba
Kileme
Kiambi
Temba-Temba
Kiambi
4
Sn
Sn
Sn
Au
Kiatukwa
Kayumba
Zn,Pb
Mwelo
7°30'S
Kikumba
Sn
Mutabala
Kisimba
7
6
5
Luwe



Route

Sentier

Route parcourue par les chercheurs

Ligne de vol (Stancioff) Mars 1980

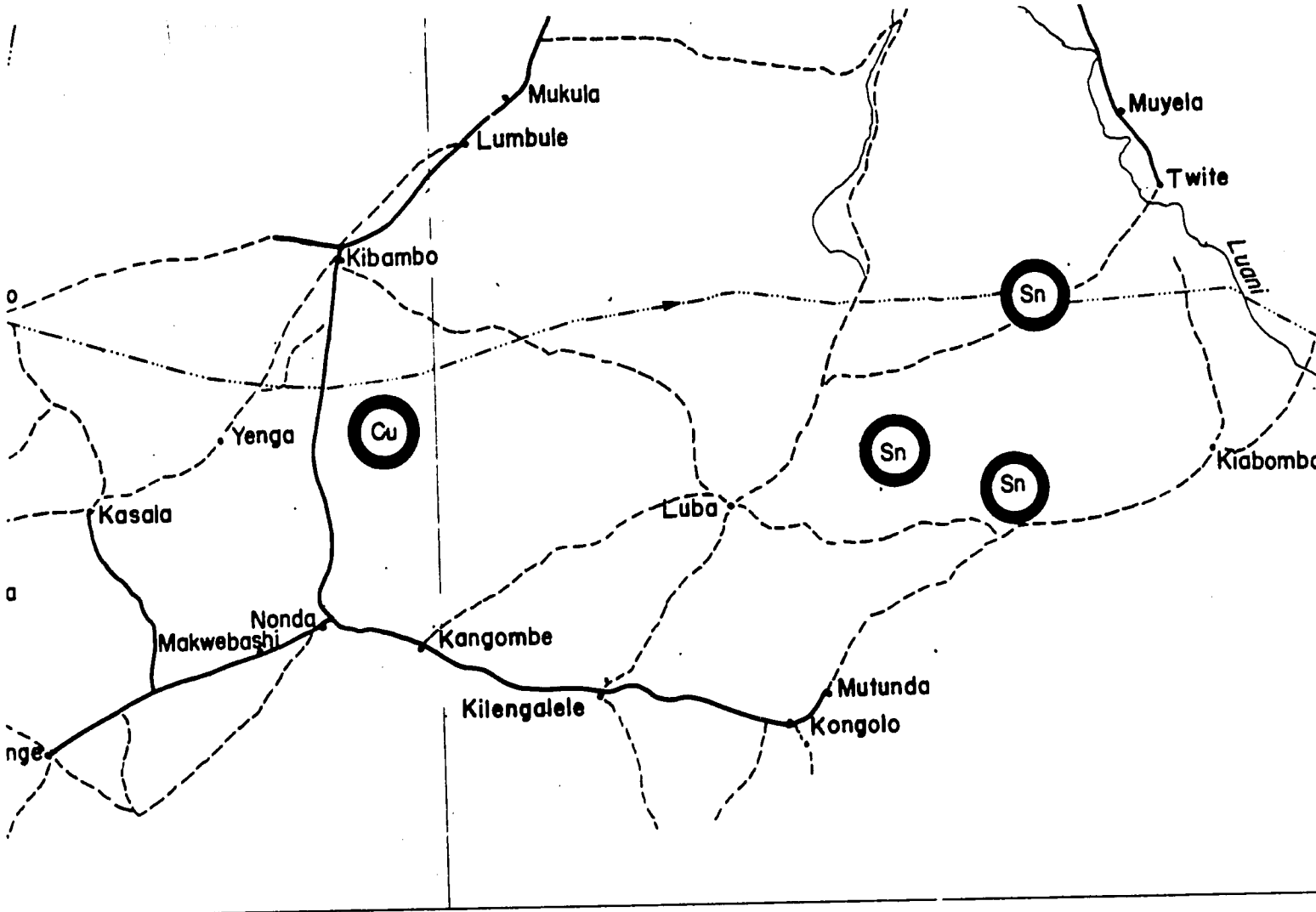
Ville de de Manono

Localité

Centre important

Sn Mines ou anciennes mines d'etain

PLANCHE N°12 : CARTE D'ITINERAIRES, PLAN DE VOL, ECHANT



L E G E N D

Au — Indice d'or (d'après la carte des gites minéraux du Zaïre)

Sn — Indice d'étain " "

Cu — Indice de cuivre " "

Zn,Pb — Indice de zinc et de plomb "

Sn — Filon d'étain " "

Sn — Sn — Zone minér

1 → Veine

2 → Biotit

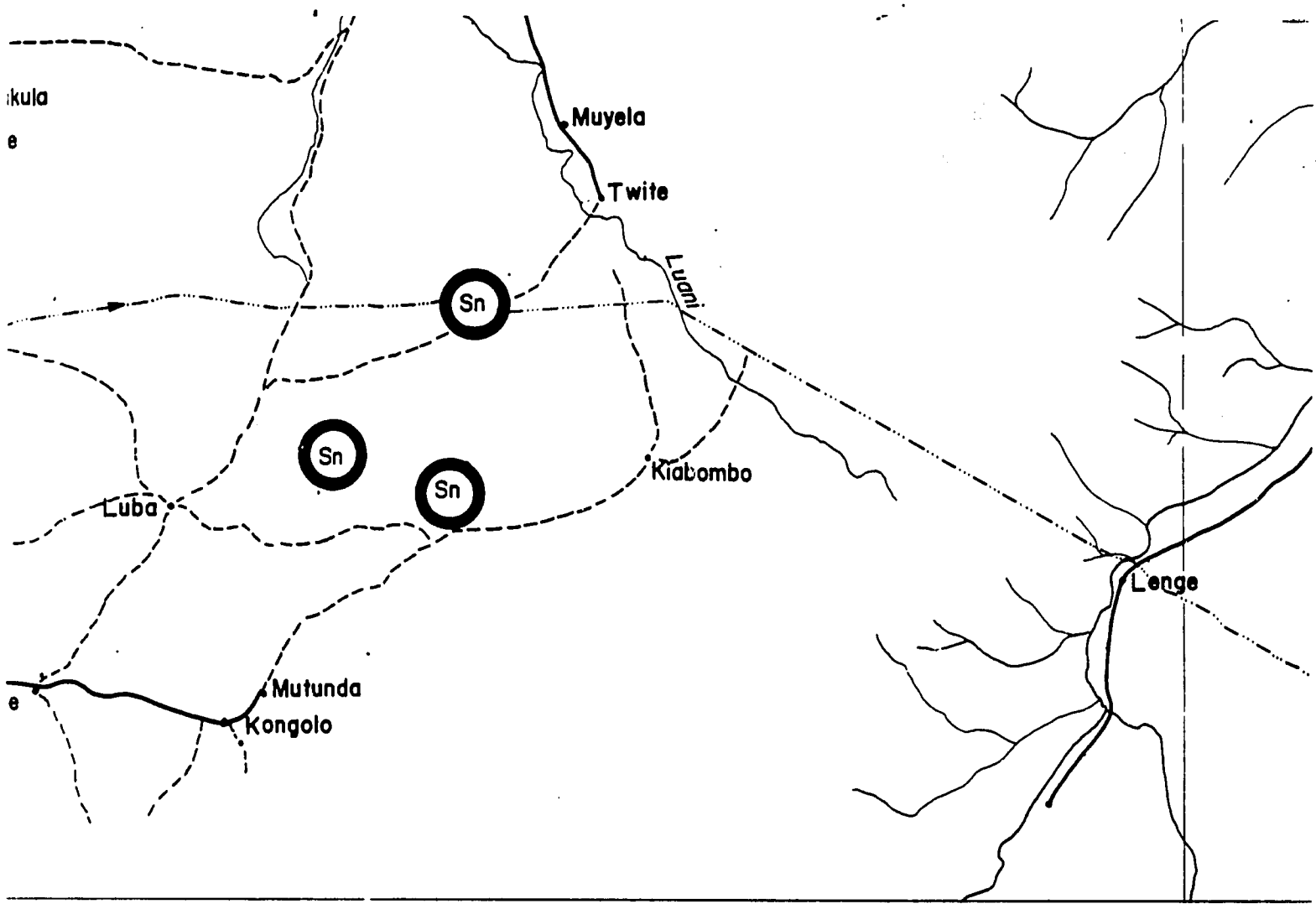
3 → Grani

4 → Pegm

Echelle 1/200.000

5 0 5 10 15

,ECHANTILLONAGE. C Scene Landsat de MANONO



L E G E N D E

arte des gites minéraux du Zaïre)

,, ,,

,, ,,

lomb ,,

,, ,,

Sn

Sn

Zone à faible teneur d'étain (d'après la carte de minéraux du Zaire)

1 → ✱ Veine de quartz avec quelque paillettes de mica

2 → ✱ Biotite , Arbite , Augen , Orthoclase , Gneiss

3 → ✱ Granite

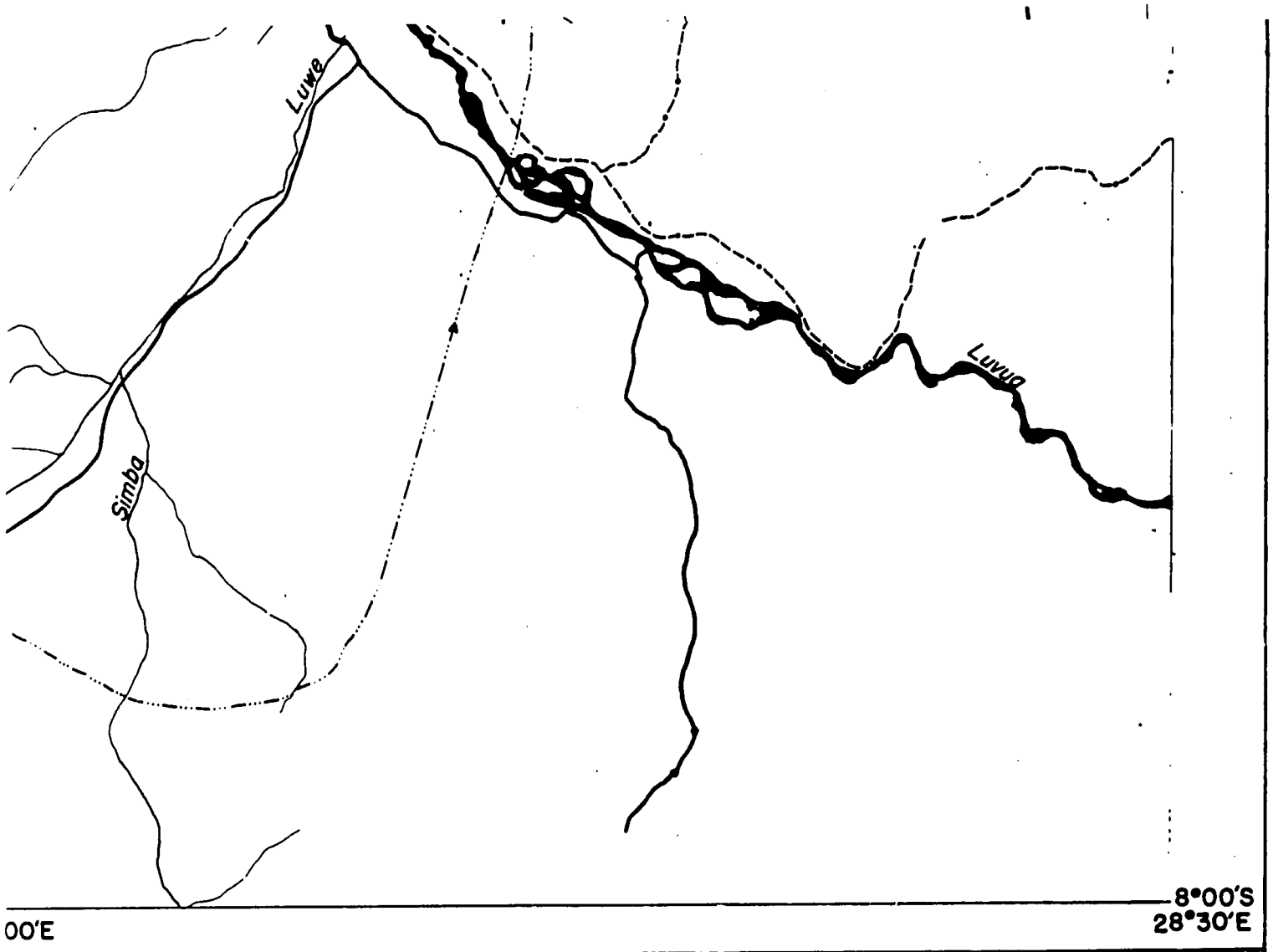
4 → ✱ Pegmatite (exploitation artisanale de cassiterite)

Echelle : 1/200.000

5 0 5 10 15

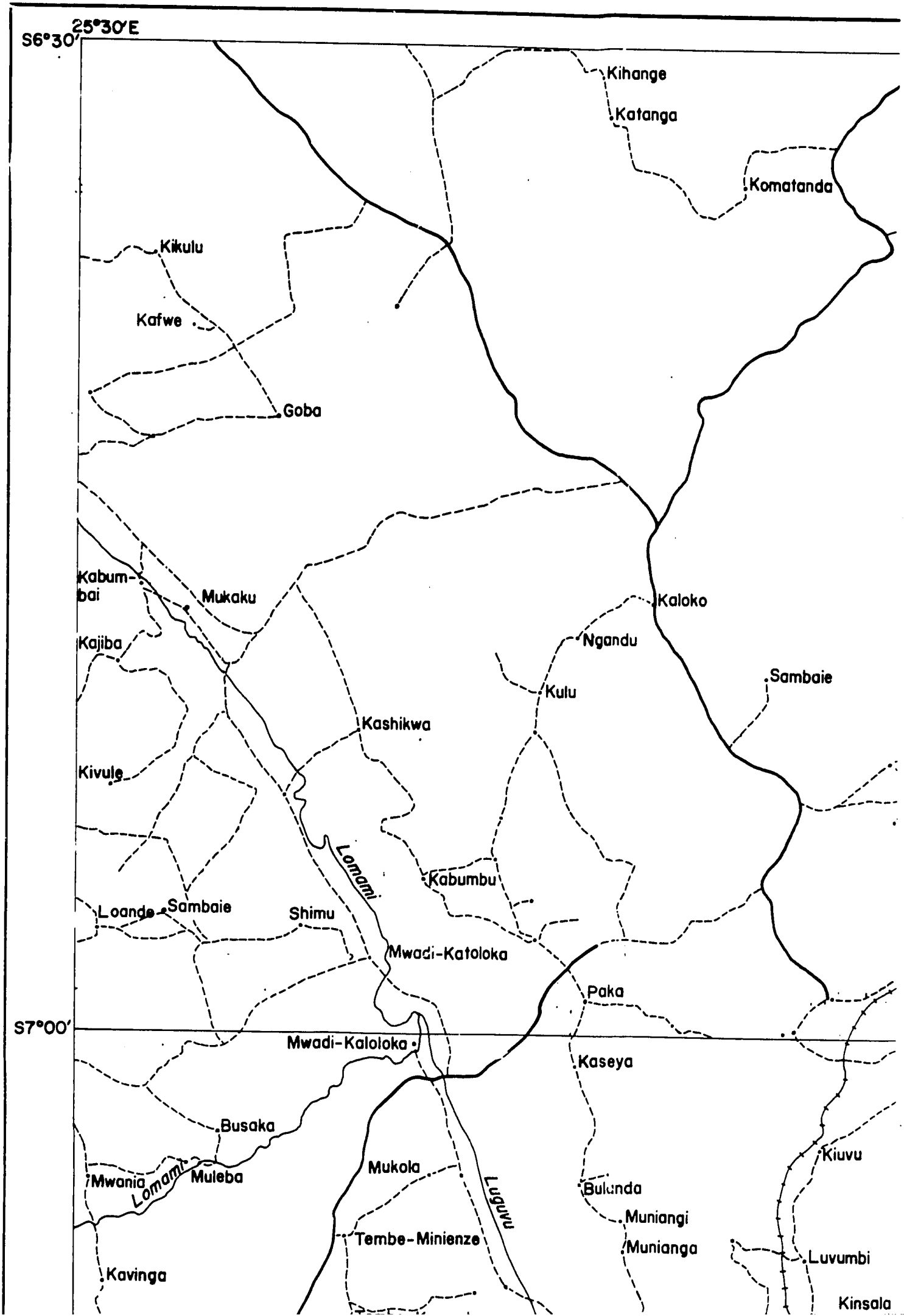
ANONO

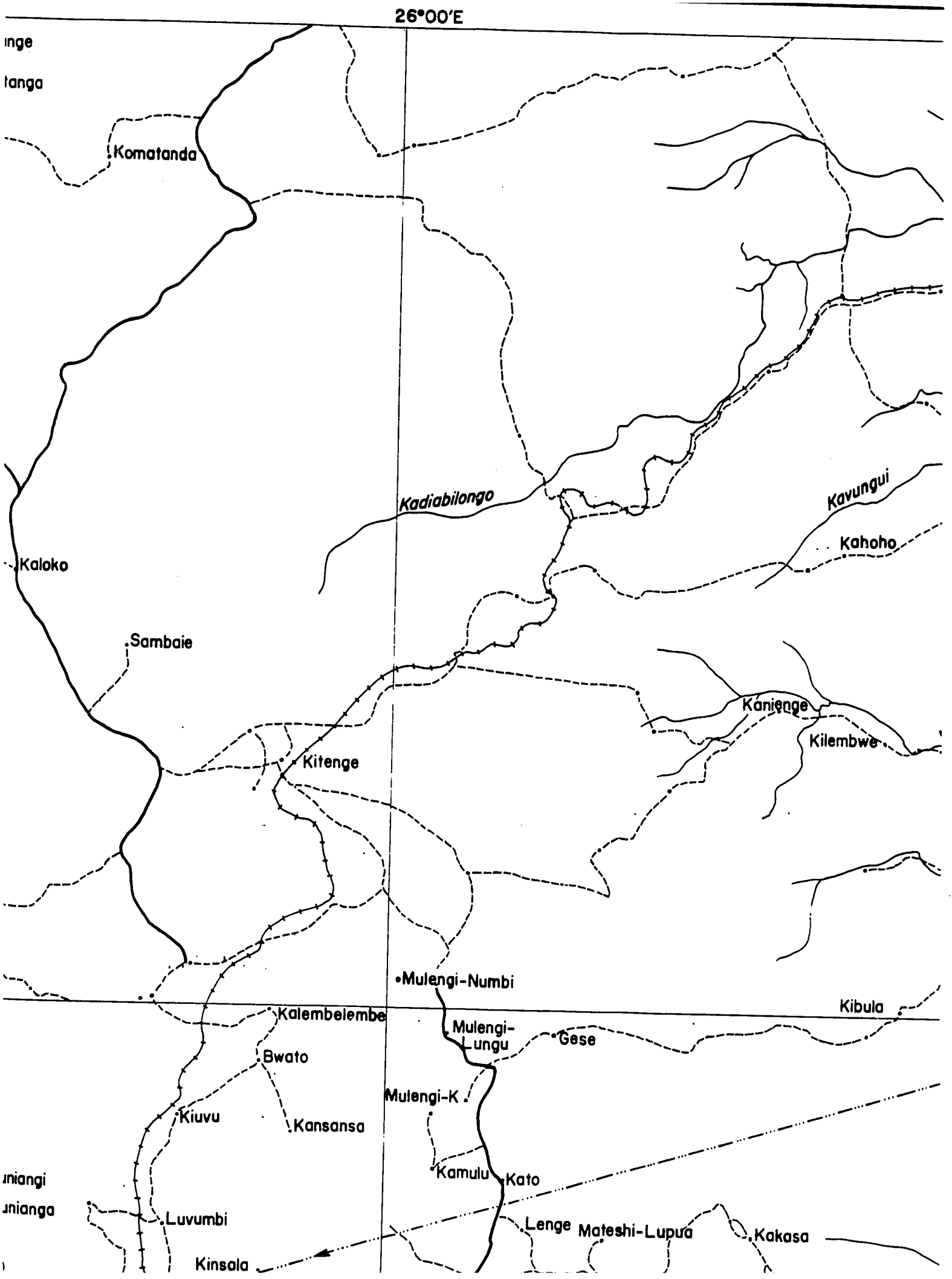
DESSINATEUR LUMBU

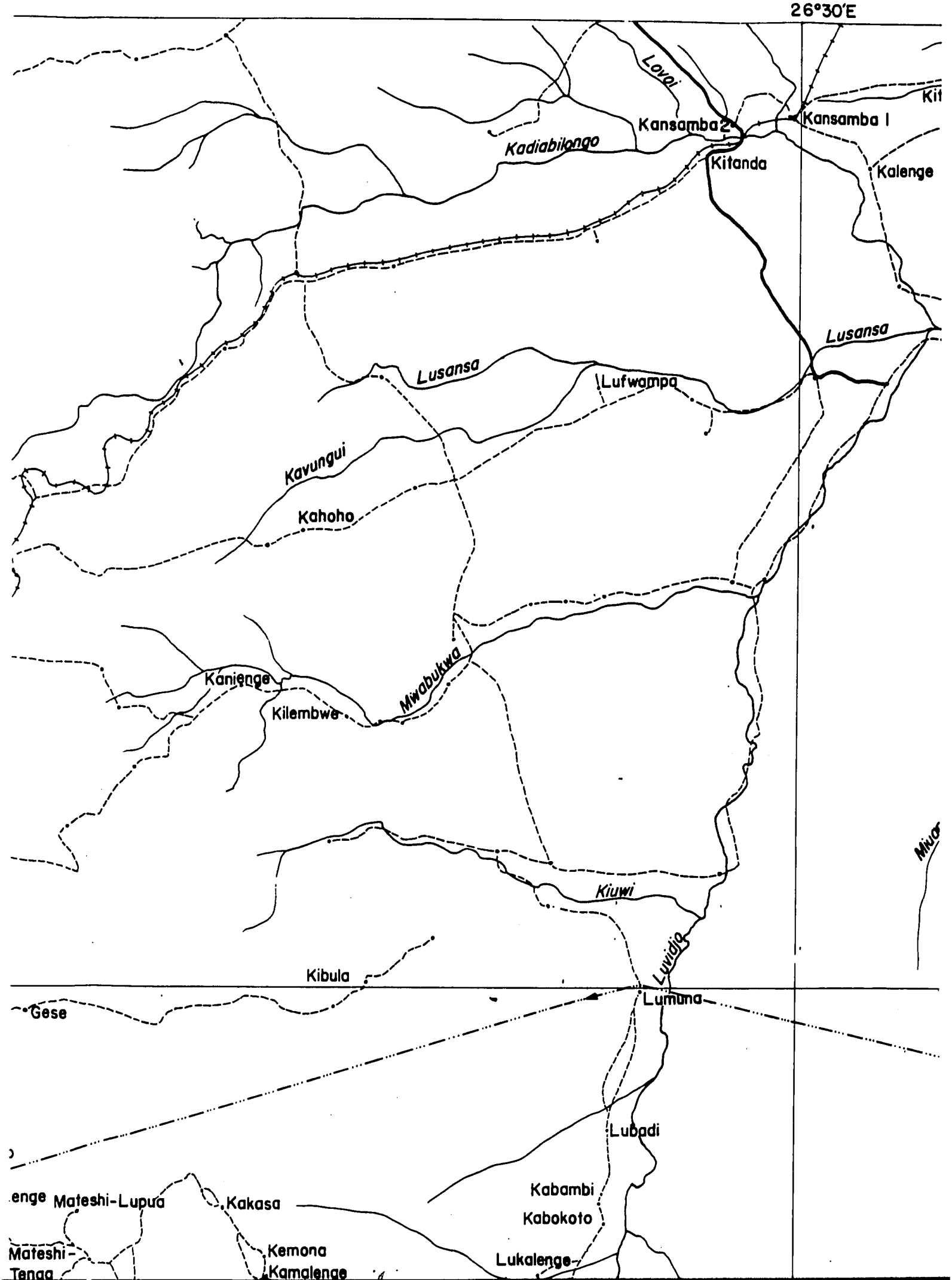


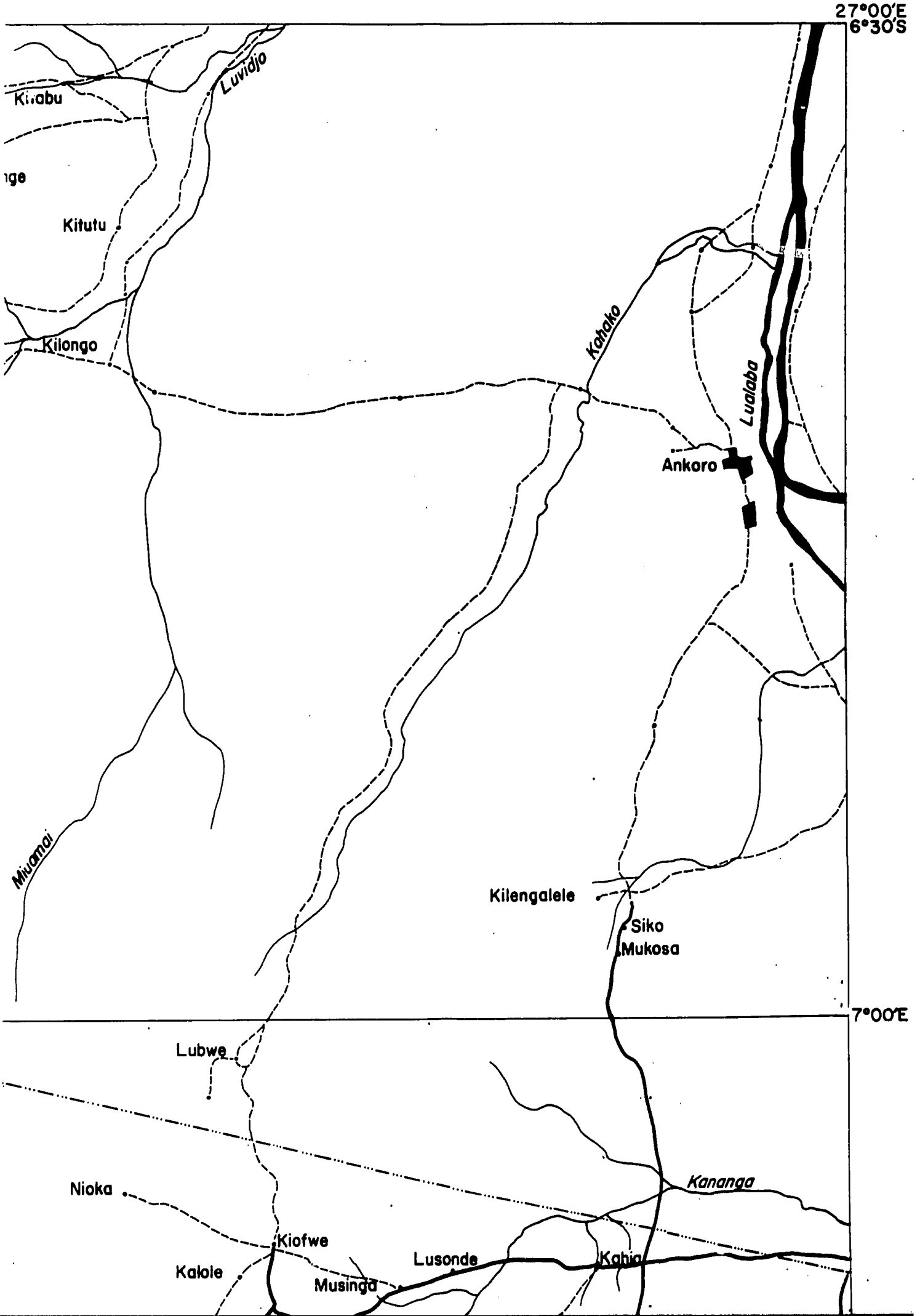
	5 → ✱ Gneiss , Schiste
	6 → ✱ Gneiss , Schiste
arte de gites	7 → ✱ Gneiss , Diorite , Gabbro
	8 & 9 → ✱ Gneiss , Pegmatite , Mica
	10 → ✱ Gneiss , Pegmatite
de mica	11 → ✱ Source hydrothermale
	12 → ✱ Gneiss , Pegmatite , Granite (Mine de Bukena)
	13 → ✱ Sable noir
terite)	14 → ✱ Pegmatite mines de Kitotolo

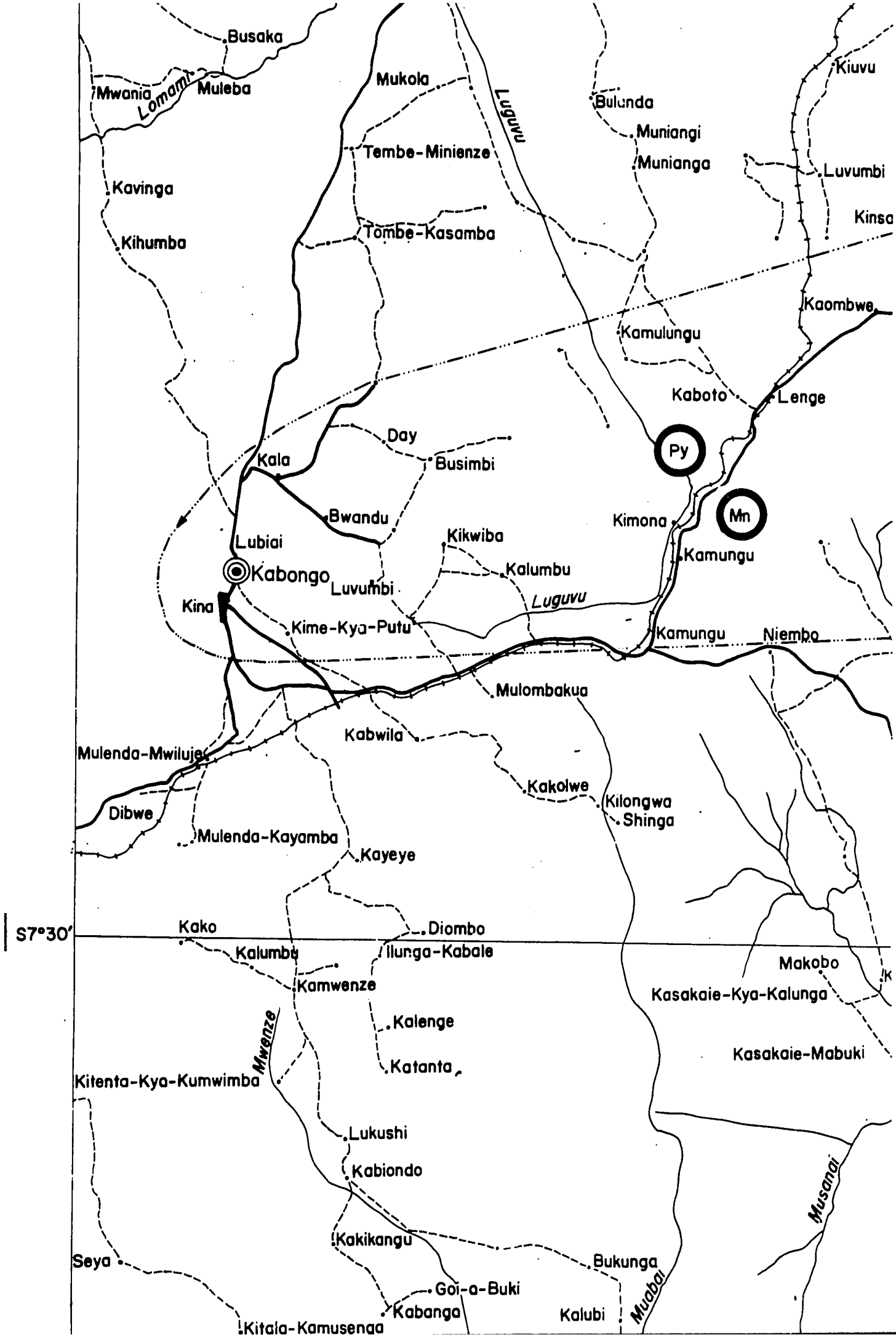
MBU

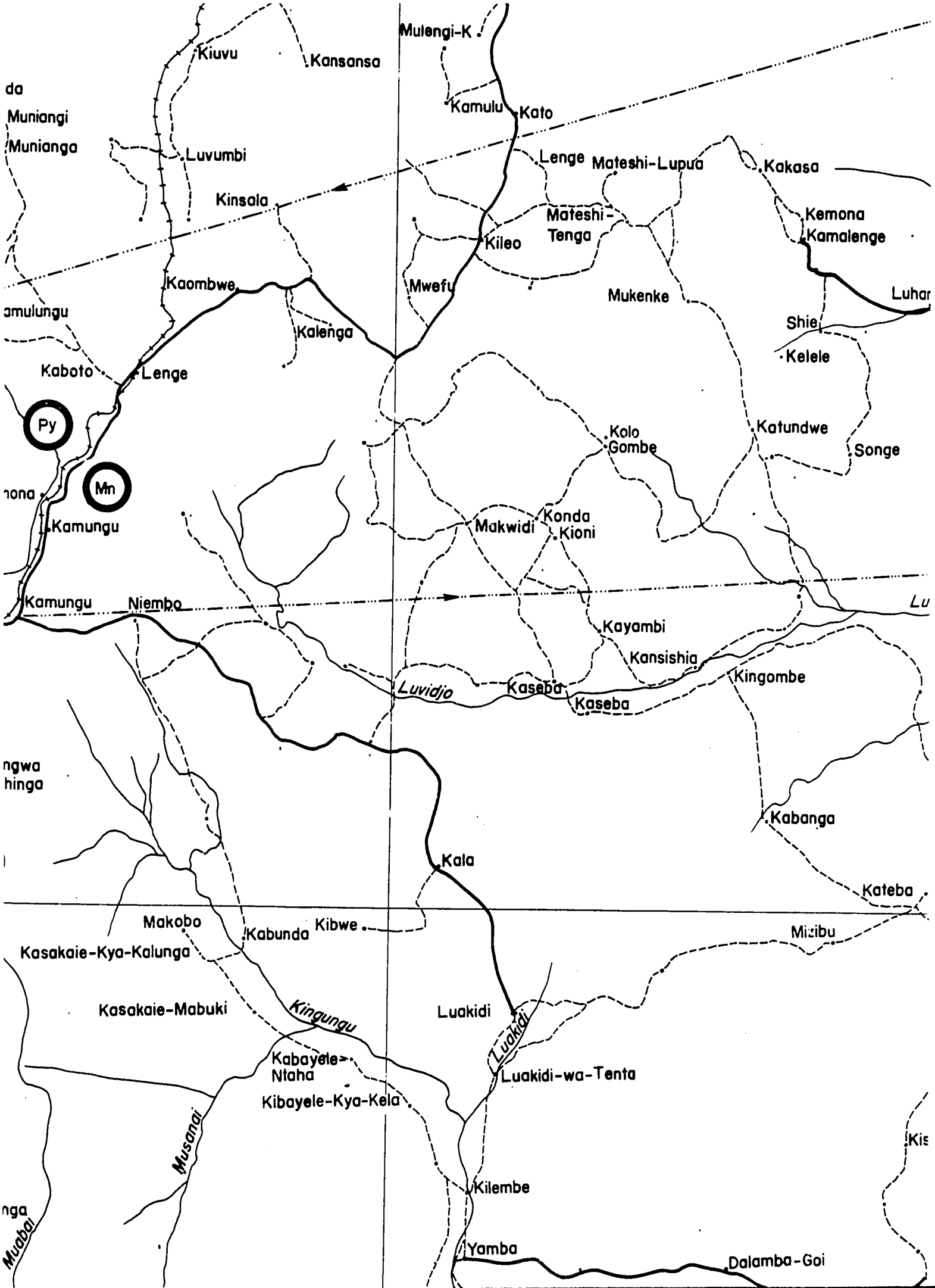

25°30'E
S6°30'
S7°00'
Kihange
Katanga
Komatanda
Kikulu
Kafwe
Goba
Kabum-
bai
Mukaku
Kajiba
Kaloko
Ngandu
Sambaie
Kulu
Kashikwa
Kivule
Lomami
Kabumbu
Loande
Sambaie
Shimu
Mwadi-Katoloka
Paka
Mwadi-Kaloloka
Kaseya
Busaka
Mwania
Lomami
Muleba
Mukola
Lugufu
Bulunda
Kiuvu
Muniangi
Tembe-Minienze
Munianga
Luvumbi
Kavinga
Kinsala

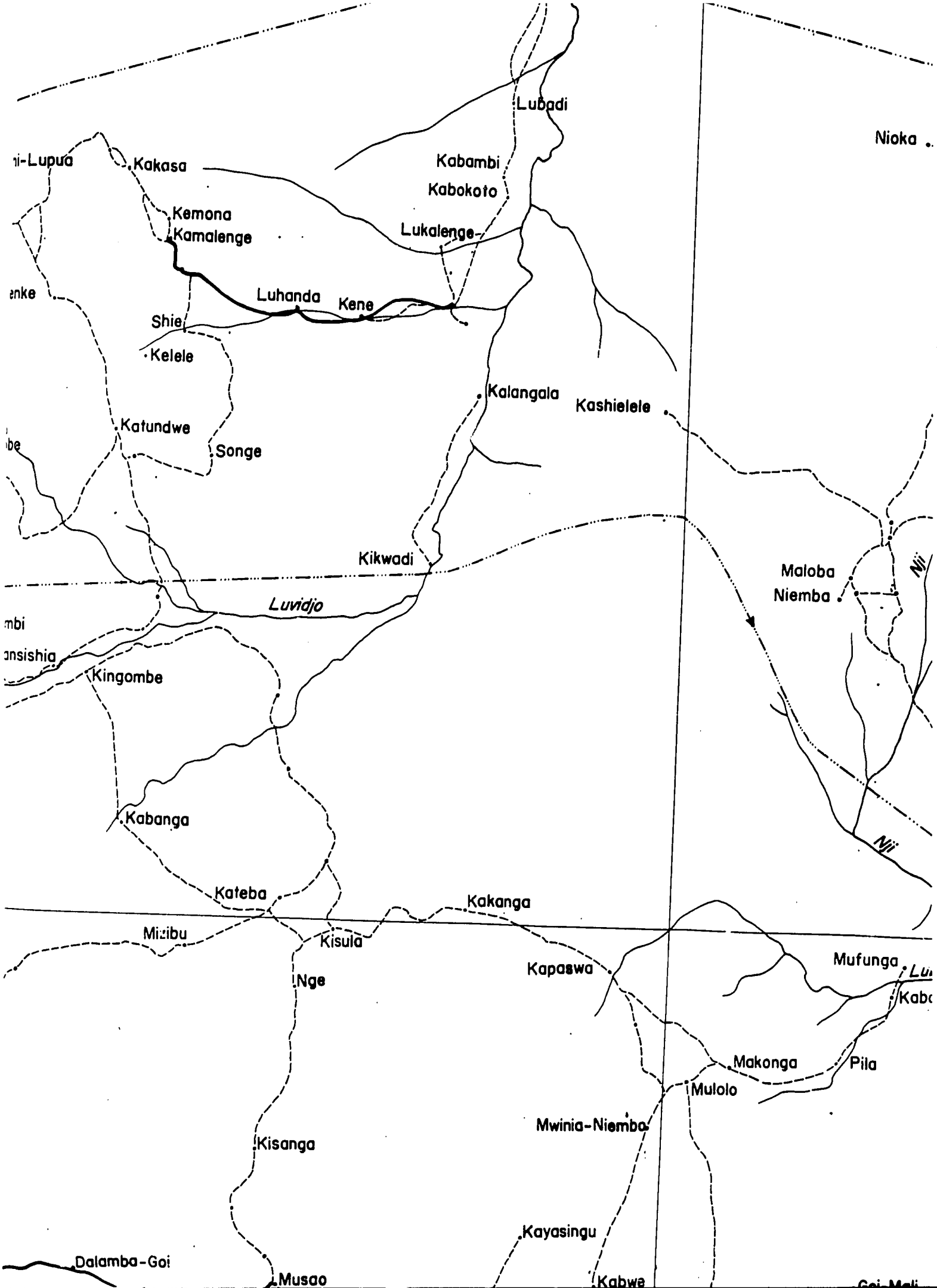

26°00'E
inge
tanga
Komatanda
Kadiabilongo
Kavungui
Kahoho
Kaloko
Sambaie
Kanienge
Kilembwe
Kitenge
Mulengi-Numbi
Kibula
Kalembelembe
Mulengi-Lungu
Gese
Bwato
Mulengi-K
Kiuvu
Kansansa
Kamulu
Kato
uniangi
unianga
Luvumbi
Lenge
Mateshi-Lupua
Kakasa
Kinsala

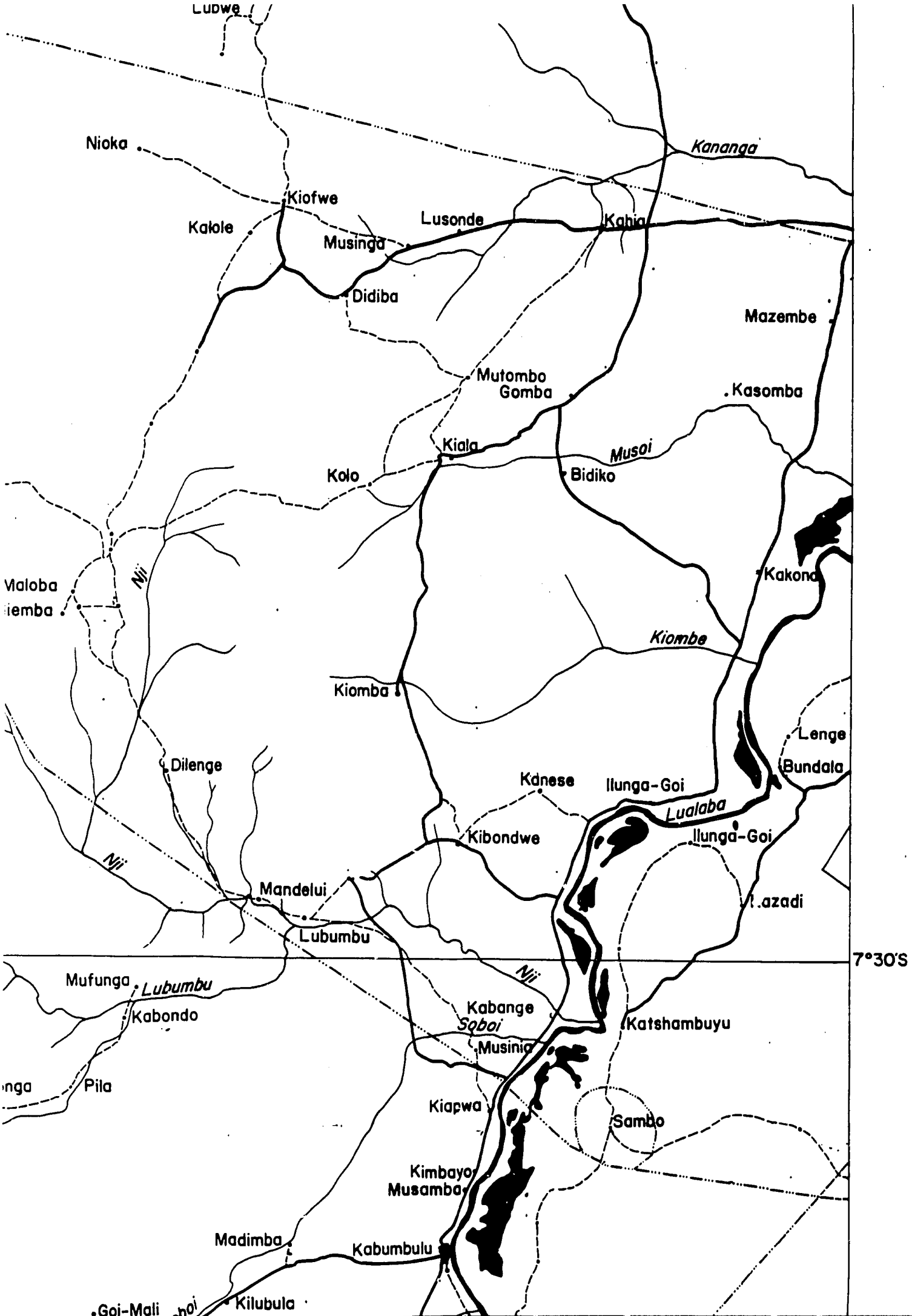

26°30'E
Lovai
Kit
Kansamba 2
Kansamba I
Kadiabilongo
Kitanda
Kalenge
Lusansa
Lusansa
Lufwampa
Kavungui
Kahoho
Kanienge
Mwabukwa
Kilembwe
Kiuwi
Luvidjo
Kibula
Lumuna
Gese
Lubadi
Kabambi
Kabokoto
Lukalenge
Mateshi-Lupua
Kakasa
Kemona
Kamalenge
Mateshi-
Tenga

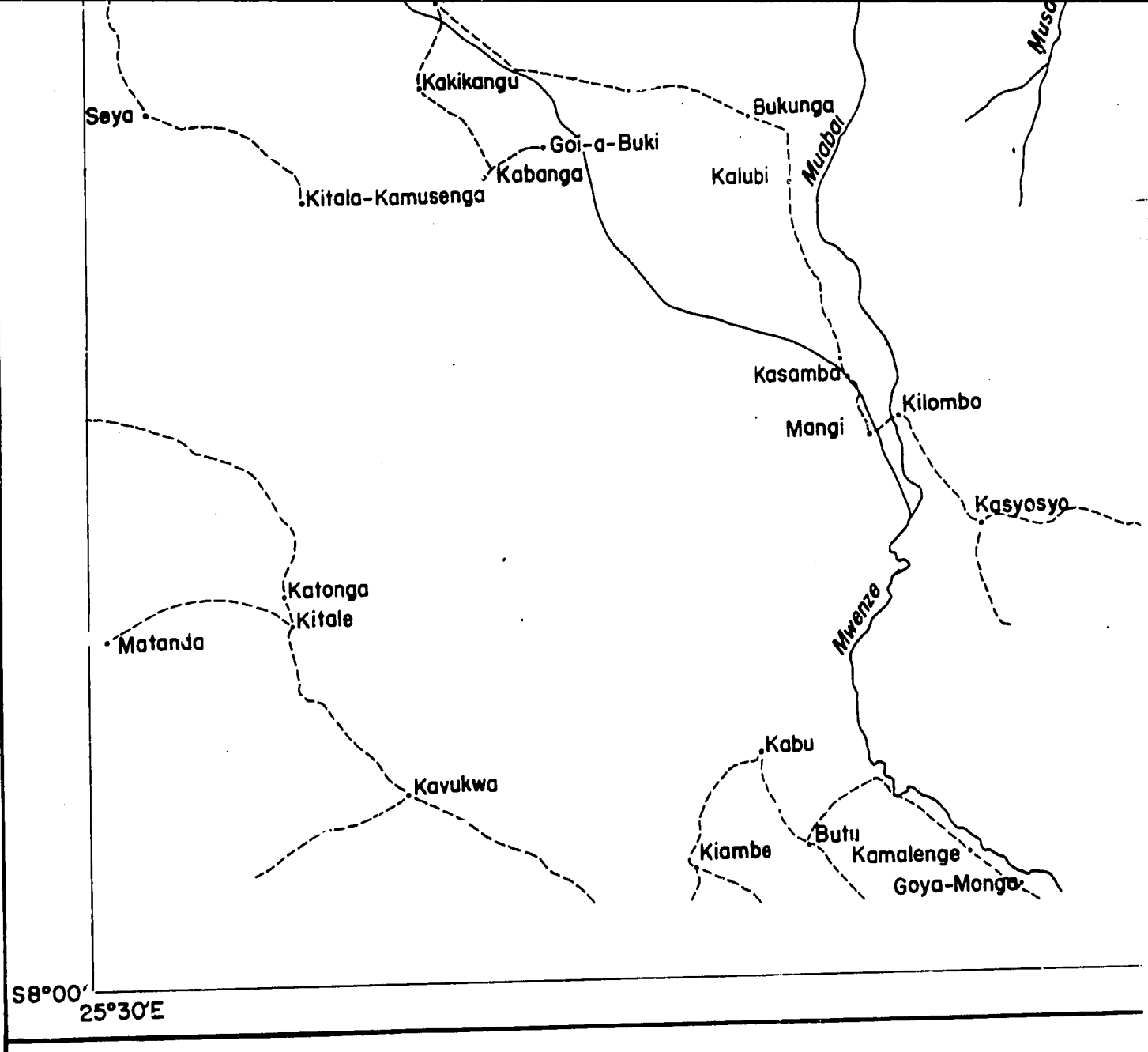

27°00'E
6°30'S
Luvidjo
Kitabu
Kitutu
Kilongo
Kahako
Lualaba
Ankoro
Miuamai
Kilengalele
Siko
Mukosa
7°00'E
Lubwe
Nioka
Kananga
Kiofwe
Kalole
Lusonde
Kahia
Musinga


Busaka
Mwania
Lomami
Muleba
Mukola
Luguvu
Bulunda
Kiuvu
Muniangi
Tembe-Minienze
Munianga
Luvumbi
Kavinga
Kinsa
Tombe-Kasamba
Kihumba
Kaombwe
Kamulungu
Kaboto
Lenge
Day
Py
Kala
Busimbi
Mn
Bwandu
Kimona
Kikwiba
Lubiai
Kamungu
Kabongo
Kalumbu
Luvumbi
Luguvu
Kina
Kime-Kya-Putu
Kamungu
Niembo
Mulombakua
Kabwila
Mulenda-Mwilujes
Kakolwe
Kilongwa
Dibwe
Shinga
Mulenda-Kayamba
Kayeye
S7°30'
Kako
Diombo
Kalumbu
Ilunga-Kabale
Makobo
Kamwenze
Kasakaie-Kya-Kalunga
Kalenge
Mwenze
Kasakaie-Mabuki
Katanta
Kitenta-Kya-Kumwimba
Lukushi
Kabiondo
Musanai
Kakikangu
Seya
Bukunga
Goi-a-Buki
Kabanga
Kalubi
Muabai
Kitala-Kamusenga


Mulengi-K
Kiuvu
Kansansa
da
Muniangi
Munianga
Kamulu
Kato
Luvumbi
Lenge
Mateshi-Lupua
Kakasa
Kinsala
Mateshi-Tenga
Kemona
Kamalenge
Kileo
Kaombwe
Mwefu
Mukenke
Luhar
amulungu
Kalenga
Shie
Kelele
Kaboto
Lenge
Py
Kolo Gombe
Katundwe
Songe
Mn
nona
Kamungu
Makwidi
Konda
Kioni
Kamungu
Niembo
Lu
Kayambi
Kansishia
Kingombe
Luvidjo
Kaseba
Kaseba
ngwa
hinga
Kabanga
Kala
Kateba
Makobo
Kabunda
Kibwe
Mizibu
Kasakaie-Kya-Kalunga
Kasakaie-Mabuki
Kingungu
Luakidi
Luakidi
Kabayele-Ntaha
Luakidi-wa-Tenta
Kibayele-Kya-Kela
Musanai
Kis
Kilembe
nga
Muabai
Yamba
Dalamba-Goi


Lubadi
Nioka
Kakasa
Kabambi
Kabokoto
Kemona
Kamalenge
Lukalenge
Luhanda
Kene
Shie
Kelele
Kalangala
Kashielele
Katundwe
Songe
Kikwadi
Maloba
Niemba
Luvidjo
Kingombe
Kabanga
Kateba
Kakanga
Mizibu
Kisula
Nge
Kapaswa
Mufunga
Makonga
Pila
Mulolo
Mwinia-Niemba
Kisanga
Kayasingu
Dalamba-Goi
Musao
Kabwe


Ludwe
Nioka
Kananga
Kiofwe
Kalole
Lusonde
Kahia
Musinga
Didiba
Mazembe
Mutombo
Gomba
Kasomba
Kiala
Musoi
Kolo
Bidiko
Kakona
Maloba
Nji
Kiombe
Kiomba
Lenge
Bundala
Dilenge
Kanese
Ilunga-Goi
Lualaba
Kibondwe
Ilunga-Goi
Nji
Mandelui
Lubumbu
7°30'S
Mufunga
Lubumbu
Nji
Kabondo
Kabange
Soboi
Katshambuyu
Musinia
Pila
Kiapwa
Sambo
Kimbayo
Musamba
Madimba
Kabumbulu
Goi-Mali
Kilubula



Route

Sentier

Chemin de fer

Ligne de vol (STANCIOFF) Mars 1980

Chef-lieu de Zone

Localité

Centre important

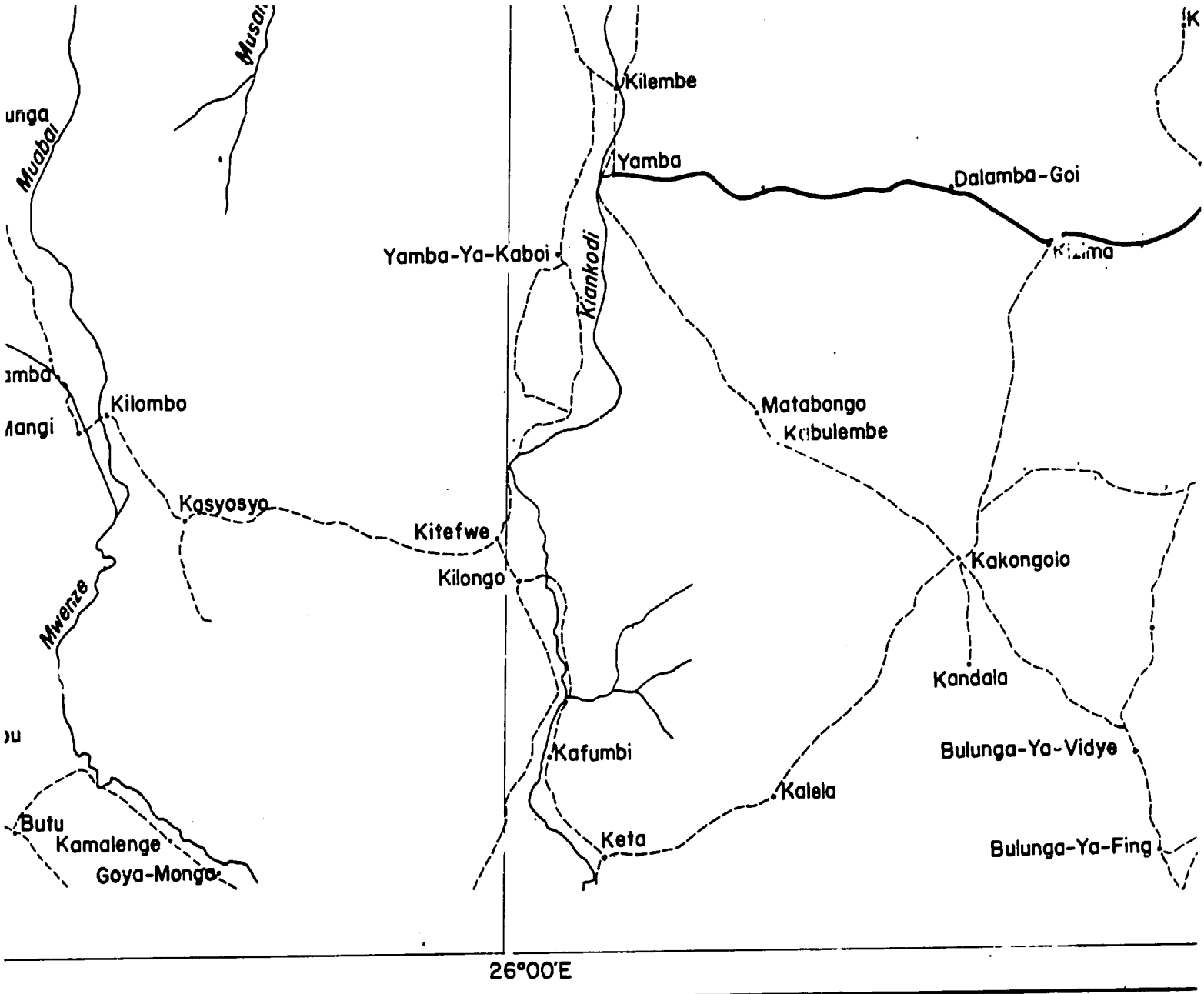
Sn Indi

Py Indi

Mn Ind

Sn Mi

PLANCHE N°12 : CARTE D'ITINERAIRES, PLAN DE VOL, ECHANTIL



LEGEN

Sn — Indice d'étain (d'après la carte des gites minéraux du Zaïre)

Py — Indice de pyrite " "

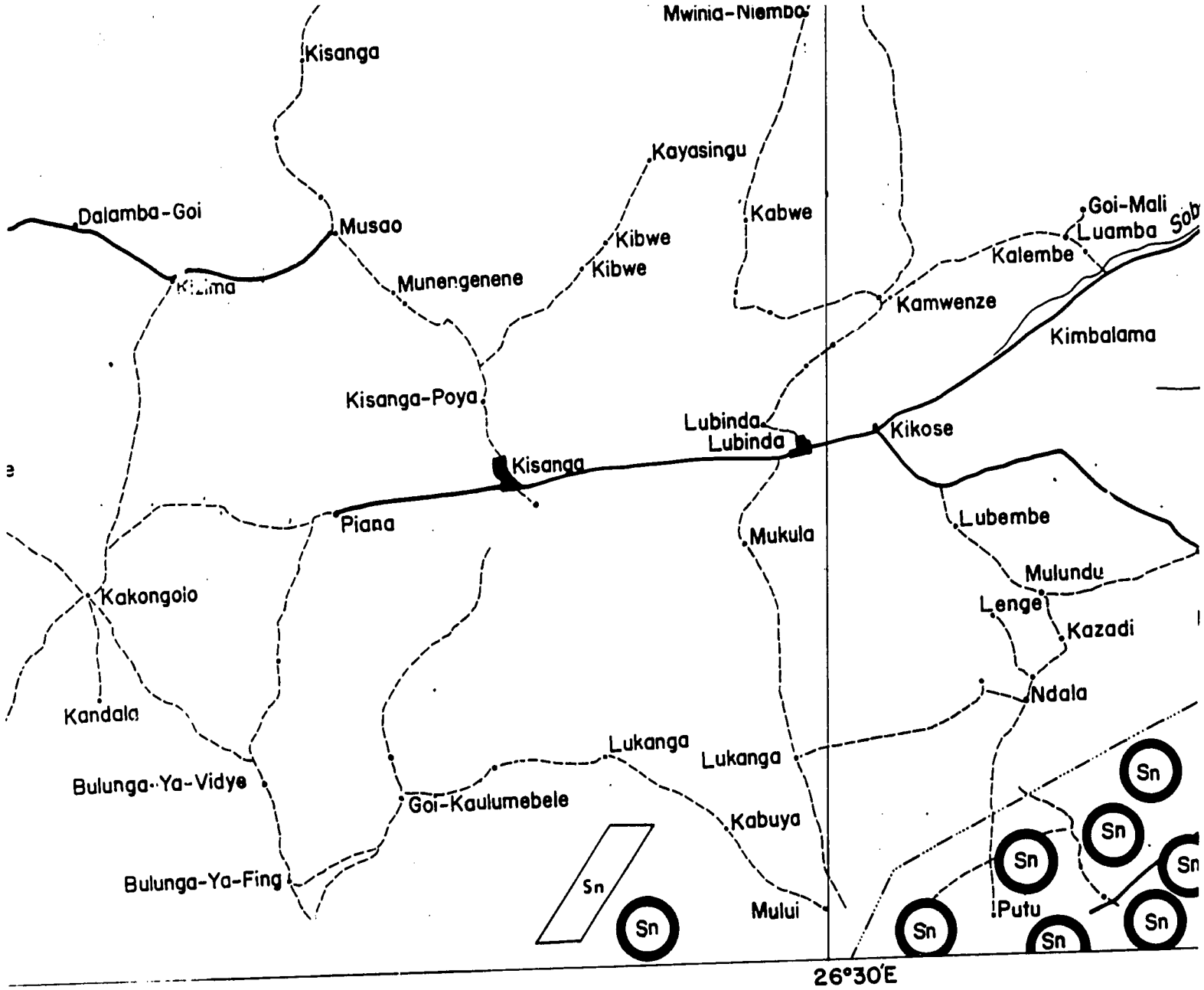
Mn — Indice de manganèse " "

S n — Mines ou anciennes mines d etain

Echelle 1/200

5 0 5

'LAN DE VOL, ECHANTILLONAGE. D Scène Landsat de MWANZA KABONGO



LEGENDE

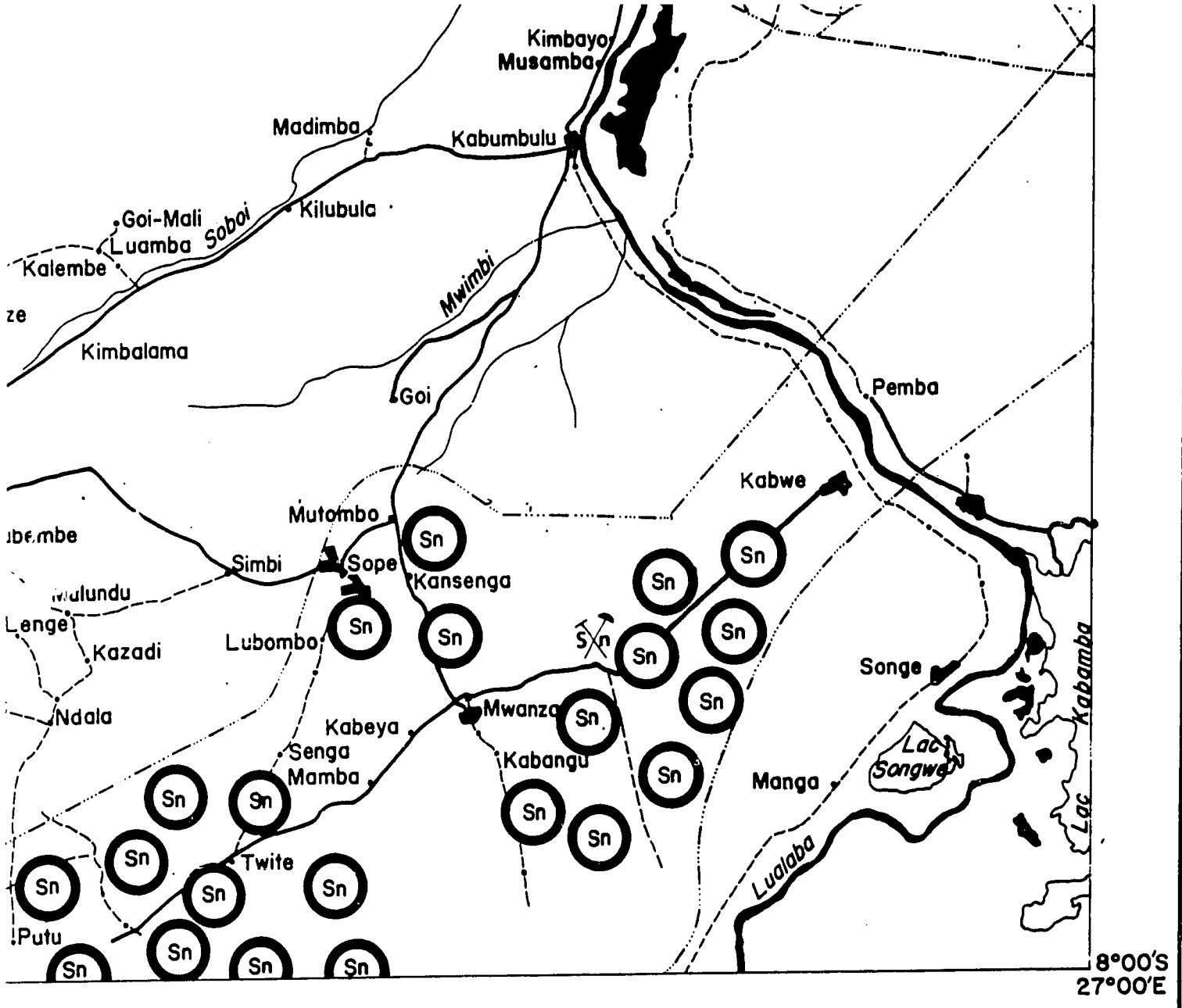
Sn — Filon d'étain (d'après la carte des gites minéraux du Zaïre)

Sn — Zone à faible teneur d'etain (d'apres la carte des gites mineraux du Zaïre)

Echelle 1/200.000

5 0 5 10 15

DESSINATEUR LUMBU

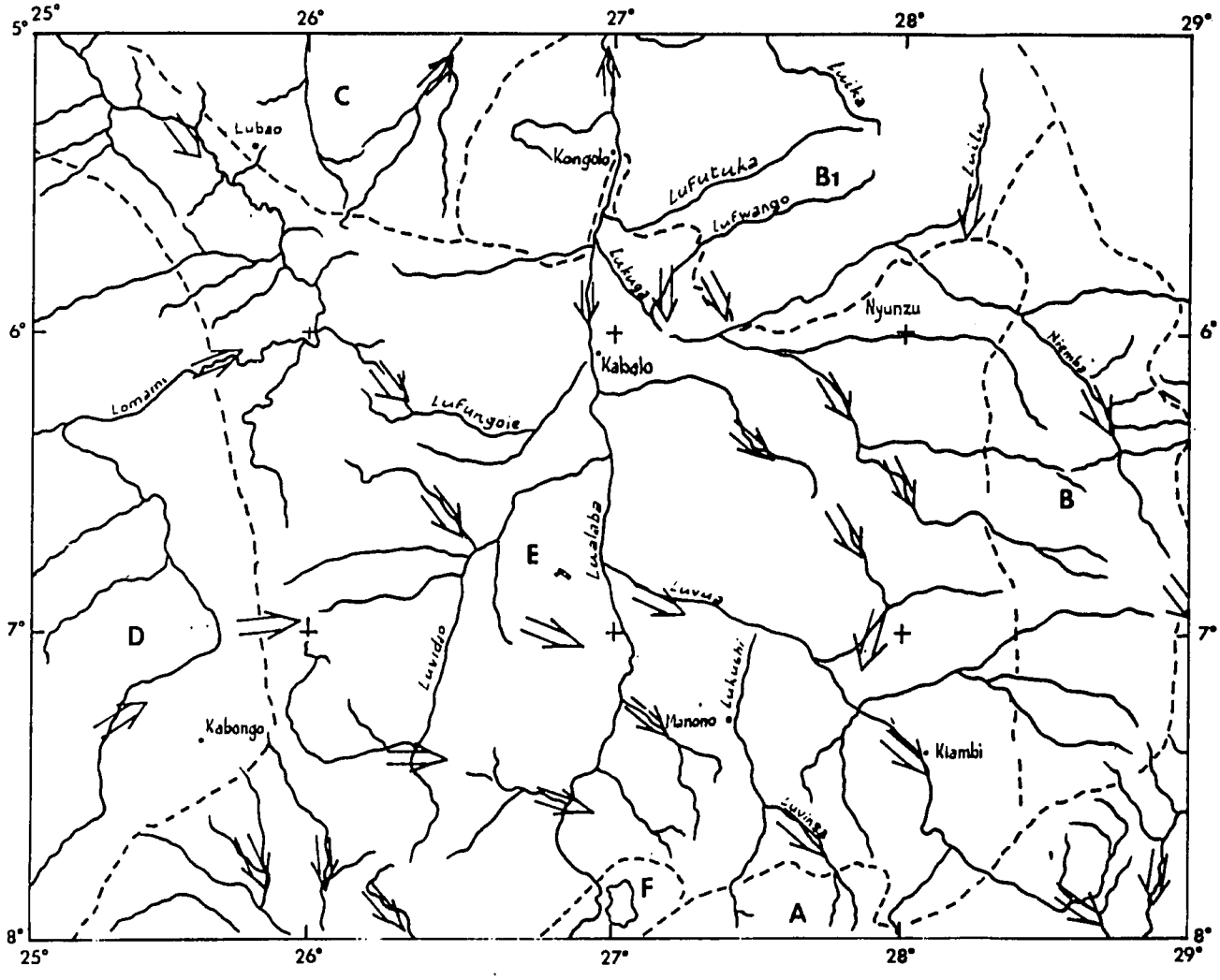


gites mineraux du

EUR LUMBU

PLANCHE 13

SCHEMA GEOMORPHOLOGIQUE



Légende

- Province élevée du Rift
- B Province des hauteurs Kibaro / Ruzizien
- C. Province des hauteurs Parmocarbonifère
- D. Province des hauteurs Bushimaiennes / Mesozoiques
- E. Le plateau de Lubao (Santery) / Manono ou ancienne vallée de la Lomami / Luvinza
- F. Province du Graben de l'Upemba
- ⟹ Cours des fleuves (supposés) à la fin du mesoique

Echelle: 0 1 2 3 km