GEOLOGICAL AND GEOCHEMICAL INVESTIGATIONS *OF* THE GOLD OCCURRENCES NORTH OF ISANLU (SHEET 225 NE AND NW), KWARA STATE

BY

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A Thesis submitted to the Post-Graduate School, Ahmadu Bello University, Zaria, in partial fulfillment of the requirements for the degree of Master of Science (Mineral Exploration)

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July, 1985

D E C L A R A T I O N

I declare that this thesis is my own work and has not been submitted in any other form for another degree and information derived from the published and unpublished work of others has been acknowledged in the text.

Signature of Candidate (Date)

C E R T I F I C A T I O N

This thesis entitled GEOLOGICAL AND GEOCHEMICAL INVESTIGATION OF THE GOLD OCCURRENCES NORTH OF ISANLU (SHEET 225 NE AND NW), KWARA STATE by IBRAHIM GARBA meets the regulations governing the awards of the degree of M.Sc.(Mineral Exploration) of Ahmadu Bello University and is approved for its contribution to Scientific knowledge and literary presentation.

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D E D I C A T I O N

This work is dedicated to those who labour their lives in search of minerals for the betterment of mankind.



QOUTATIONS

1. Nature makes it clear that the production of gold is labourious, the guarding of it difficult, the zest for it very great, and its use balanced between pleasure and pain.

- Diodorus Siculus, 1st Century B.C.

2. Clearly the technology of gold - its mining, metallurgy, and sales is well established. The limits to mining are pushed forward, the processes of extraction are well understood. The problem remains in exploration and so we seek a knowledge of the geological and geochemical processes which are foundamental to the search.

- K.A. Viewing, 1982.

A C K N O W L E D G E M E N T

My greatest indebtness is to the Nigerian Mining Corporation for sponsoring the programme both in the fieldwork and at Ahmadu Bello University.

I sincerely appreciate the tremendous inspiration, ideas and supervision recieved from Mr. Micheal Woakes of the Department of Geology, Ahmadu Bello University.

I must thank the Exploration staff of the N.M.C., especially Dr. S.O. Ford, Dr. O.M. Ojo and also the geologists and assistants who contributed in the fieldwork. It wouldn't have been a success without their contributions.

The N.M.C's Laboratory Manager, Mr. M. Hussain and all his staff are duly acknowledge for their contribution in the speedy analysis of the samples used in the work.

I thank Malam S.I. Doguwa of the Department of Mathematics and also the staff of the Computer Centre, all of Ahmadu Bello University for their various assistance in the computer analysis of the data used in the work.

Finally, I thank Dr. E. Ike and other staff of the Department of Geology, Ahmadu Bello University; and also the many others who contributed in one way or another to the success of the work.

A B S T R A C T

The gold occurrences north of Isanlu (Kwara State) were investigated using combined geological and geochemical prospecting methods. The general geology, stream sediments and gold in heavy mineral concentrates were surveyed.

The area studied is part of the schist belts of the S.W Nigerian Basement Complex and the geology is favourable for gold being similar to the Ilesha schist belt. Gold mineralization occurs in primary quartz veins, disseminated in amphibolites and also in secondary eluvial and alluvial deposits.

Data obtained from the stream sediment survey were subjected to statistical interpretation and it was found that the lognormal distribution pattern appears to be the one most applicable to the data . The heavy mineral survey was used to field-check for gold occurrences as the investigations progressed, and it also prove its worth in confirming anomalies detected by the stream sediment survey. The significant correlation that exists between Pb/Cu and Pb/Zn was taken to probably distinguish vain mineralization from disseminated mineralization in amphibolites. Whether or not they are indicators for gold remain uncertain.

The investigations succeeded in delineating known gold occurrences and has indicated some prospective gold targets. Gome of the known occurrences have been assessed partially and are recommended for further detailed work. The methods of investigations used were useful but the heavy mineral survey is a better exploration tool at this stago.

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CHAPTER 1

INTRODUCTION

1.1. Objectives of the Work

The Nigerian Mining Corporation has initiated a mineral exploration programme in the former Ilorin and Kabba Provinces of Kwara State. This programme (named Kwara Gold Project) covers a total area of about 46300 square kilometers which lies between latitude 7° 16'N to 11° 8'N and longitude 3°24'E to 6° 45'E. The area is covered by N.M.C.'s ASEPL Number 258 and an unnumbered one, all of 1978. This thesis covers part of the above programme.

The primary objective of the programme was to locate gold deposits that can be exploited with minimum capital expenditure and in the shortest possible time. It was therefore planned that a systematic search for gold placers and primary gold deposits would be carried out. This would include, for the placers, the study of geomorphological features associated with placer accummulation, heavy minerals in the drainage and surficial products. For the primary deposits, it would include the study of the geology, stream sediments and vein materials.

The fieldwork lasted from January, 1983 to July, 1983 with some later visits to complete the study.

1.2. Location and Accessibility

The geological, geochemical and heavy mineral investigations which form the basis of this thesis was concentrated in the northern part of Isanlu (Sheets 225 NE and NW, 1.50,000). The area covers about 1140 square kilometers, situated between latitude $8^{\circ}15'N$ to 8° 30'N and longitude 5° 38'E to 6° 00'E and is in the former Kabba Province (now Oyi L.G.A) in Kwara State Figure 1).

The southern part of the study area is accessible by a few all season roads which link some villages. The northern part of the study where most of the work was carried out is an extensive forest reserve with no human habitation and no motorable roads. There are, however, a few tracks used mostly by hunters. The inaccessibility has limited the extent of the work and coverage is not complete.

1.3. Climate and Vegetation

Rainfall in Egbe, the nearest weather station, has a mean of 1845mm, characterized by double peaks in July and September and concentrated mainly between May and October (Jeje et al, 1982).

The entire area lies within the Woodland Savanna belt and is characterized by a seasonally luxuriant growth of vegetation.

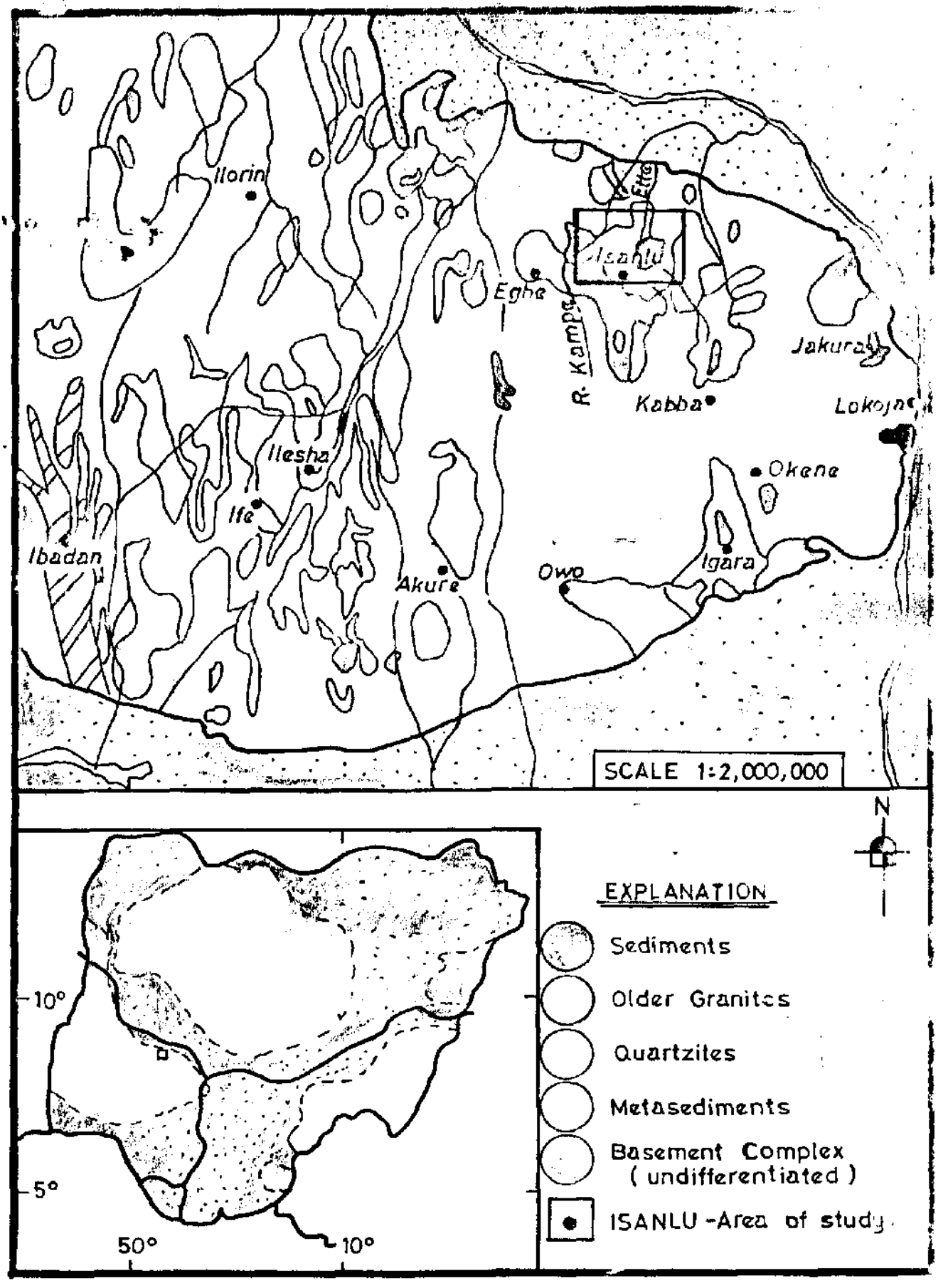


FIG. 1. LOCATION OF THE STUDY AREA WITHIN THE SOUTH-WESTERN NIGERIA BASEMENT COMPLEX (AFTER G.S.N. 1974).

1.4. Geomorphology

The study area is drained by River Kampe (Oyi) and its tributaries. Generally, the relief of the area is moderate with gentle rolling terrain and flat plains. Occassional occurrences of hill massifs and round topped hills are encountered. The valleys of River Kampe and its major tributaries are broad and often contain alluvial terraces. The valley-side slopes between the tributaries are long and gently inclined at 2° to 7°, and have mostly convex - rectilinear - concave profiles (Jeje et al, 1982). The general geomorphic pattern of the area can be shown in the section in Figure 2.

1.5. Previous Work

There had not been much geological work done in the study area though many workers were interested in the southern part of Sheet 225 because of the mineralization of Cassiterite - tantalite - columbite in pegmatites. The few workers that previously studied various aspects of the area include:

(i) Jaques (1944 - 45); from his reconnaissance survey he gave a specific account of the country situated between latitude 8° 00'N to 9° 40'N and longitude 5° 20'E to 6° 20'E. He recorded the mineralization within the pegmatites, of cassiterite and columbite/tantalite, as well as gold in quartz veins in the area. In his description of gold workings on quartz veins in the area, he noted among other things that "there are no records of

any reliable sampling or assay undertaken in connection with any of the workings, so that the relation between values and vein widths or country rocks cannot be assessed".

(ii) Macleod (1963) wrote a memorandum on the talc deposit north of Isanlu Makutu.

(iii) Arogundade (1973) reported on the geology of the Isanlu Area, Sheet 225, 1:100,000.

(iv) Bafor (1981) worked on the occurrences of Sulphide mineralization in the Egbe Area of Southwestern Nigeria, the coverage of which extended to parts of the area of the present study.

1.6. Methodology of the Present Work

A combined geological and geochemical investigation was planned and carried out. This included geological mapping, geochemical sampling of stream sediments and collecting heavy mineral concentrates all on a scale of 1: 50,000 and sampling interval varies from 1/4km to 2km. Traverses were usually taken along streams and rivers; and a total of about 1,700 line-kilometers were covered by vehicle and on foot. This coverage was achieved within about 150 geologist man-days.

Detailed investigation of some primary and secondary prospects has been carried out by detailed mapping and sampling of mineralized veins and pitting and sampling of gold eluvium and alluvial placers.

Air photographs were examined but were available for only part of the study area and were not found to be very

useful tools for the work. However, SLAR and LANDSAT Imageries of the region were examined and revealed some structural features of importance. Aeromagnetic map of the area was not available for examination.

The overall extent of the field investigations was limited by the coming of the rainy season.

CHAPTER 2

GEOLOGY

2.1. INTRODUCTION

The area of study falls within the Precambrian Basement Complex of SW Nigeria (Figure 1), which in the context of African geology is a part of the Pan-African mobile belt forming the eastern flank of the West African Craton (Woakes and Bafor, 1982).

Rahaman (1976) described the Precambrian of SW Nigeria and grouped the major rock units as follows:

(i) Migmatite-gneiss complex comprising biotite-hornblende gneisses, quartzites and quartz schists, small lenses of calc-silicate rocks, biotite - hornblende schists and amphibolites.

(ii) Slightly migmatised to unmigmatised para-schist and metaigmeous rocks which consist of pelitic schist, quartzites, amphibolites, talcose rocks, metaconglomerates, marbles, and calc-silicate rocks.

(iii) Charnokitic rocks.

(iv) Older Granites which comprise rocks varying in composition from granodiorite to true granite and potassic syenite.

(v) Unmetamorphosed dolerite dykes believed to the youngest.

Turner (1983) described the three main groups of Schist belts of SW Nigeria. The Western group (mainly the Iseyin) occurs near the western frontier of SW Nigeria and is not shown in Figure I. The central belt (Ife-Ilesha) with its early mafic to ultramafic igneous suite, marks the possible site of a former ocean basin. The eastern group of schist belts (Igara, Owo, Kabba, Jakura) contain shelf or miogeosynclinal deposits with no associated igneous rocks. The area of study is situated roughly in-between the central and eastern groups of schist belts but is closer to the eastern group.

The most easternly schist belt in the Southwestern Nigeria, as described by Turner (1983), is distributed around the Okene migmatitic nucleus. It trends NNW with a length of only 50km (the Igara) and is joined to the NW - trending Owo belt. Similar lithologies occur in schist belts in the Kabba, and Jakura areas. Porphyritic granites intrude the centre and margins of the belts.

The Ilesha schist belt, according to Turner (1983) lies east of the Ibadan Archaen to Lower Proterozoic massifs. It has a N-S length of over 200km. It consists of two structural units with contrasting lithologies, separated by the NNE - trending Ife fault zone. The western unit consists of amphibolites, amphibole schists and pelitic schists with much intimately associated trondhjemitic granite, gneiss and pegmatite. It shows a

moderately open style of folding with N-S axes. East of the fault, quartzite is dominant, occurring together with quartz schist, quartzo-feldspathic gneiss and minor iron-rich schists and quartzites. This is the Effon Psammite Formation and shows tight isoclinal folds.

The area of the present study has not been described by either Rahaman (1976) or Turner (1983) in their work on the Precambrian and schist belts of SW Nigeria respectively. The study area, as mentioned earlier, is situated closer to the easterly schist belts of SW Nigeria but does not resemble them in many respects - notably its E-W trend and its widespread volcanics and gold mineralization. The eastern belts are known to contain no widespread volcanic rocks and also lack gold mineralization. However, a possible correlation may exist between the study area and the Ife - Ilesha schist belt. This can be substantiated from the occurrences of widespread metavolcanics (amphibolites) and gold mineralization which are characteristics of the two areas. The study area may be a fragment of a former ocean basin or an extension of the one proposed for the Ilesha belt by Turner (1983).

The present mapping has considerably extended the area formerly known to be underlain by metasedimentary and metavolcanic rocks.

2.2. GEOLOGY

The main lithologic units mapped in the area of study include:

7. Surficial Deposits
6. Quartz Veins
5. Pegmatites
4. Older Granites
3. Metavolcanics (Amphibolites)
2. Metasediments
1. Migmatite-gneiss Complex

The geology of the area is shown in Figure 2.

2.2.1. Migmatite - gneiss Complex

The migmatite-gneiss complex predominates in the northern and north-eastern part of the area occupying about one-third of the total area of study, and is thought to be the oldest rock group in the area.

In hand specimen the gneisses are usually grey, foliated, biotite and/or hornblend quartzo - feldspathic rocks. Alternating mafic and quartzo feldspathic materials define banding in the migmatitic gneisses. In thin sections, quartz and feldspars jointly form the bulk of the mineral composition in the simple biotite gneiss which predominates (Plate I). In these gneisses, plagioclase and K-feldspar occur in about equal proportions. Mica, mainly biotite and some muscovite are aligned and indicate foliation in the rock fabric. In migmatitic-



Plate I.

Biotite gneiss. Quartz and feldspars form the bulk composition while foliation is defined by alignment of micas.

X polars.

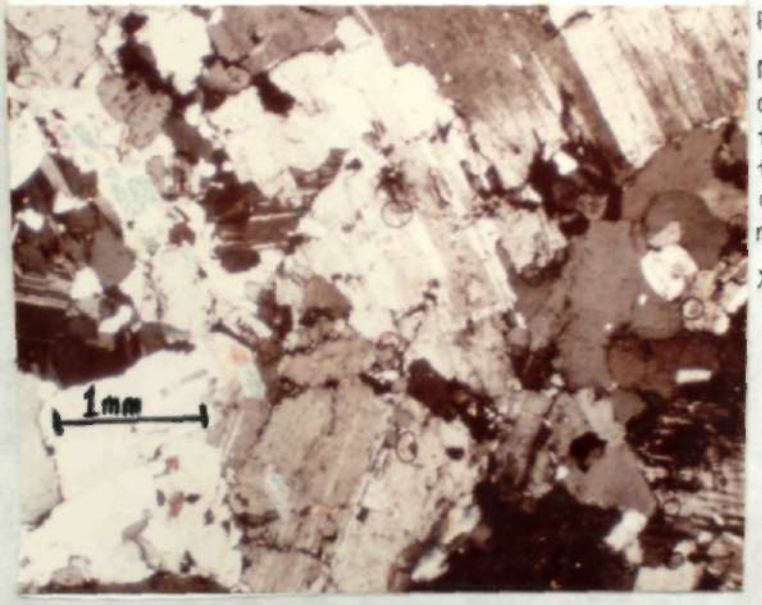


Plate II.

Migmatite gneiss. A fairly coarse band of quartz and feldspars bordering a finer-grained foliated band of quartz, feldspars and micas.

X polars.

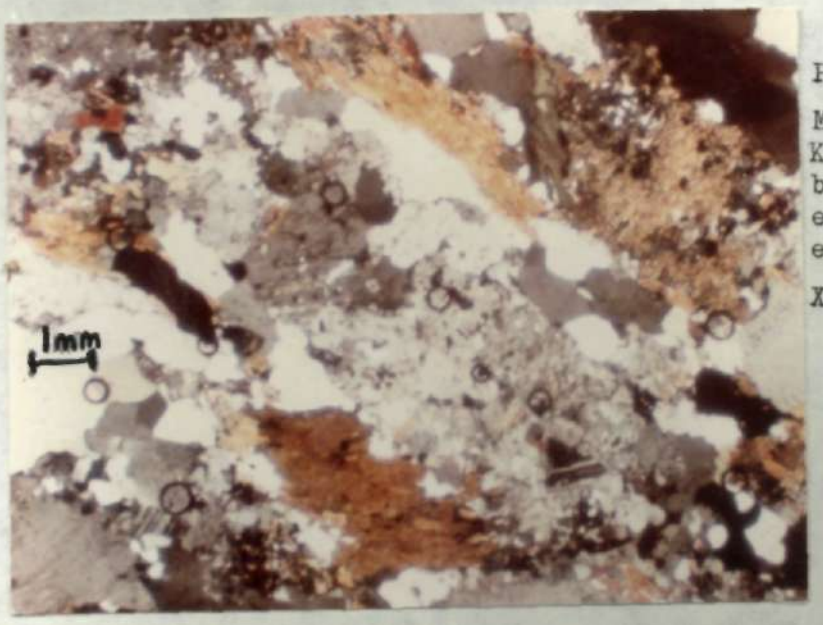


Plate III.

Migmatite. The absence of K-feldspar and abundance of biotite, hornblende and epidote representing an epidioritic composition.

X polars.

gneisses, (plate II) plagioclase is subordinate to K-feldspar. In migmatites, (plate III) K-feldspar is absent and hornblend , biotite and epidote are common, representing an epidioritic composition. Textures generally are coarse to medium grained in most of the gneisses. Accessory minerals include sphene, apatite, rutile zircon and opaque minerals.

Biotite gneiss is the commonest rock-type in the complex while the complexly folded migmatite occur only in a few localities. Aplo-pegmatitic gneiss occurs usually near contacts with granite masses. The occurrence of 'augen' gneiss has been noted along the Dogon-Daji sheared zone. The textural variations of the gneisses can often be observed in the same locality and it has not been possible to show them as separate units at the scale of the mapping.

2.2.2. Metasediments.

The metasediments are essentially schists and quartzites, and occupy the southern half of the study area and are part of a more extensive belt to the south and west. They are believed to unconformably overlie the gneisses and are intruded and bordered by granites and also invaded by swarms of volcanic rocks.

The metasediments are generally regarded as forming a supracrustal cover upon an ancient gneissic basement and subsequently folded prior to the emplacement of the

Older Granites (Russ, 1957; Ajibade,1976; Rahaman, 1976 and Turner, 1983).

The Schists. In hand specimen, the schists are fine to medium grained schistose rocks of argillaceous to arenaceous character. In thin section a typical schist contains up to 50 percent quartz and also about 50 percent mica with few feldspars which have been altered to muscovite and sericite. The mica minerals are biotite, muscovite and sometimes sericite (Plate IV). The mica minerals make up the bulk composition in micaceous schists. Garnets, sphene and opaque minerals are the common accessory minerals. In sheared schists (phyllonites) cataclastic texture is developed (Plate V) and consists of aggregates of quartz porphyroclasts which form porphyroblasts in a very fine grained matrix of ill-defined mineralogy. Tourmalinized schist (Plate VI) show alternating bands of quartz and tourmaline. The tourmaline may have been introduced and may be replacing the feldspars and micas in the schist. Opaque minerals are common and may be [illegible] alteration products.

The schistose units mapped consist of mica-schists and quartz-schists with argillaceous and arenaceous characters respectively.

The Quartzites. The quartzites form prominent ridges which outcrop in few locations and are closely associated with the schists and amphibolites.

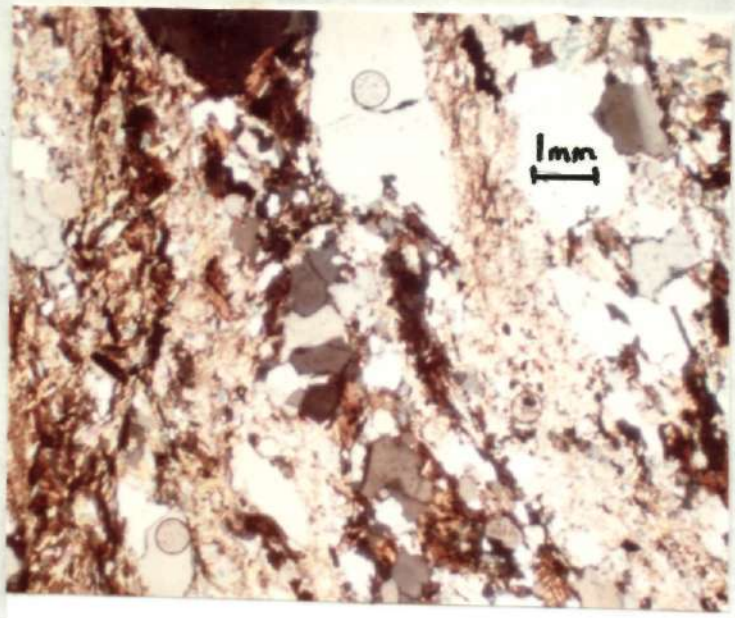


Plate IV.

Mica-schist.
The alignment and segregation of the mica minerals give the rock a well-defined schistosity.

X polars.

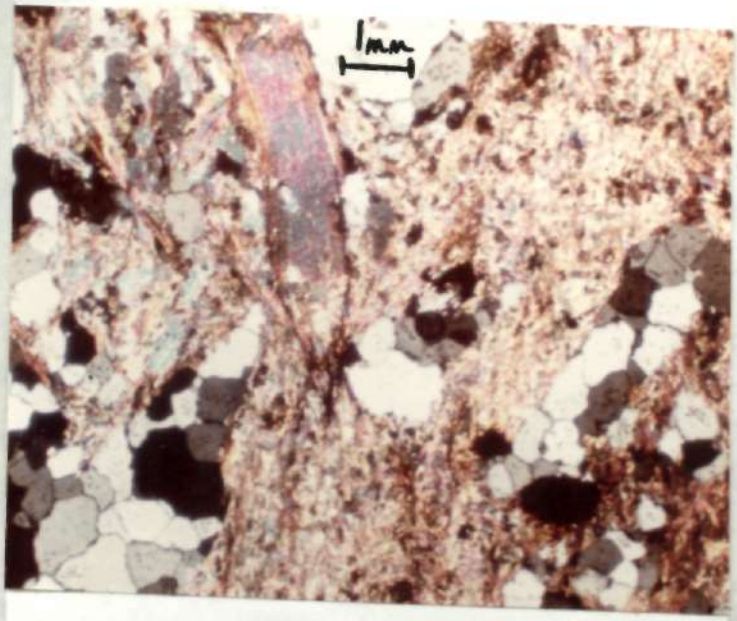


Plate V.

Cataclastic texture in sheared schist (phyllonite).

X polars.

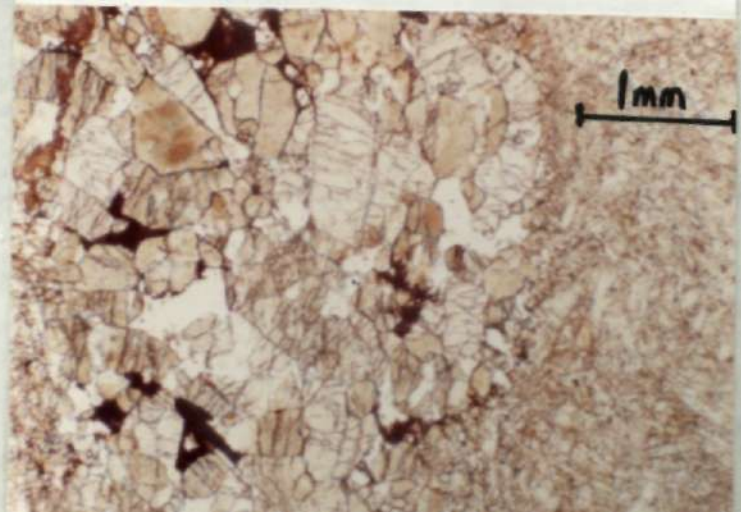


Plate VI.

Alternating bands of quartz, tourmaline in tourmalinized schist.

1 polar.

In hand specimen, they are quartzitic rocks which vary from massive granular types to foliated, usually fissile types which tend to weather along foliation planes. Some degree of ferruginization has been observed in some specimens.

In thin section (Plate VII), the quartzite consists of more than 90 percent quartz. Mica (mainly muscovite) and feldspars form about 10 percent of the bulk composition and their alignment defines foliation in the rock. Zircon (or xenotime) and opaque minerals are accessory minerals observed in the thin section.

These quartzites are probably products of recrystallization (of the quart-rich facies of the sediments) as indicated by the 120^{o} contacts between the quartz grains (Plate VII).

2.2.3. Metavolcanics (Amphibolites).

These rocks are widespread and extensive occurrences have been noted in the northern part of the study area. Collectively the amphibolites occupy about one quarter of the total study area. They often occur as minor bodies in the form of dykes, sills and plugs. These amphibolites bodies occur in both the schists and the gneisses. There may be two generations of amphibolite, though no mappable differences were noted. Their true attitude is difficult to ascertain because they are generally only seen as float or boulders. True outcrops are seldom seen, as such their mapped geological boundaries represent the approximate

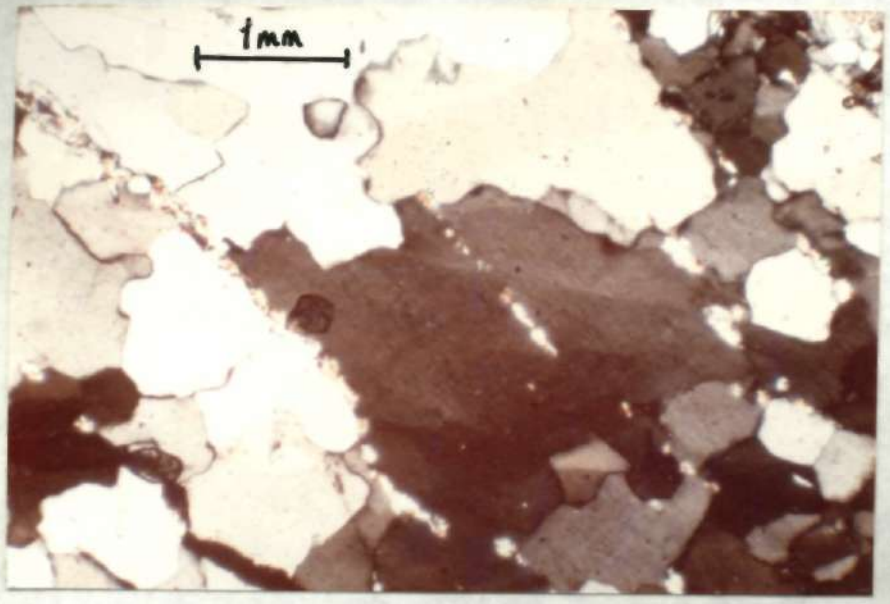


Plate VII.

Quartzite
Foliation is defined by allignment of Feldspars and micas.
X polars.

extent of the amphibolite boulder occurrences. Jaques (1945) described the amphibolites as probably representing altered basaltic rocks associated with the metasediments. They may be derived from possibly basaltic rocks (Bafor, 1981).

In hand specimen, they appear usually massive dark green to almost black amphibole'- bearing metamorphosed rocks of probably volcanic origin. The altered varieties appear greyish. The textures of amphibolites vary from fine to medium grained.

In thin section, a typical amphibolite (Plate VIII) consist of two amphiboles: hornblende and tremolite-actinolite which jointly form more than 50 percent of the bulk mineral composition. These usually occur as large grains and laths. Quartz and sodic plagioclase (An_{35} - An_{40}) feldspars form the remaining 40 percent of the mineral composition and are rather finer grained than the amphiboles. Accessory minerals include garnets, zoisite and opaques (some of which have been identified as pyrite).

The mineralogy is slightly different in altered amphibolities. In the talcose varieties, the bulk mineral composition is made up of fibrous aggregates of tremolite-actinolite and talc which form more than 90 percent (Plate IX). The remaining percentage is made up of smaller grains of quartz and plagioclase. Some of the tremolite-actinolite is altered to talc and an isotropic

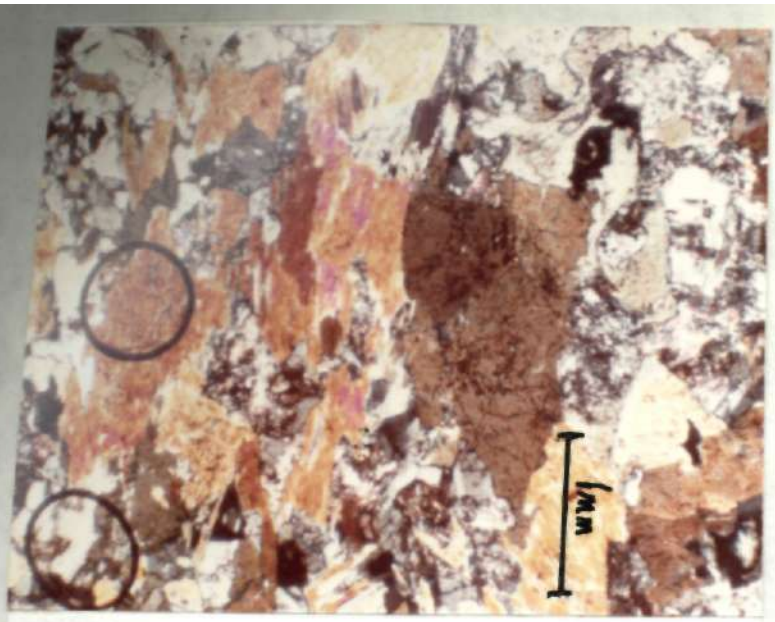


Plate VIII.

Typical amphibolite. Two amphiboles (hornblende and actinolite - tremolite), quartz and plagioclase feldspar are the characteristic minerals.

X polars.

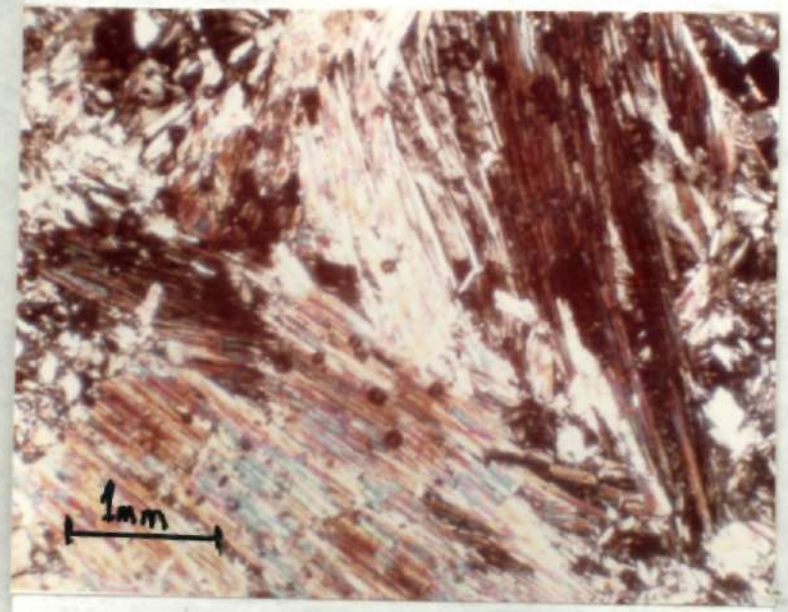


Plate IX.

Talc - amphibolite.
Fibrous aggregates of talc and tremolite - actinolite are common. The isotropic mineral may be serpentine.

X polars.

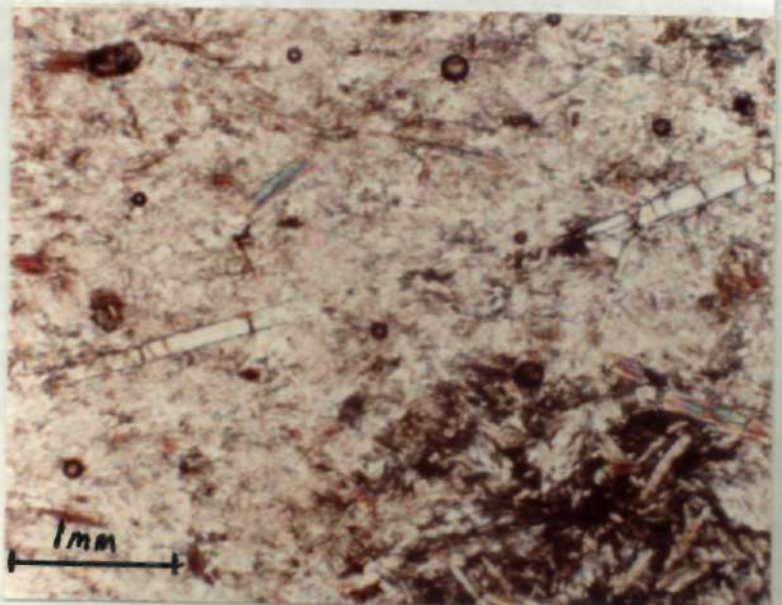


Plate X.

Steatite (soapstone).
Consists predominantly of fibrous aggregates of talc

X polars.

mineral suspected to be serpentine (PlateIX). In extreme cases of alteration the rock appears monomineralic with predominantly fibrous aggregates of talc (Plate X). In the silicified amphibolite (Plate XI), there is evidence of enrichment of quartz and garnet, also a rarity of the amphiboles which are mainly tremolite-actinolite. In some cases the garnets enclose quartz grains.

The most common of the amphibolites is the massive dark green type which often contains disseminated sulphide minerals (mainly pyrite). In altered zones especially near quartz veins and other mineralized bodies, talcose amphibolites are most common - probably represent products of extreme hydrothermal alteration (Mac Leod, 1963). The silicified, garnet rich amphibolites with pyrite are more associated with sheared zones and are probably products of extreme silicification along such zones. 'Granitization' and pegmatization of the amphibolites have been observed near contacts with granitic bodies.

2.2.4. Older Granites

These are Pan African granites and form part of the Basement Complex. They usually form conspicous hill massifs and have intruded the gneiss complex, the schist formation and the amphibolites. Pegmatitic bodies are characteristic of their contact zones. The granites are of two types and may differ in age; these are the porphyritic granites and the medium-grained granites.

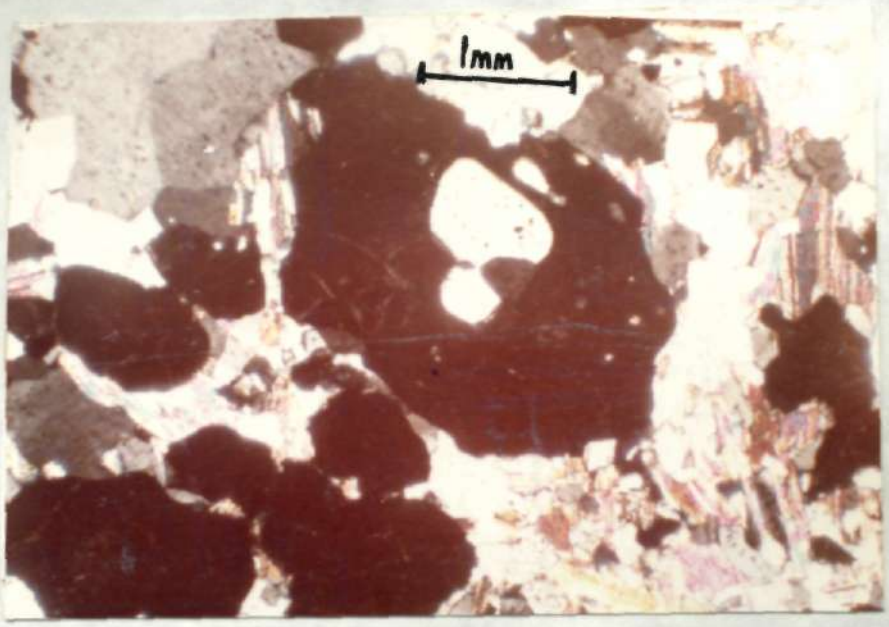


Plate XI

Silicified amphibolite.
Note the rarity of the amphiboles, and the abundance of quartz and garnets.
X polars.

The Porphyritic Granites.

These occur extensively to the extreme southwestern part of the study area around Irunda village (Figure 2).

Alignment of feldspar phenocryst and dark minerals is observed in outcrops, all in a N-S trend. Also observed are minor bodies of migmatitic material which may represent xenoliths. In thin section, the granite consists of large phenocrysts of Plagioclase (An_{20} - An_{40}) which is often zoned (Plate XII). K-feldspar occur less commonly and quartz is common and forms about 30 percent of the bulk composition. Biotite, sericite, chlorite and iron oxides constitute the dark minerals which occur in the matrix. Accessory minerals include sphene, apatite, zircon and clinozoisite.

The Medium-grained Granites.

These granites occur in the northwestern part and to the southern parts of the study area. The granites are uniformly medium-grained and have pegmatitic contact zones.

In thin section (Plate XIII), quartz forms about 30 percent, the feldspars forms about 60 percent and the mica constituting about 10 percent of the bulk composition. Generally, K-feldspars is subordinate to plagioclase the mica is mainly muscovite and some biotite. The crushed or shattered zones observed are evidence of cataclastic effect. Furthermore, some quartz grains show wavy extinction indicating stress effect.

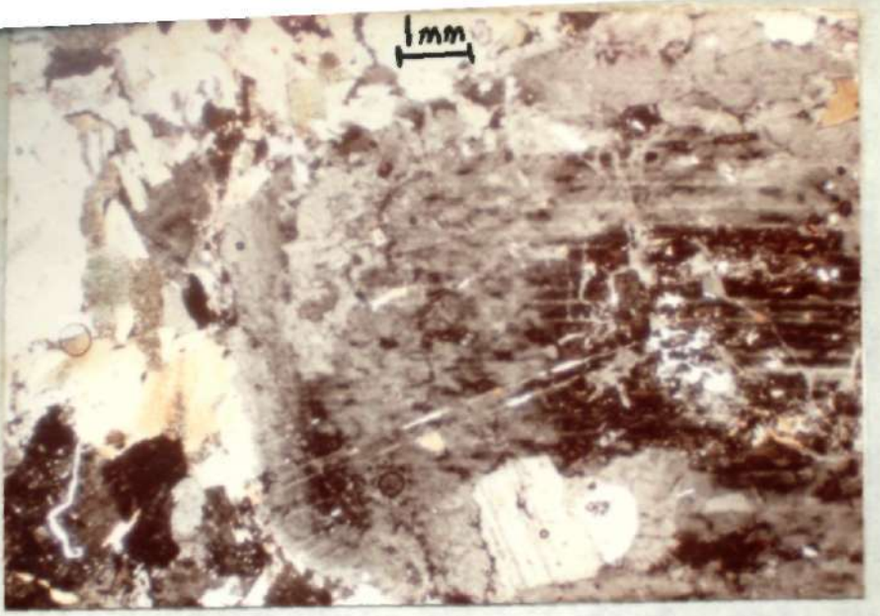


Plate XII.

Porphyritic granite.
Large plagioclase phenocrysts in a matrix of quartz, feldspars and dark minerals.
X polars.

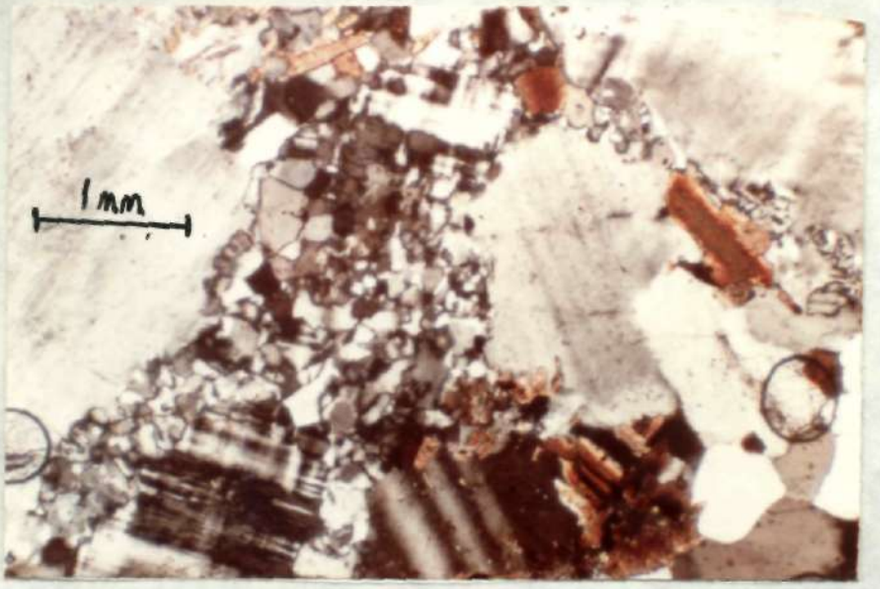


Plate XIII

Medium-grained granite with cataclastic textures.
X polars.

2.2.5. Pegmatites

Pegmatite bodies have been observed in gneisses, schists, amphibolites and granites, most commonly within contact zones of granites. They occur usually as veins, dykes and lenses. Generally the pegmatites are widespread in the southern part of the study area and decrease considerably northwards. The southern pegmatites may be part of the pegmatite belt of Central Nigeria (Matheis and Caen-Vachette, 1983).

In thin section, large crystals of quartz, feldspars and micas occur in about equal proportions. K-feldspar perthites are very common (Plate XIV) and plagioclase composition (Ab_{60} - Ab_{75}) indicates strong albitization. The micas are biotite and muscovite with more muscovite than biotite. Disseminations of tourmaline, cassiterite/columbite and sulphide minerals are observed in a few locations within the study area.

2.2.6. Quartz Veins.

Many quartz veins have been encountered during the work but only eight of these form mappable units and were mapped and sampled. The most significant and important are the Okolom Reef and the Dogon-Daji - Kachakacha group of veins, from which gold was won in the past.

The Okolom Reef. (See Figures 2 and 3) is an auriferrous quartz vein which outcrops continously for about 800m and thereafter occurs intermittently for about 3km along the

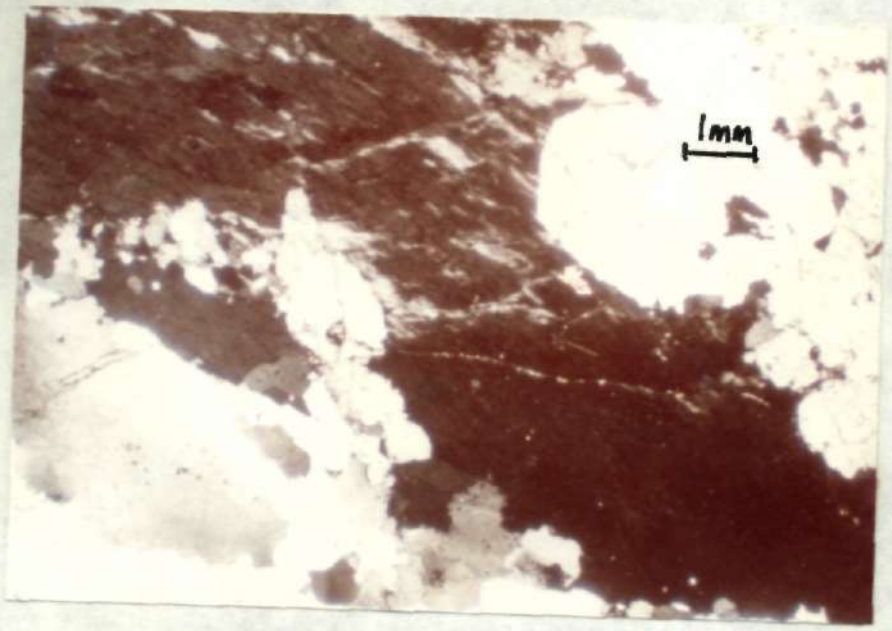


Plate XIV.

Pegmatite texture. Large quartz grains and K-Feldspar perthites are common.
X polars.

strike. The average width of the vein is about 2m. It strikes at about N10°E (NNE) and dipping steeply at 80° east or west; but it has been found to be disjointed at the southern end and strikes N50°E (NE). The wallrocks are gneiss, amphibolite and mylonite (See Figure 3).

The vein quartz is found to be shattered in many places along the strike length and such shattered zones often contain films and dissemination of pyrite, chalcopyrite, arsenopyrite, galena and iron oxides, mainly along fracture surfaces. Gold specks are seldom seen The only type of wallrock alteration observed is silicification and such silicified wallrocks are exposed only in few locations due to past mining activities which were concentrated in the weathered wallrocks of the vein (Plate XVII). See also Figure 3.

The Okolom Reef cut across the very complex contacts between gneiss and amphibolite. The complex contacts indicate a possible complex folding of the amphibolite and the gneiss and no relation with vein structure can be observed. This suggests that the Okolom vein mineralization post dated the complex folding of the two rock units.

Dogon-Daji - Kachakacha group of Veins (See Fig. 4). This group consists of a series of quartz veins which occur in a prominent shear zone consisting of silicified schists, amphibolites, biotite gneisses and mylonites. The zone persists for about $6\frac{1}{2}$ km in a N-S direction. Some of these veins are auriferous and gold was won from them in the past.

The most prominent of these veins is the Dogon-Daji vein which strikes N-S and outcrops intermittently for about 1km, dipping steeply at 70 - 80°E. The width varies between 1 to 2m. Mylonites, gneisses and amphibolites are the associated wallrocks.

To the west of the Dogon-Daji vein, a group of quartz veins, lenses and stringers run subparallel to the Dogon-Daji vein and are mainly in mylonites and silicified amphibolites (Figure 4). These are the Kachakacha veins from most of which gold was won in the past.

2.2.7. Surficial Deposits.

Surficial processes of weathering, erosion and deposition, have affected the study area and resulted in the formation of products which include laterites, eluvial and alluvial placer deposits.

Widespread lateritic development has been observed. Two lateritic formations have been identified at different topographic levels which may represent erosional surfaces marking erosional cycles. There is, thus, older and younger

lateritic formations. The older lateritic formation characterizes the upper most part of the 'ancient' pebbly alluvium deposited along major stream and river valleys (Figure 22). This laterite is possibly a transported (Secondary) type. The younger lateritic formation is developed on the present erosional levels over amphibolites, schists, some gneisses and over 'recent' loamy alluvial occurrences. Arogundade (1973), however, identified three cycles of erosion characterized by distinct lateritic formations in the Isanlu Area.

The eluvial placers are mainly found in the viginities of mineralized quartz veins and silicified zones. The alluvial placers are confined to valleys of major streams and rivers and usually occur as alluvial terraces. These placer deposits are discussed in more detial in Chapter 5.

2.3. STRUCTURE

2.3.1. Introduction.

In Nigeria the schist belts are confined to a NNE - trending zone about 300km wide in the western part of the country (Turner, 1983). Over most of the southwestern region the regional strike of foliation within the schist belts is roughly constant in a N-S direction with variations between NW - SE and NE - SW directions (Rahaman, 1976). However, the trend of the schist belt in the study area is found to be E - W and has greatly deviated from the

common NNE, and N-S trends of most schist belts in the Southwestern Nigeria; but the directions of foliation in the schists is similar to those of other belts, approximately N-S.

SLAR and LANDSAT Imagery interpretations (Figure 5) reveal a persistent NE - SW structural trend over the region. A lesser E-W trend has also been observed. These trends may be associated with rock fabric structures and linearments formed by topographic and structural features.

2.3.2. Foliation.

In gneisses, the predominant foliation trend observed is NE - SW with average dip of 45°E. In some cases the trend diverges up to NW - SE. In the schists, schistosity is well developed and trends predominantly N-S and vertical. In quartzites, foliation is NE - SW trending.

2.3.3. Folds.

Major folds have not been delimited in the study area because of poor exposure and lack of marker units. In gneisses, disharmonic folding is common which may indicate complex folding pattern or local folding in fiarly high grade metamorphism (Plate XVI). The axes of such folds trend NNE - SSW and conform with the regional trend. The prominent N-S schistosity in schists may indicate axial planes of tight folds. The outcrop pattern of the amphibolites may indicate complex folding.

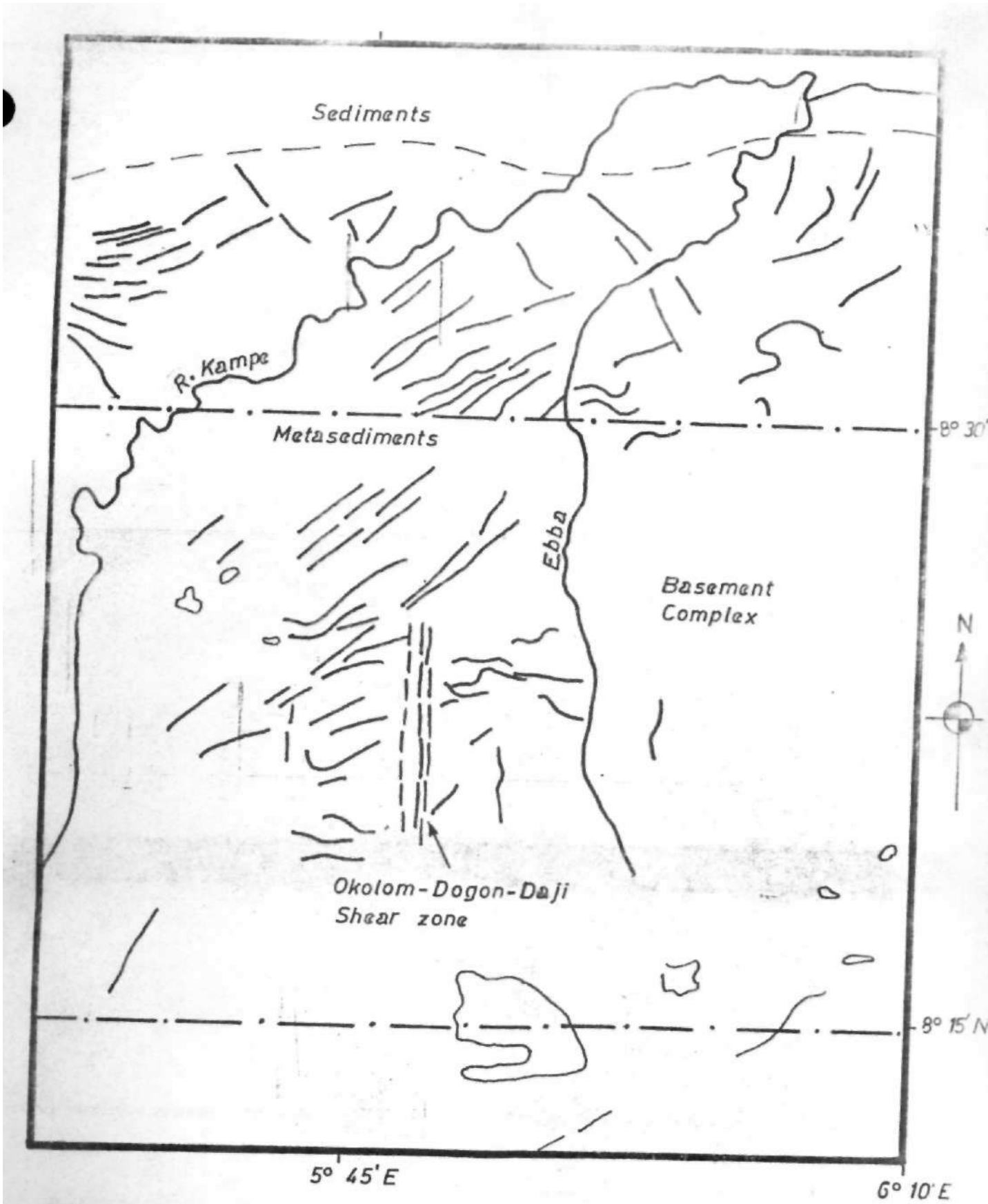


FIG. 5. SLAR IMAGERY INTERPRETATION OF REGIONAL STRUCTURES IN THE STUDY AREA.

—•—•— OUTLINE OF AREA MAPPED.

SCALE 1:250, 000

Plate XV

Disharmonic folds in migmatite - gneiss complex.



2.3.4. Fractures.

Field mapping reveals the existence of fractures, some infilled by quartz. Gaping joints are common and have an irregular trend. No major fault displacement has been observed from the fieldwork; however, SLAR imagery shows a major linearment in a N-S direction coinciding with the zone of Okolom Reef (Figure 5).

2.3.5. Shear Zones and Mylonites.

Rock types indicating shearing have been noted in many parts of the study area especially around the Dogon-Daji - Kachakacha sector. Most of the major rock units have been sheared to varying degrees. Intense shearing has been accompanied by silicification and/or Mylonitization depending on the affected rock units. The shearing affected the area in a N-S direction.

Silicification is widespread in the shear zones. In gneisses and schists within the zone, silicification culminates in the development of the numerous quartz veins, lenses and stringers (Figure 4). Silicified amphibolites may be the products of response to shearing by the rocks. These rocks show massive replacement of most of the bulk minerals by quartz and resulted in the formation of hard resistant rocks (Plate XI). Many of the silicified amphibolites occur within known shear zones, but are not always restricted to such known zones.

Mylonites are possibly derived from the gneisses and schists, and are classified as phyllonites according to Higgins (1971) and Sibson(1977). These phyllonites are highly schistose, finegrained and resemble phyllites and mica-schists (Ajibade, 1982). They form bodies a few hundred metres across with a persistent N-S schistosity and usually contain quartz lenses and stringer which are often auriferous (Plate XVI). In thin section (Plate V) the mylonites consist of aggregates of quartz which form porphyroblasts in a very fine grained matrix of ill-defined mineralogy. Mica minerals which are aligned give the rock a definite schistosity.

2.4. METAMORPHISM.

Rahaman (1976) reported that the metamorphic grade in the Southwestern Nigeria Basement Complex ranges from greenschist to amphibolite facies.

In the area of study two types of metamorphism have been recognized. The first and the major type is regional metamorphism which prevailed in the whole region. The second type is dislocation metamorphism and is often restricted to particular zones. This has brought about cataclasis and the development of mylonites in the zones of dislocation (or shearing).

The minerals - talc, tremolite - actinolite, hornblende, biotite, muscovite, sericite, quartz and garnet are characteristically common in the area of



Plate XVI.

Weathered mylonite (phyllonite) with quartz stringers at Kachakacha. Gold was won from the weathered rock in the past.

study. This assemblage is diagnostic of upper greenschist to lower amphibolite facies of metamorphism.

The schists may be of higher grade because of the relatively high amount of garnets contained in them. Amphibolites, quartzites and gneisses are typical of the amphibolite facies (Milovsky, 1982). The migmatite-gneiss complex is of higher grade of metamorphism than the metasediments and amphibolites.

2.5. GEOLOGIC EVOLUTION.

The pre - Pan - African rocks of Nigeria are largely gneisses and migmatites. These form a basement to schist belts which, although of Upper Proterozoic age, have been compared with the greestone belts in Archaean gneissic and granitic terrains (Wright and McCurry, 1970). The Pan-African tectonics imposed the generally N-S structural trend on the region; its magmatism led to widespread emplacement of granites and chancckites; and its thermal activity set mineral ages in the 500 - 600 Ma range in almost all rocks of the area (Turner, 1983). "The Kibaran in West Africa is generally over printed by Pan-African structures and magmatism. There is thus a coincidence of schist belts of Kibaran and Pan African age in the same zone" according to Turner, (1983), which makes it difficult to distinguish between them if both occur.

Southwestern Nigeria, in common with the rest of the Precambrian rocks in Nigeria lies within the zone of Pan - African reactivation 600 ± 150 Ma. The gneisses are probably Eburnean (1950 ± 250 Ma) or older Rahaman , 1976).

Field relationships and petrochemical data suggest that the Ilesha metasediments represent Proterozoic supracrustal sequences that are derived from granitoids and are deposited in an environment that is comparable to an eugeosynclinal domain (Elueze, 1981). The quartzites appear to represent metamorphosed sandstones (Jaques, 1945) in the Egbe area. Deswardt (1953) and Oyawoye (1964, 1972) believed the quartzites of Southwestern Nigeria to be prominent members of the Newer metasediments and are younger than the gneisses. Dempster (1967) showed the quartzites as belonging to two ages, the older ones are interbanded with the gneisses and the younger belong to the Psammite formations. The quartzites of the study area belong to the later group.

The amphibolites in Egbe area have been described by Bafor (1979) as tholeiites typical of an oceanic environment but because of the interlayered sediments he suggests a Red-Sea- type fault-bound marginal basin. The amphibolites in the Ilesha area have been shown by Elueze (1982) to be largely metatholeiites because of their strong petro-chemical and petrogenetic affinity with tholeiites.

The amphibolites in the study area are similar to the ones described by Bafor (1979).

Most of the pegmatites in the Egbe area and their corresponding Older Granites are Pan-African emplaced between 562 to 545 Ma (Mathies and Caen-Vachette, 1983).

The quartz veins in the study area are thought to represent products of extreme silicification along zones of dislocation. Pergeter, (1958) holds a similar view on the quartz veins in weathered schists around Diko in Abuja area of Central Nigeria.

The study area forms one of the schist belts of Southwestern Nigeria Basement Complex but differ in many respects from other neighbouring schists belts. It has an E-W morphological trend and cannot be correlated with the nearest belts (such as the Kabba belt) but rather shows similarities with the more distant Ilesha belt. The geological composition of the area consists of an eugeosynclinal sequence on an ancient gneissic complex with associated granitic bodies, similar to the Ilesha belt (Elueze, 1981).

The mylonites are brought about by dislocation metamorphism (Higgins, 1971; Ajibade, 1982) of both the gneissic basement and the metavolcano - sedimentary rocks. The Pan-African tectnoics brought about the folding together of both the gneissic basement and metasediments with the imposition of the N-S structural trend on the area.

This has probably masked the pre-Pan-African trends. The Pan-African magmatism led to the emplacement of the associated granites.

The amphibolites could be products of ocean basin opening in an eugeosynclinal domain similar to the models proposed for the Ilesha belt (Elueze, 1982). Whether or not the amphibolites in the gneisses and in the schist are of the same age has not been ascertained. However, a possibility may exist that the amphibolites in the gneisses would be the same generations as those in the schists, and were intrusive feeders to the now eroded supracrustal cover sequence.

The pegmatites and quartz veins in the area can seemingly be only related to Pan-African tectonics and magmatism, though Mathies and Caen-Vachette (1983) suggest that some mineralized pegmatites are much younger.

Generally, the study area may be considered to represent a marginal belt of a large NE-trending eugeosynclinal basin (Figure 1) beginning from the Ilesha area to the cretaceous Niger Basin, and probably extending up to the Zungeru area. Olade and Elueze (1979), in considering the evolution of Pan-African domain of SW Nigeria, concluded that the schist belts evolved as ensialic mobile belts based on their petrochemistry. Recently, contrary opinion have been expressed that the metavolcano-sedimentary sequence in the Ife - Ilesha area exhibit a

characteristic stratigraphic evolution, typical for the Archaean granite-greenstone terrains with the regional occurrence within a mobile belt and metamorphism has masked its real geological setting (Klemm et al, 1984).

CHAPTER 3

MINERALIZATION

The Isanlu area was extensively explored for gold and tin/tantalite in the period 1930s - 1950s. In the northern part covered by the present work, gold was extensively worked from primary quartz veins and secondary alluvial and eluvial deposits . Searching old records and reports, combined with field work has found most of these primary and secondary mineralization which are described in this Chapter.

3.1. VEIN-TYPE GOLD-SULPHIDE MINERALIZATION

Vein-type mineralization comprising quartz, gold and sulphides occur in the form of quartz veins, lenses, stringers and other silicified bodies; and are usually related to zones of dislocation brought about by fracturing and/or shearing. Some of these bodies are associated with the altered wallrocks of major veins. The sulphide minerals observed include pyrite chalcopyrite (arsenopyrite), galena and sphalerite which usually occur disseminated in the quartz bodies and as films along shattered portions of the quartz veins. Gold occurs in native form but is seldom seen. Oxides, often secondary, are seen occurring in massive forms along with the sulphides in some veins. A catalogue of the main quartz veins mapped is given in Table 3.1. showing

TABLE 3.1. CATALOGUE OF QUARTZ VEINS - MAPPED AND SAMPLED.

NO.	LOCATION	ATTITUDES		LENGTH (m)	WIDTH (m)	COUNTRY ROCKS	PAST MINING	ANALYTICAL RESULTS (IN PPM)						SAMPLE NO.
		STRIKE	DIP					Au	Ag	Cd	Cu	Pb	Zn	
0	1Km NNW of Okolom	010°	80-90° E/W	800-3,000	2	Amphibolite, mylonite and gneiss.	Gold workings mainly in weathered altered wall rocks.	See	Appendix	(i)				44 rock samples.
I	Dogon Daji 10Km NW of Okolom.	000°	80°E	~1,000	1	Amphibolite, gneiss and mylonite.	Gold workings in both vein quartz and altered wall rocks.	75.0	1.0	3.0	26	3	7	RIK 4026
								0.05	3.0	1.0	16	1	12	RIK 4119
II	3.5Km NW of Iye	040°	85iv	200	2	Quartz - mica schist.	Mining attempted and abandoned.	0.1	2.0	3.0	8	1	4	RIIK 4095
								0.05	3.0	3.0	13	1	19	RIIK 4096
								0.05	0.0	1.0	9	1	8	" 4097
								0.05	2.0	0.0	15	1	15	" 4098
								0.05	0.0	4.0	8	1	42	" 4099
								0.1	0.0	1.0	30	1	22	" 4100
								0.1	0.0	0.0	12	1	7	" 4101
III	6.5Km NW of Odogbe	020°	90°	400	0,5	Amphibolite, schist and mylonite	Gold workings in vein quartz and in mylonite.	0.1	2!	2	9	0	8	RIIIK 4046
IV.	2.5Km NE of Odogbe	030°	90°	250	4	Quartz - schist.	None.	0	3	1	4	0	9	RIVK 4045
V.	Kachakacha	000°	90°	500	0.5	Silicified amphibolite and mylonite.	Gold workings mainly in eluvium and quartz veins.	2.45	3	2	20	0	8	RVK 4030
VI.	2.5Km NW of Odogbe	030°	90°	200	2	Amphibolite.	None.	0.1	2	2	4	1	7	RVIK 4039
VII.	1Km NW of Ilefin.	000°	75°E	200	1	Quartz - schist	None.	0.05	3	4	9	1	20	RVIIK 4042

some information including analytical values of Au, Ag, Cd, Cu, Pb and Zn. The two most prominent of these veins are the Okolom Reef and the Dogon-Daji - Kachakacha group of veins whose main geologic features have been described in Chapter 2. See also Figures 3 and 4.

The quartz - gold - sulphide veins are hydrothermal in origin (Smirnov et al, 1983); with the fractures and dislocation zones acting as permeable conduits for the discharge of the hydrothermal fluids from which the quartz, gold and sulphides were precipitated

3.1.1. Sampling and Analysis.

The Okolom Reef has been mapped in detail at a scale of 1: 2,000 and sampling was done along grids at approximately 50m intervals (Figure 3). At the points of intersection of the grids with the main vein and other minor veins and lenses, each sample was collected by chipping the vein quartz across its width. A total of 44 samples each weighing about 2kg were collected from Okolom Reef. The other veins mapped at 1:25,000 and 1:50,000 are shown in Figure 2 and Table 3.1 and at least one sample was collected from each vein. All samples were sent to N.M.C's Laboratory in Jos.

In the laboratory the samples were first crushed to about 1 to 2 cm sizes. Further crushing and grinding, using pulverisers and grinders respectively, reduced the sizes to - 180 mesh sizes. These were packed in polythene

bags for chemical analysis. All samples were hot-extracted and analysed (using AAS) for Au, Ag, Cd, Cu, Pb and Zn, using the same procedure described for stream sediment samples in Chapter 4.

Analytical results are tabulated in Table 3.1 and also in Figure 4. Graphical representation of the values is shown in Figure 3 for Okolom Reef.

3.1.2. Metal Distribution Characteristics.

The discussion below holds only for Okolom Reef because it is only here that the 44 samples were collected. In the other veins, the samples collected were too few (in most cases only one) to warrant the interpretation done for Okolom below.

The data obtained from the analyses of the 44 samples from Okolom Reef (See appendix (i)) were studied and interpreted using simple statistical methods. The use of electronic computer has been useful in this respect and the SPSS version have been used as described in Chapter 4.

Some statistical parameters of importance for the six elelement (Au, Ag, Cd, Cu, Pb and Zn) studied are shown in Table 3.2. below.

Table 3.2. Some Statistical data for the six elements studied in Ckolom Reef, values in ppm.

	Au	Ag	Cd	Cu	Pb	Zn
Mean	3	1.5	2	44	16	16.6
Median	0.3	1.0	2	-	2	7
Mode	0.2	0	3	20	1	4
Standard Deviation	9	2	2	50.6	52	22.5
Minimum Value	0	0	0	5	0	2
Maximum Value	56.9	9	4	268	327	117

Histogram constructed for the arithmetic and logarithmic values of each of the six elements have been shown in Figure 6, showing their relative frequency distribution. The following observations can be made from the histograms about the distribution of the elements:

- Au shows, two populations, but both show neither normal nor lognormal distribution pattern.
- Ag and Cd show no defined pattern because of the discrete nature of their values (See appendix (i)), but Cd tends towards lognormal.
- Cu shows some indications of a normal pattern comprising overlapping population sets.
- Pb and Zn show conspicously skewed pattern of normal and lognormal distribution.

FIG. 6

Histograms of frequency distribution (in %) of arithmetic and logarithmic values of Au, Ag, Cd, Cu, Pb and Zn in Okolom Reef.

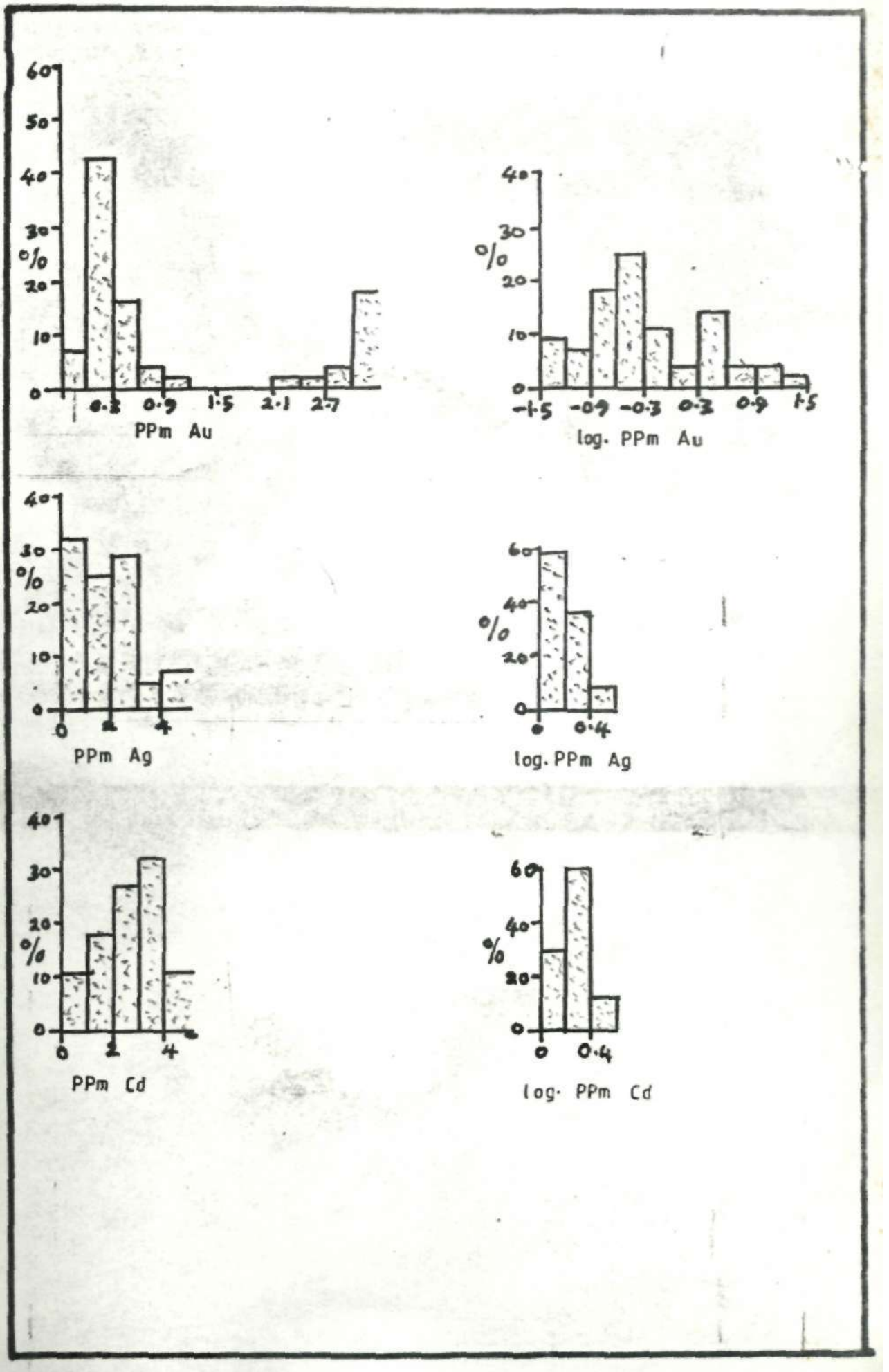
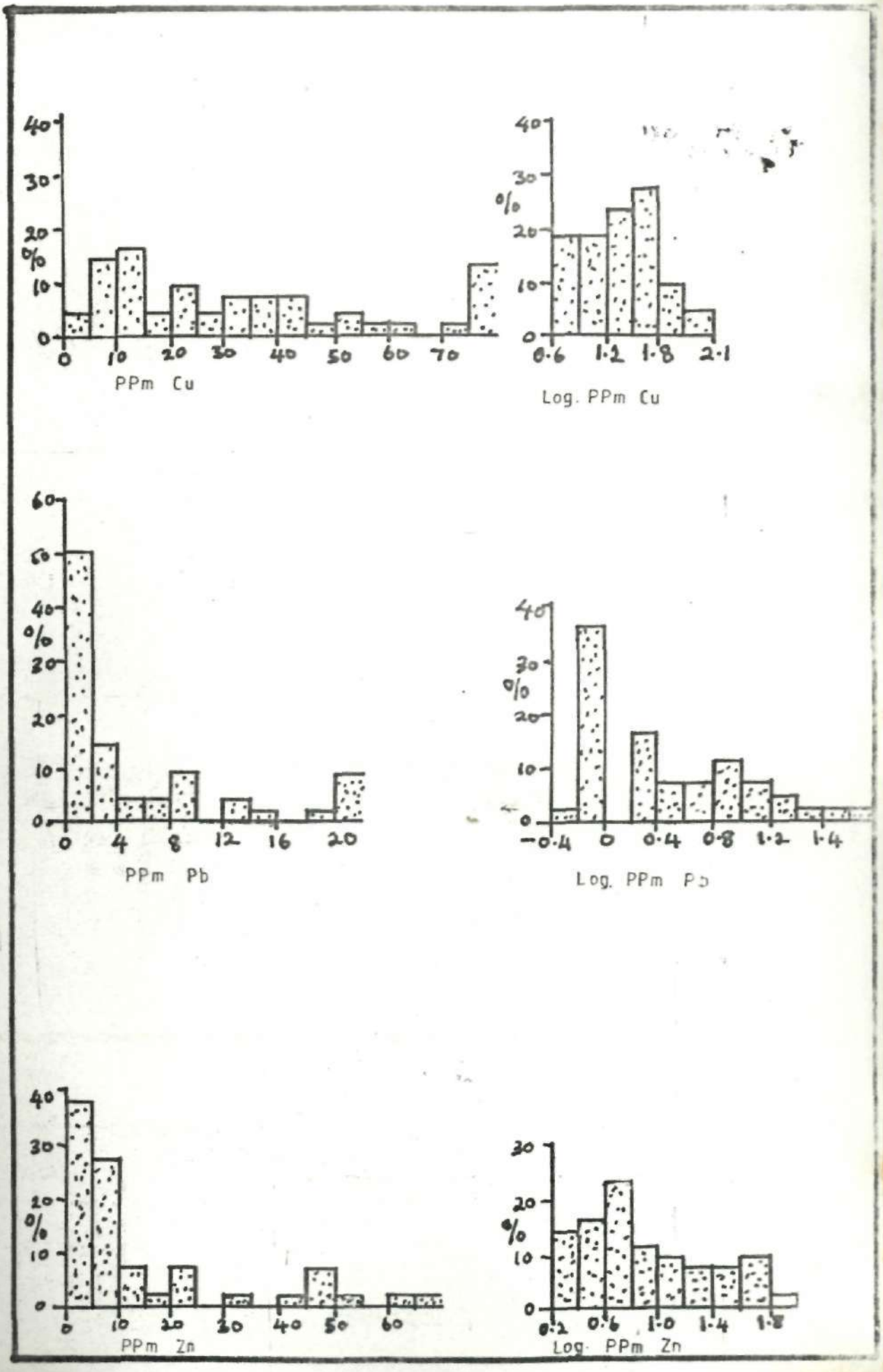


FIG. 6 contd.


40
30
20
%
10
0
0 10 20 30 40 50 60 70
PPm Cu
40
30
%
20
10
0
0·6 1·2 1·8 2·1
Log. PPm Cu
60
50
40
%
20
20
10
0
0 4 8 12 16 20
PPm Pb
40
30
%
20
10
0
−0·4 0 0·4 0·8 1·2 1·4
Log. PPm Pb
40
30
20
%
10
0
0 10 20 30 40 50 60
PPm Zn
30
20
%
10
0
0·2 0·6 1·0 1·4 1·8
Log. PPm Zn

Distribution curves (in Figure 3) have shown the distribution of the elements along the length of the reef. The correlation matrix below shows inter-element relationships in the reef.

Log-transformed data were used for correlation analysis using the SPSS version. Pearson Product Moment Correlation analysis was done and the results expressed as correlation coefficients (p) and levels of significance (s) Table 3.3).

Table 3.3.

Au	Ag	Cd	Cu	Pb	Zn	
p=1.000	0.352	-0.009	0.351	0.566	0.018	Au
s=0.001	0.009	0.477	0.010	0.001	0.453	
	p=1.000	0.327	0.591	0.502	0.189	Ag
	s=0.001	0.015	0.001	0.001	0.109	
		p=1.000	0.260	0.258	0.265	Cd
		s=0.001	0.044	0.045	0.041	
			p=1.000	0.313	0.205	Cu
			s=0.001	0.019	0.091	
				p=1.000	0.276	Pb
				s=0.001	0.035	
					p=1.000	Zn
					s=0.001	

Significant correlation is shown to exists between Au and Pb, Ag and Pb and Ag and Cu and these relationships have been reflected in curves of element distributions (Figure 3) along the length of the main Ore - zone of Okolom Reef. These associations probably indicate that Ag follows Pb in galena. The Au/Pb association may be explained by the mututal occurrences of Au and galena in the Ore zones which has been reported (Woakes and Bafor, 1982) in other gold occurrences in the Nigerian Basement.

The indications of more than one population of some of the elements (notably Au, Cu and Pb) in the Okolom Reef shown in Figure 6 may be explained by the nature of occurrences of the elements in the Reef. This can be distinguished into a fairly uniformly distributed low values of the elements along the Reef and restricted concentrations of high values associated with the main ore-zones of the Reef.

3.2. DISSEMINATED PRIMARY GOLD - SULPHIDE MINERALIZATION IN AMPHIBOLITES

Sulphide minerals occur disseminated in the amphibolites. The main sulphide mineral is pyrite and is widespread. Analyses indicate gold content in the amphibolites to be high (average of about 0.1ppm) as shown in Table 3.4. The gold values in the amphibolites, though high, are within the range of gold values in amphibolites in other parts of the world (Boyle, 1979).

Table 3.4

Analytical results of amphibolites in the study area

(Values are in ppm)

Sample No.	Description	Location	Au	Ag	Cd	Cu	Pb	Zn
RK 4107	Silicified-amphibolite	Near Odosin	0.05	2.0	1.0	102.0	8.5	22.5
RK 4122	Talc - amphibolite	Okolom Reef	0.10	1.0	1.8	47.0	5.0	16.0
RK 7001	Amphibolite	Okolom	0.18	4.0	1.4	8.0	2.5	1.0
RK 302	Amphibolite	Okolom	0.10	0	3.0	82.0	3.0	23.0
RK 303	Amphibolite	Okolom	0.07	1.0	0.12	3.0	2.0	16.0
RK 306	Amphibolite	Okolom	0.10	0	2.4	51.0	6.0	4.0
RK 307	Silicified amphibolite	Kachkacha	0.11	0	0.08	8.0	4.0	4.0
RK 311	Amphibolite	Dogon-Daji	0.07	0	0.08	102.0	7.0	6.0
		Average	0.09	1.0	1.23	50.4	4.75	11.56

The gold values do not vary greatly in the different varieties of altered amphibolites. This may mean that there was no relationship between the gold mineralization and the alteration processes that affected the amphibolites. The values of Cu, Pb and Zn in the amphibolites may indicate the presence of other sulphide minerals in the rock.

Work elsewhere suggests that gold occurs in sulphides (Boyle, 1979). The amphibolites have been shown to be largely metatholeiitic and contain disseminations of sulphide and oxide minerals that are intimately related to the gold mineralization in the Ilesha area (Elueze, 1982).

3.3. ELUVIAL AND ALLUVIAL GOLD DEPOSITS

The eluvial gold deposits are formed from mechanical and chemical concentration of the gold and associated minerals in the weathered residue overlying or near auriferous deposit (Boyle, 1979). Two of such occurrences of eluvial deposits have been noted to be associated with the Okolom Reef and the Kachakacha silicified zones. Only the Okolom eluvial deposit has been studied in some detail (Chapter 5). The Okolom eluvial extends for at least 500m on either side of the vein and the depth to weathered bedrock is about 1m.

The alluvial gold placers are confined to the valleys of major streams and rivers in the study area. They are concentrated in streaks in stream or river gravels and sands. The major occurrences of the alluvial placers are found in the valleys of River Ossam and its tributaries (Figure 2 and 22). Such occurrences have been studied in some detail (Chapter 5).

3.4. METALLOGENY

Elueze (1982) inferred that the sulphide and oxide minerals in the Ilesha amphibolites are essentially syngenetic. DeSwardt (1953), Cooray (1974) and Elueze and Olade (1977) believed that the gold in the minor veins and more important alluvial deposits in the Ilesha area has its source in the amphibolites. [illegible] the Ilesha gold-[illegible] in [illegible] (pegmatites) away [illegible] the amphibol[illegible]

Chemical analysis of the amphibolites in the Isanlu area have shown the amphibolites to be gold bearing similar to the ones in Ilesha area.

The origin of primary gold-vein deposits has been ascribed to the leaching of gold from rocks (especially basic volcanics) during metamorphism, either by large volumes of circulating hydrothermal solutions or by diffusion - migration in a hydrous environment (Boyle, 1979); and subsequentlconcentration and deposition in favourable dilatant structural environments (Woakes and Bafor, 1982). In the Isanlu area, a favourable structural environment for hydrothermally ransported gold does exist in the form of fractured zones, and the source of the gold may be ascribed to the associated amphibolites.

The gold-sulphide mineralization in the mafic amphibolites is probably syngenetic. Subsequent techtono-metamorphic processes have brought about the remobilization of the gold and the sulphide minerals and also their subsequent concentration and deposition

in the quartz veins. These processes may have been connected with Pan-African tectonism and the magmatism may well have provided the heat necessary.

CHAPTER 4

GEOCHEMICAL PROSPECTING

4.1. SAMPLING PROCEDURE

Investigation of stream sediments and heavy mineral concentrates from the drainage channels was carried out in the area of study, where-ever access was possible, within the period of the fieldwork. The sampling of stream sediments and for heavy mineral concentrates has been done concurrently from the stream bed of the drainage system: but occasionally bank alluvial materials were sampled for the heavy minerals. Figures 7 and 8 show the locations of the samples collected as stream sediments and heavy mineral concentrates respectively. Sample intervals vary between one sample per 250m to about one sample per 2km depending on physical conditions. The stream sediment samples were analysed for Au, Ag, Cu, Pb, Zn, Fe and Mn to determine geochemical data of these elements and their association with gold mineralization in the study area. The heavy mineral concentrates obtained by panning were used mainly for field checking for the occurrence of gold in the drainage channels as the geological and geochemical investigation continued and to quickly help delineate areas of high Au-values which might indicate alluvial placers. The concentrates which reflect the composition of mechanical secondary dispersion haloes, help to reconstruct a picture of the desintegration, transportation and concentration of primary gold

mineralization (Kreiter, 1968).

The presence of visible alluvial gold in panned concentrate has led to the discovery of a vast number of the world's important gold deposits. Gold in panned concentrate has been found to be a more reliable indicator of mineralized area in the Absarok Mountains of Wyoming and Montana, U.S.A.(Anteweiler and Campbell, 1982).

The sampling of the two media simultaneously is cost-efficient and the elimination of one would not necessary reduce the cost of the operation significantly.

Because of the high costs of geochemical analyses it was necessary to be selective and samples from two areas were chosen for analysis to evaluate the usefulness of this method of geochemical prospecting. Even within the chosen areas not all samples were chosen. The two areas are marked A and B (on Figure 7) which are considered mineralized and 'barren' respectively in respect to known primary gold occurrences; but both areas include amphibolites, believed to be associated with gold in the study area. A total of 160 stream sediment samples were selected out of which 119 were from A and 41 from B.

Again, due to the high cost of geochemical analyses, only a few elements could be considered for the analyses at this time. Since it has been observed that the primary mineralization in the study area is a gold-quartz-sulphide type, Au, Ag, Cu, Pb and Zn were selected and also Fe and

Mn because of their role in 'scavenging' (adsorption) and creating false anomalies of the base metals. Thus, seven elements Au, Ag, Cu, Pb, Zn, Fe and Mn were analysed in the 160 stream sediment samples from A and B. As was also considered for analysis but lack of the necessary chemicals at the time prevented its determination.

4.2. SAMPLE COLLECTION AND REPARATION

4.2.1. Heavy Mineral Concentrates.

The method of sampling heavy mineral concentrates consists of collecting two headpan - volumes (approximately $0.016m^3$) of sediments to represent one sample from a site, usually near rock outcrops in the stream channel which were considered favourable for heavy mineral concentration. The material was deslimed by panning and screened through 11 and 18 mesh sieves. Those mesh fractions were further panned to about 10 to 20 grams. This concentrate was packed and sent to the near-by field laboratory for analysis by amalgamation.

4.2.2. Stream Sediment Samples.

Conventional geochemical procedures are generally inadequate in the context of the use of geochemistry in regional reconnaissance for gold deposits. An appreciation of basic problems of sampling related to the nature of gold and its distribution in geologic media is needed (Harris, 1982).

The sampling of the stream sediments was in most cases biased towards material with heavy mineral concentration as samples were collected from the same locations as the material for panning - infact often from the same material prior to panning. This may explain the very high values of gold obtained and discussed in Section 4.5.5.

In order to obtain a representative sample of sediment at a site, a small amount of fine sediment should be collected at three to six localities along 5 - 10m of stream bed and composited into a single container (Rose et al, 1979). But in this case about one to two kilograms of sediment were taken at a single site along the stream bed as one sample and it was collected from material selected to be high in heavy mineral concentrates.

The samples were packed in polythene bags, with their relevant drainage data records, and sent to the N.M.C.'s Laboratory in Jos for preparation and analysis. In the laboratory, the samples were dried in either hot air ovens (2- 4 hours) or in corrugated zinc sheets under sunlight depending on the weather and the wetness of the samples. The samples were later disaggregated using mortar and pestle and sieved through 180 mesh brash screens, either manually or using electric sieve shaker. The 180 mesh samples were then packed in polythene bags and were ready for chemical analysis.

4.3. SAMPLE ANALYSIS.

4.3.1. Heavy Mineral Concentrate

The analysis of the heavy mineral concentrates obtained by panning was done by amalgamation process in the field laboratory. This involved the moistening of the concentrate fractions (which were about 10 - 20 grammes) with water and then mercury was added to the wet samples in testubes. The mercury formed amalgam with any gold present in the samples. The amalgam was separated and then dissolved in 1M HNO_3 and the gold was precipitated. The gold grains were washed with water, dried and weighed on a METTLER balance. The weight of the gold (in grams) was converted and expressed as grams per cubic metre of sample material. The values in g/m^3 were later plotted on the base map (Figure 8). The conversion was done as follows:

2 headpan - fulls = $0.016m^3$ (16 litres)

(one sample)

If, for example, there was 0.05g Au in one sample, the value will be expressed as $0.05 \times 62.5 = 3.125g/m^3$. ($0.016 \times 62.5 = 1m^3$).

4.3.2. Stream Sediment Samples.

The 160 stream sediments samples from areas A and B were analysed for Au, Ag, Cu, Pb, Zn, Fe and Mn by atomic absorption spectrophotometry (AAS) using the PYE UNICAM SP9 model. All the analyses were done in the NMC's

laboratory in Jos.

All samples were hot extracted (Hx) using HNO_3 + Hcl (3:1) heated in a water bath with one gram of sample for about two hours. The volume was then made up to 20ml and run on the AAS. For Au, 20g of sample was heated in a furnace (700° to 800°C) for about one hour to eliminate impurities such as organic matter. The sample was then moistened with water and HNO_3 + $KBrO_4$ added. The sample was shaken thoroughly and the volume made up to 20ml with water. 4ml of MIBK (Methyl isobutyl ketone) was added and shaken and then centrifuged to separate the organic layer. The MIBK extracted and concentrated the Au into the organic layer. This was then run on the AAS; and the concentration is expressed in parts per million (ppm).

4.3.3. Geochemical Analyses

Routine checks were carried out by duplicate analysis of every tenth sample to determine the repeatability of the analytical method. Working standards were also frequently analysed to determine the repeatability of the AAS. The results of the duplicate analyses are presented on Table 4.1. It can be observed that the differences between paired values are not very significant.

As the analyses were carried out as part of the routine work of the NMC Geochemical Laboratory special replicate analyses were not considered necessary for this study. The laboratory has given 90 - 95 percent as the

confidence limit (or the measure of precision) for their analyses.

The reliability of the analysis of the heavy mineral concentrate by amalgamation was not determined.

Table 4.1.

Results of the duplicate analyses of 13 selected samples. (values in ppm)

Sample No.	Au	Ag	Cu	Pb	Zn	Cd
ROK 4080	-	0	17.0	2.0	8.0	0.00
	-	0	16.6	2.1	8.08	1.00
ROK 4056	-	0	26.0	4.4	2.0	3.0
	-	0	21.0	4.0	2.0	1.4
ROK 4094	0.85	1.2	190	1.0	7.8	2.8
	0.80	2.0	182	1.5	8.8	1.6
ROK 4042	0.05	-	-	-	-	-
	0.05	-	-	-	-	-
RIIK 4096	-	2.6	14.0	0.4	16.4	2.8
	-	2.6	12.0	0.7	21.6	2.8
GK 3116	-	1.2	11.4	2.4	300	-
	-	1.2	11.4	2.2	306	-
GK 4233	-	2.0	8.2	1.2	41.6	-
	-	2.6	8.1	1.2	41.8	-
GK 5784	-	3.4	11.0	1.8	8.4	-
	-	3.4	11.0	2.1	8.4	-
GK 4076	-	3.0	29.0	64.0	49.2	-
	-	3.0	28.0	58.0	48.0	-
GK 7058	0.45	-	-	-	-	-
	0.50	-	-	-	-	-
GK 7031	0.3	-	-	-	-	-
	0.3	-	-	-	-	-
GK 3129	0.2	-	-	-	-	-
	0.2	-	-	-	-	-
GK 2214	0.5	-	-	-	-	-
	0.6	-	-	-	-	-
Maximum % "Variation" from mean	9.1	25	10.4	27.3	13.7	100

confidence limit (or the measure of precision) for their analyses.

The reliability of the analysis of the heavy mineral concentrate by amalgamation was not determined.

Table 4.1.

Results of the duplicate analyses of 13 selected samples. (values in ppm)

Sample No.	Au	Ag	Cu	Pb	Zn	Cd
ROK 4050	-	0	17.0	2.0	8.0	0.00
"	-	0	16.6	2.1	8.08	1.00
ROK 4056	-	0	26.0	4.4	2.0	3.0
"	-	0	21.0	4.0	2.0	1.4
ROK 4094	0.85	1.2	190	1.0	7.8	2.8
"	0.80	2.0	182	1.5	8.8	1.6
ROK 4042	0.05	-	-	-	-	-
"	0.05	-	-	-	-	-
RIIK 4096	-	2.6	14.0	0.4	16.4	2.8
"	-	2.6	12.0	0.7	21.6	2.8
GK 3116	-	1.2	11.4	2.4	300	-
"	-	1.2	11.4	2.2	306	-
GK 4233	-	2.0	8.2	1.2	41.8	-
"	-	2.6	8.1	1.2	41.8	-
GK 5784	-	3.4	11.0	1.8	8.4	-
"	-	3.4	11.0	2.1	8.4	-
GK 4076	-	3.0	29.0	64.0	49.2	-
"	-	3.0	28.0	58.0	46.0	-
GK 7058	0.45	-	-	-	-	-
"	0.50	-	-	-	-	-
GK 7031	0.3	-	-	-	-	-
"	0.3	-	-	-	-	-
GK 3129	0.2	-	-	-	-	-
"	0.2	-	-	-	-	-
GK 2214	0.5	-	-	-	-	-
"	0.6	-	-	-	-	-

4.4. STATISTICAL TREATMENT OF AAS ANALYSES

The data obtained from geochemical analyses are tabulated in Appendixes (ii) and (iii) and were subjected to simple statistical analyses and interpretation using statistical methods.

The use of the electronic computer has been useful in the statistical analyses of the data. The work was carried out in the A.B.U. Computer Centre using the Vogelback Model programe of NW University, U.S.A. SPSS version 6.50 of 76/04/01. The SPSS (Statistical Package for Social Sciences) was used to find general statistical parameters and for the Pearson Correlation Analysis.

4.4.1. General Statistical Data.

Table 4.2. shows some statistical data of importance obtained for the seven elements (Au, Ag, Cu, Pb, Zn, Fe and Mn) analysed in the 119, 41 and 160 stream sediment samples from A, B and A and B combined respectively. All figures are rounded-off.

Table 4.2.

Statistical data for the seven elements analysed in stream sediment samples.

	Au	Ag	Cu	Pb	Zn	Fe	Mn
A (119 samples)							
Mean	1.7	2	24	14	45	9333	736
Median	0.5	2	20	4	34	8263	502
Mode	0.3	3	20	1	36	6528	500
Standard Dev.	6.5	1.5	31	17	44	6135	1215
Minimum Value	0	0	4	1	3	726	80
Maximum Value	37.5	5	332	64	270	28000	12500
B (41 samples)							
Mean	1.0	3	20	17	56	7873	604
Median	0.6	2	18	2	39	6462	497
Mode	0.5	2	20	1	22	3188	200
Standard Dev.	1.5	3	12	10	76	5546	621
Minimum Value	0.03	0	4	1	7	764	130
Maximum Value	8.6	16	54	56	392	18528	3600
A + B (160 samples)							
Mean	1.6	2	23	15	48	8959	702
Median	0.5	2	20	3.5	35.5	7723	502
Mode	0.3	3	20	1	22	6528	500
Standard Dev.	4.1	2	28	13	54	6007	1094
Minimum Value	0	0	4	1	3	726	80
Maximum Value	37.5	16	332	64	392	28000	12500

4.4.2. Frequency Distributions.

Distribution patterns of the elements considered have been studied graphically. This included the construction of histograms on normal arithmatic paper (Figures 9, 10, and 11) and construction of cumulative frequency distribution curves (CFD) on probablity graph papers (Figures 12, 13 and 14).

The histograms of the arithmetic and logarithmic values of each of the seven elements have been constructed for Area A, Area B and for the two areas combined.

The cumulative frequency distribution curves (CFD) using the Lepeltier (1969) method have also been constructed for the seven elements in the three set of data considered above. The main purpose in constructing the CFD curves for the seven element population in the areas considered was to check further if they fit a lognormal distribution (Lepeltier, 1969), and if they do to estimate graphically some basic parameters such as backgrounds, thresholds and different populations.

4.4.3. Pearson Correlation.

Pearson Correlation Analysis was done on the different sets of data to study inter-element relationships. The analyses was done using the SPSS computer programme. The results are shown as correlation matrices in Tables 4.3, 4.4 and 4.5 showing correlation relationships between

FIG. 9

Histograms of frequency distribution (in %) of arithmatic and logarith
of Au, Ag, Cu, Pb, Zn, Fe and Mn in stream sediments of Area A.

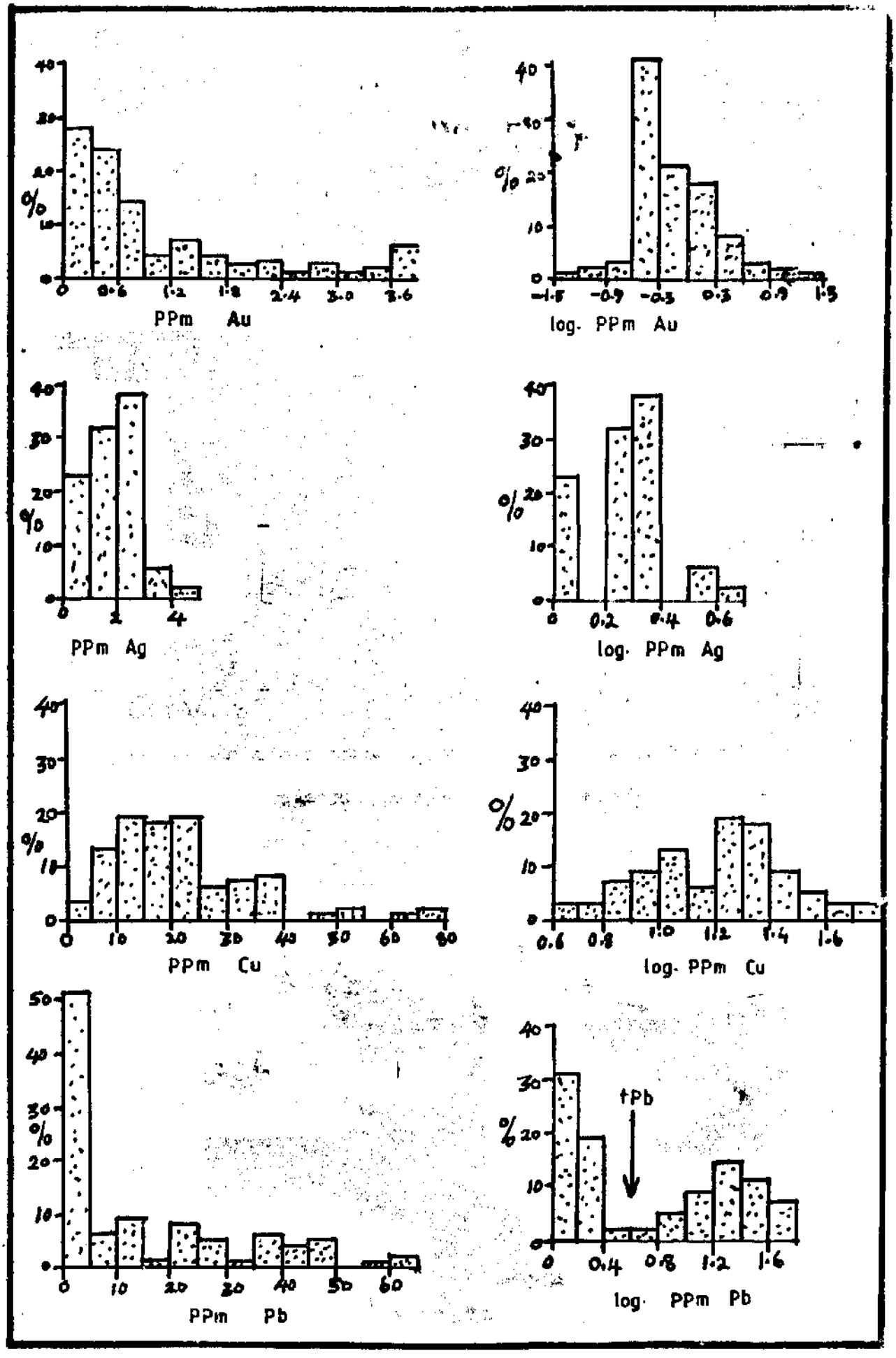
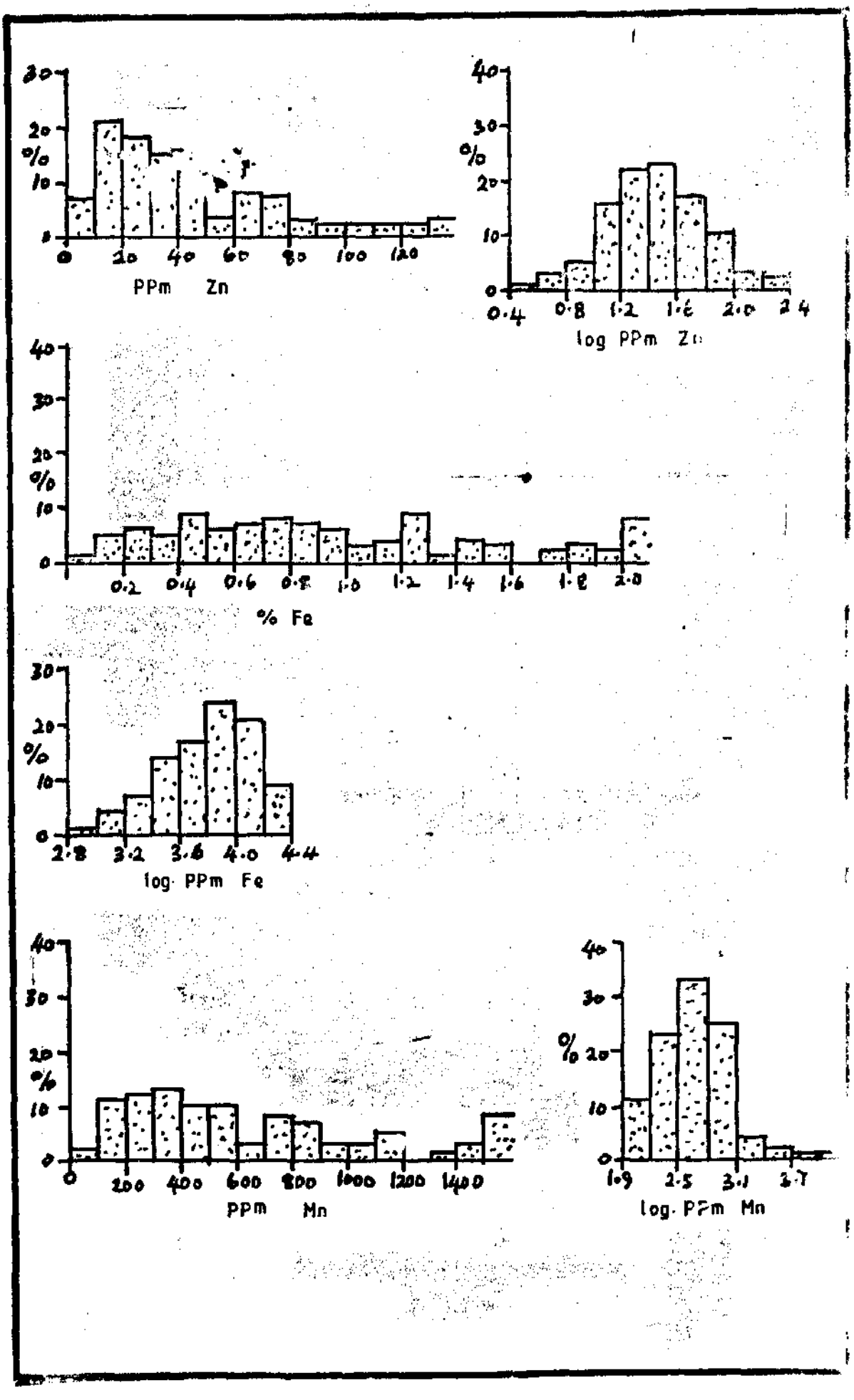


FIG. 9 Contd.



Histograms of frequency distribution (in %) of arithmetic and logarithmic values of Au, Ag, Cu, Pb, Zn, Fe and Mn in stream sediments of Area B.

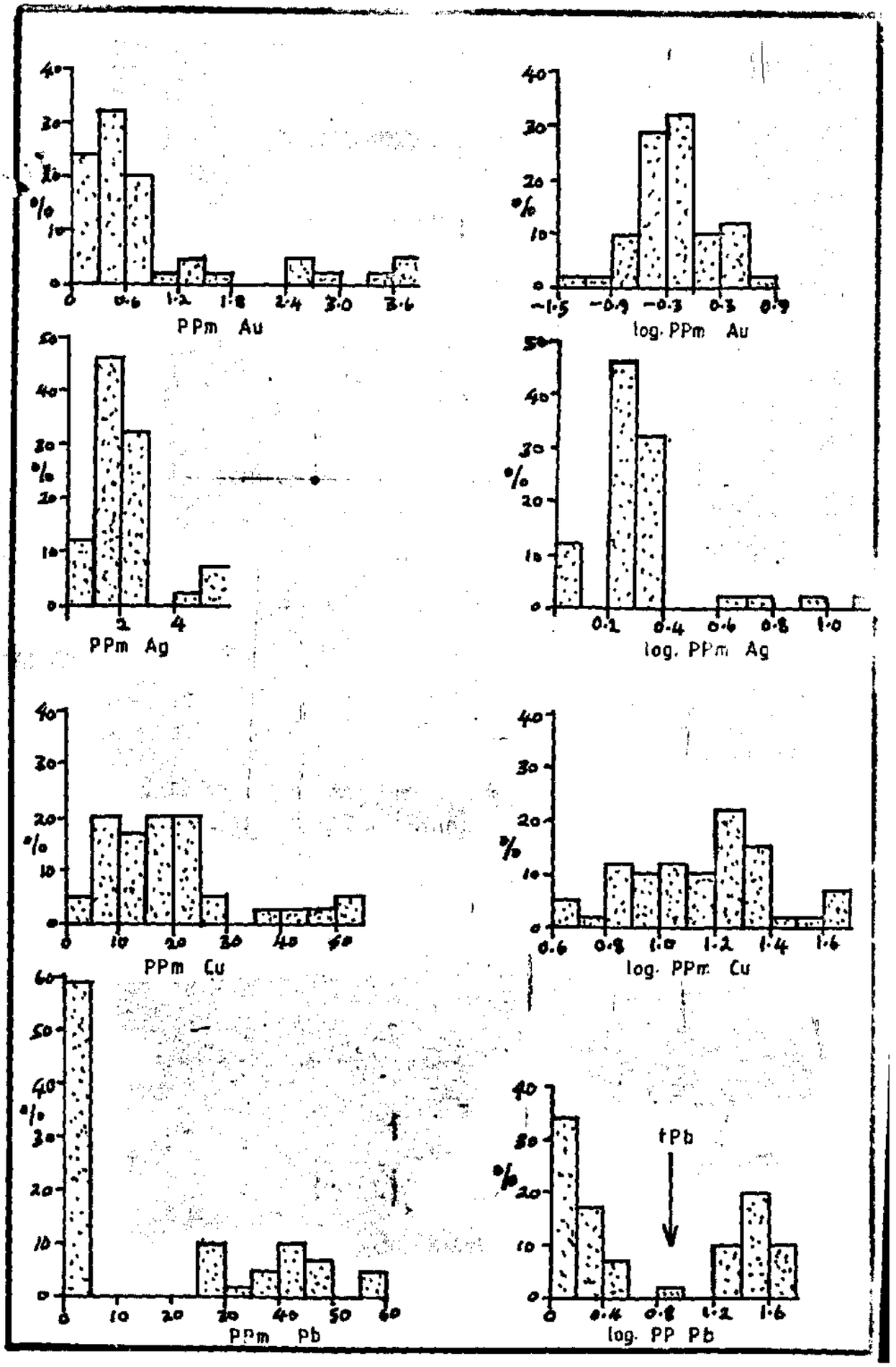
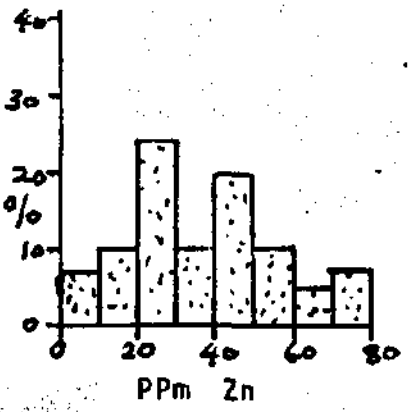
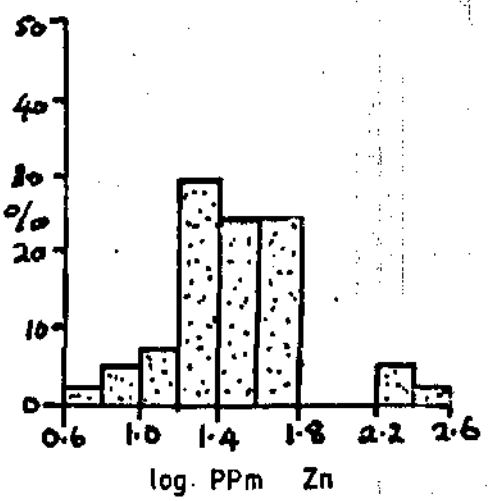
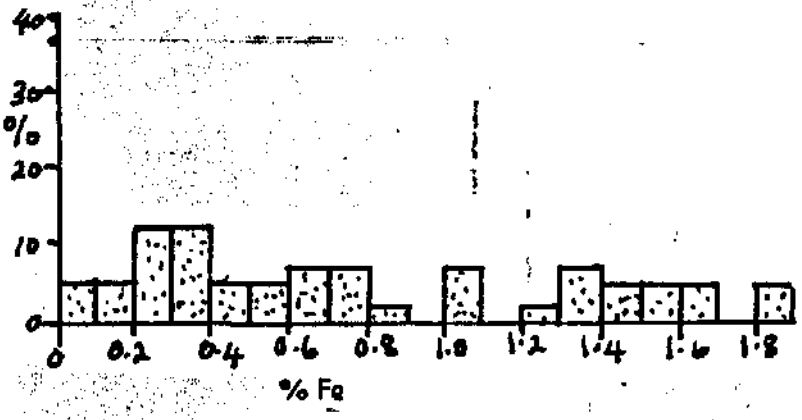
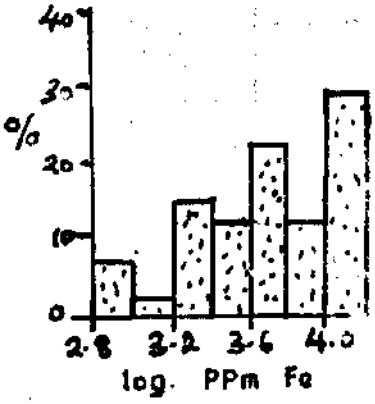


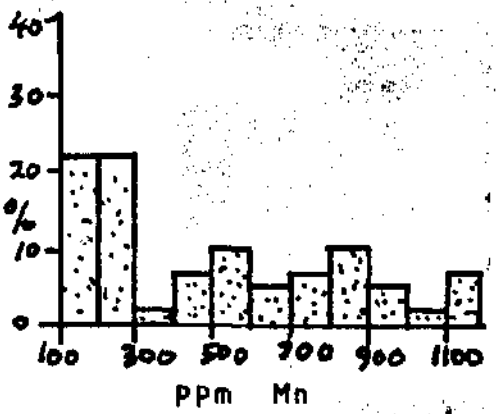
FIG. 10 Contd.


40
30
20
%
10
0
0
20
40
60
80
PPm Zn


50
40
30
%
20
10
0
0.6
1.0
1.4
1.8
2.2
2.6
log. PPm Zn


40
30
%
20
10
0
0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
% Fe


40
30
%
20
10
0
2.8
3.2
3.6
4.0
log. PPm Fe


40
30
20
%
10
0
100
300
500
700
900
1100
PPm Mn

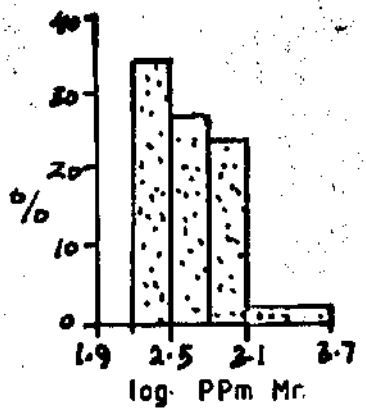

40
30
20
%
10
0
1.9
2.5
2.1
3.7
log. PPm Mn

FIG.11

Histograms Of frequency distribution (in %) of arithmetic and logarithmic values of Au, Ag, Cu, Pb, Zn, Fe and Mn in stream sediments of area A and B combined

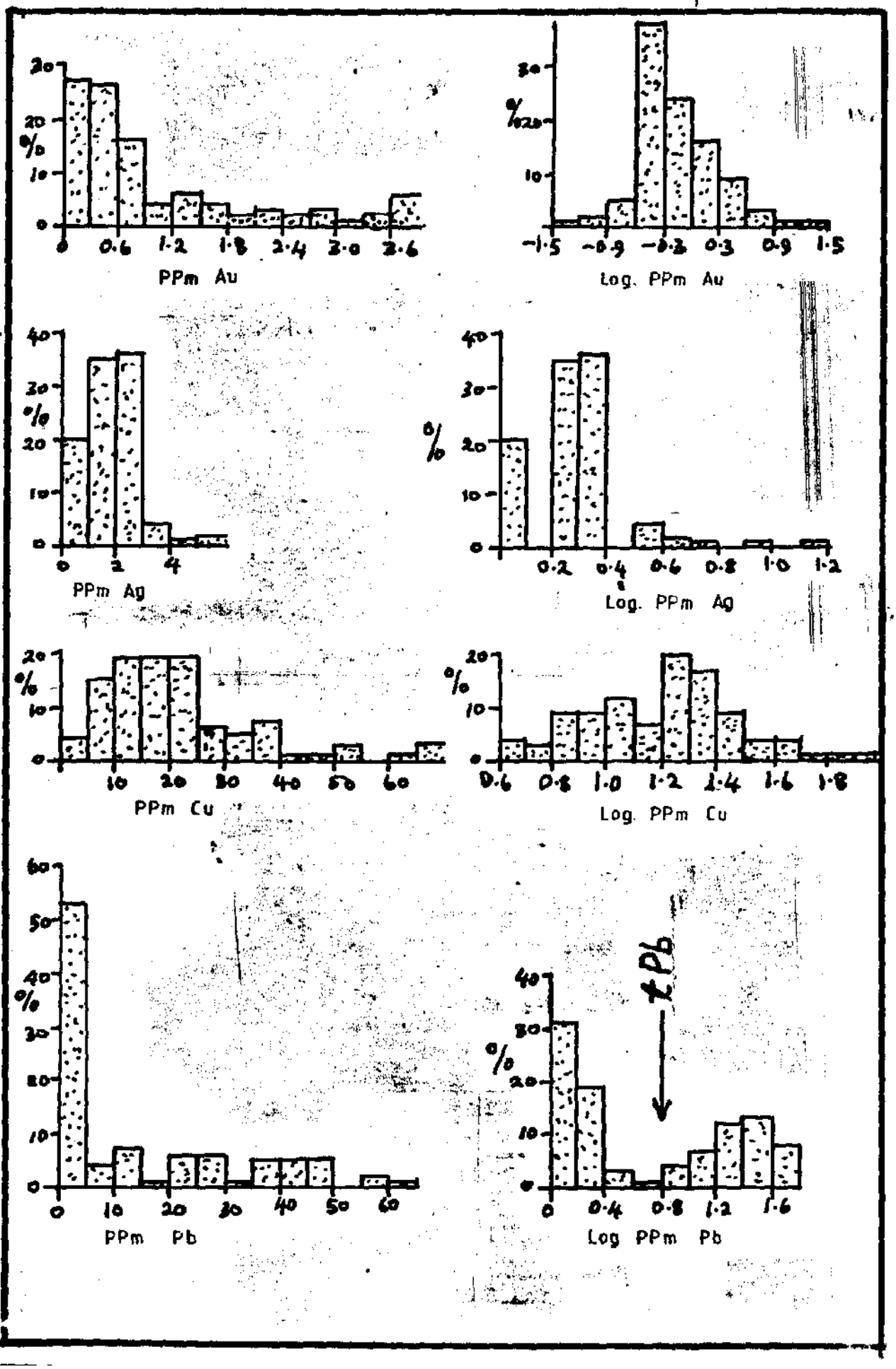


FIG.11 contd

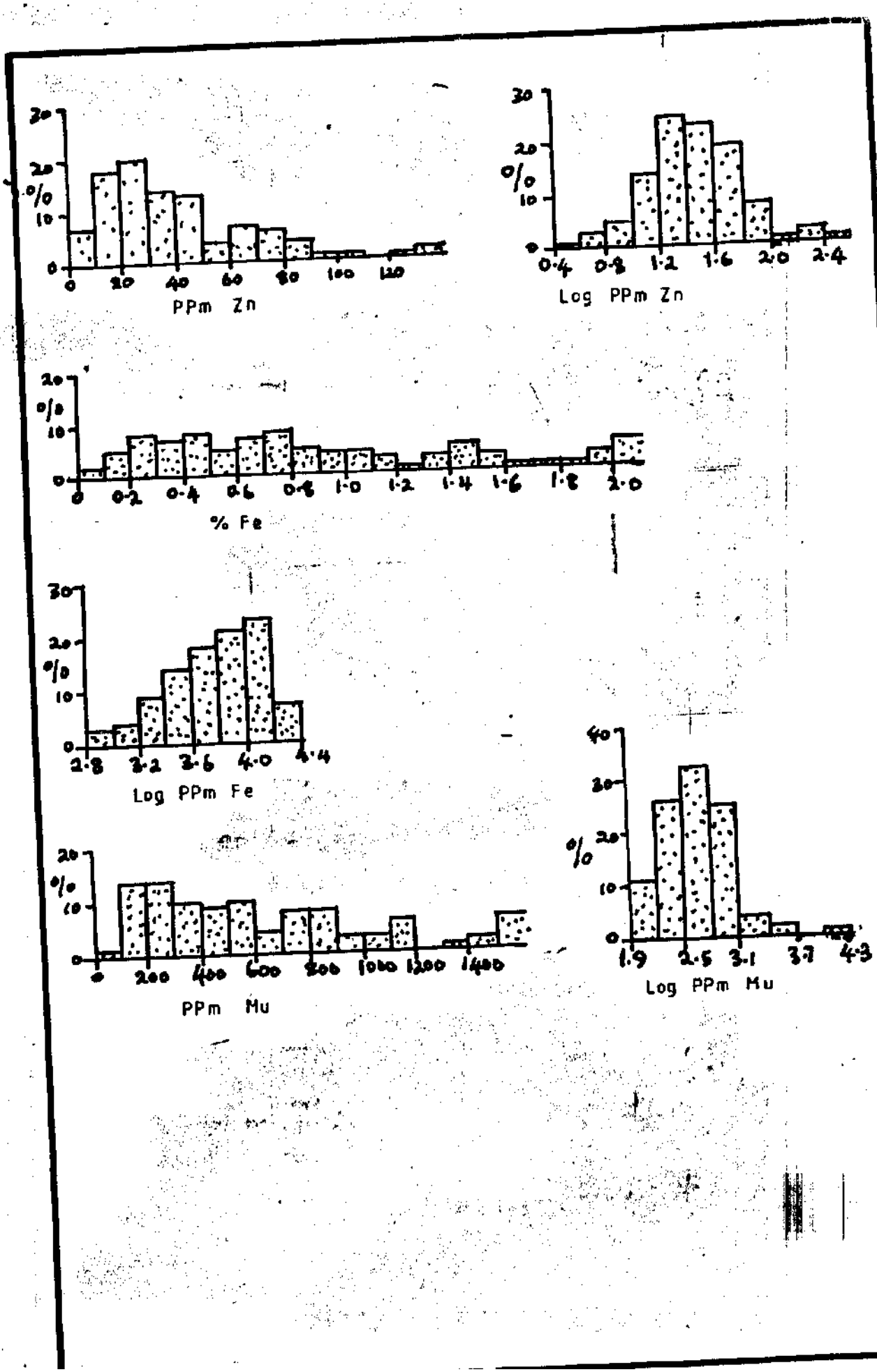

30
20
%
10
0
0 20 40 60 80 100 120
PPm Zn
30
20
%
10
0
0·4 0·8 1·2 1·6 2·0 2·4
Log PPm Zn
20
%
10
0
0 0·2 0·4 0·6 0·8 1·0 1·2 1·4 1·6 1·8 2·0
% Fe
30
20
%
10
0
2·8 3·2 3·6 4·0 4·4
Log PPm Fe
20
%
10
0
0 200 400 600 800 1000 1200 1400
PPm Mu
40
30
%
20
10
0
1·9 2·5 3·1 3·7 4·3
Log PPm Mu

FIG. 12

Cummulative frequency distribution (CFD) Curves for Au, Ag, Cu, Pb, Zn, Fe and Mn in stream sediments (119 Samples) from Area A. — (Adopted from Lepeltier, 1969)

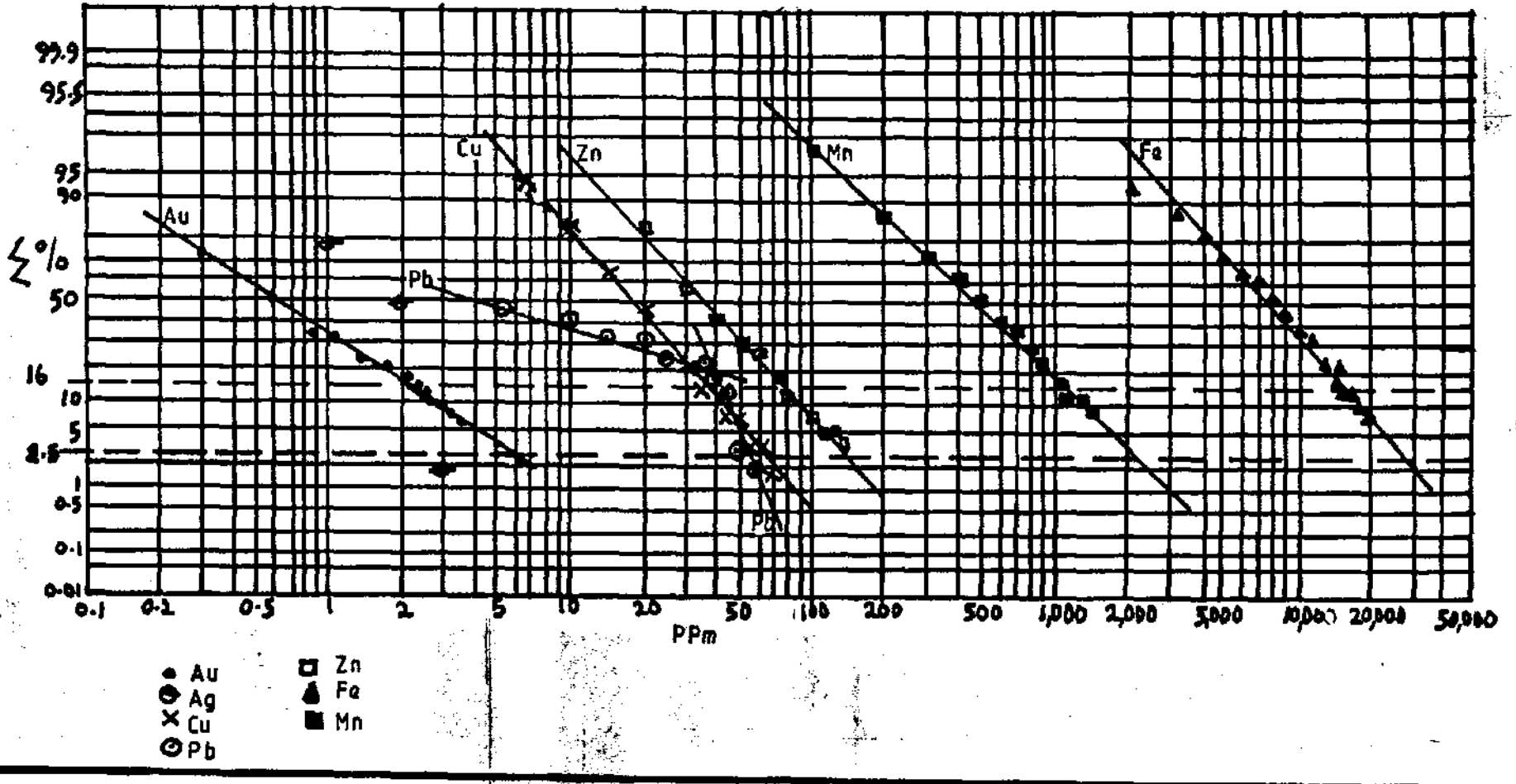


FIG. 13

Cummulative frequency distribution (CFD) Curves for Au, Ag, Cu, Pb, Zn Fe and Mn in stream sediments (41 Samples) from Area B. (Adopted from Lepeltier, 1969)

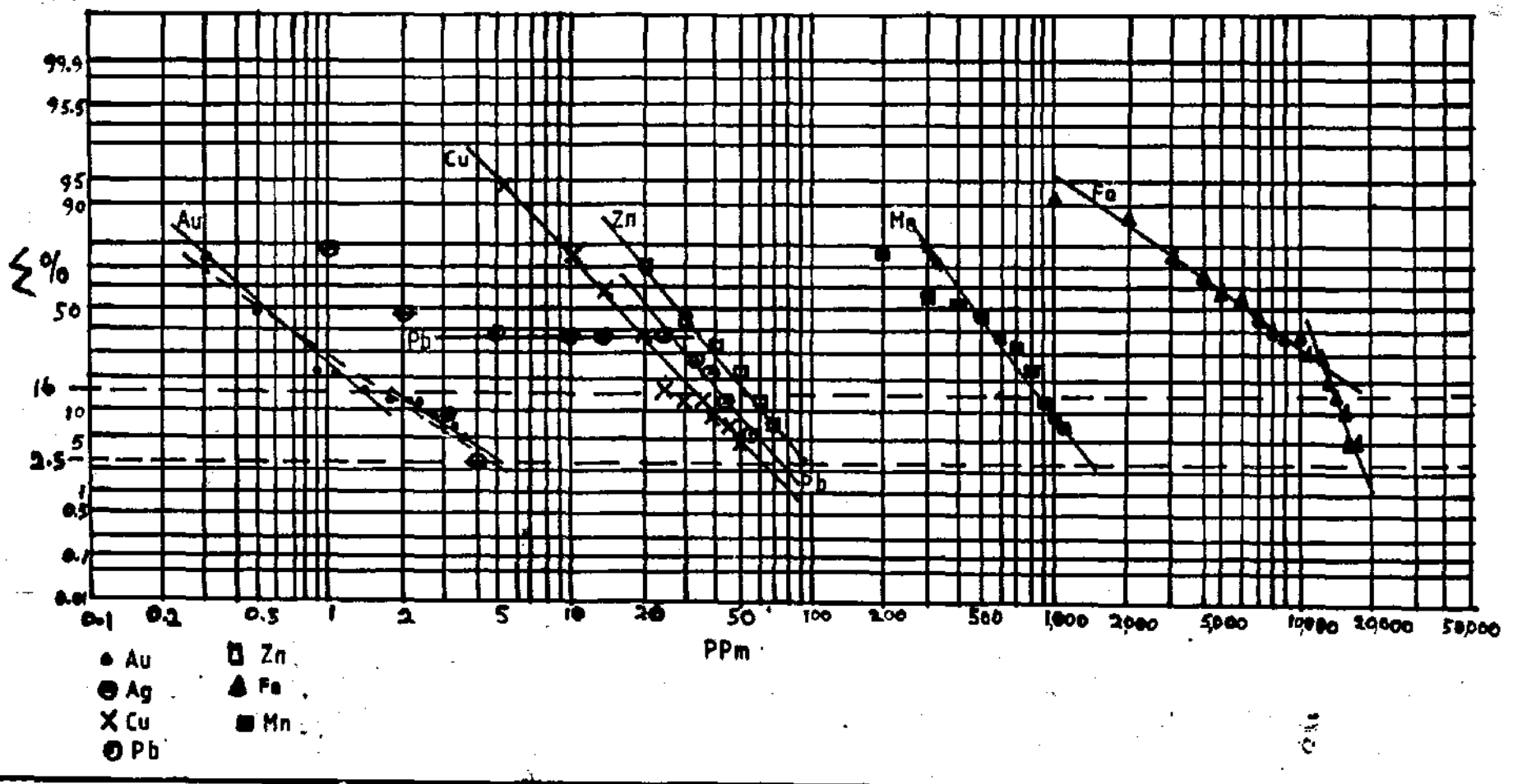
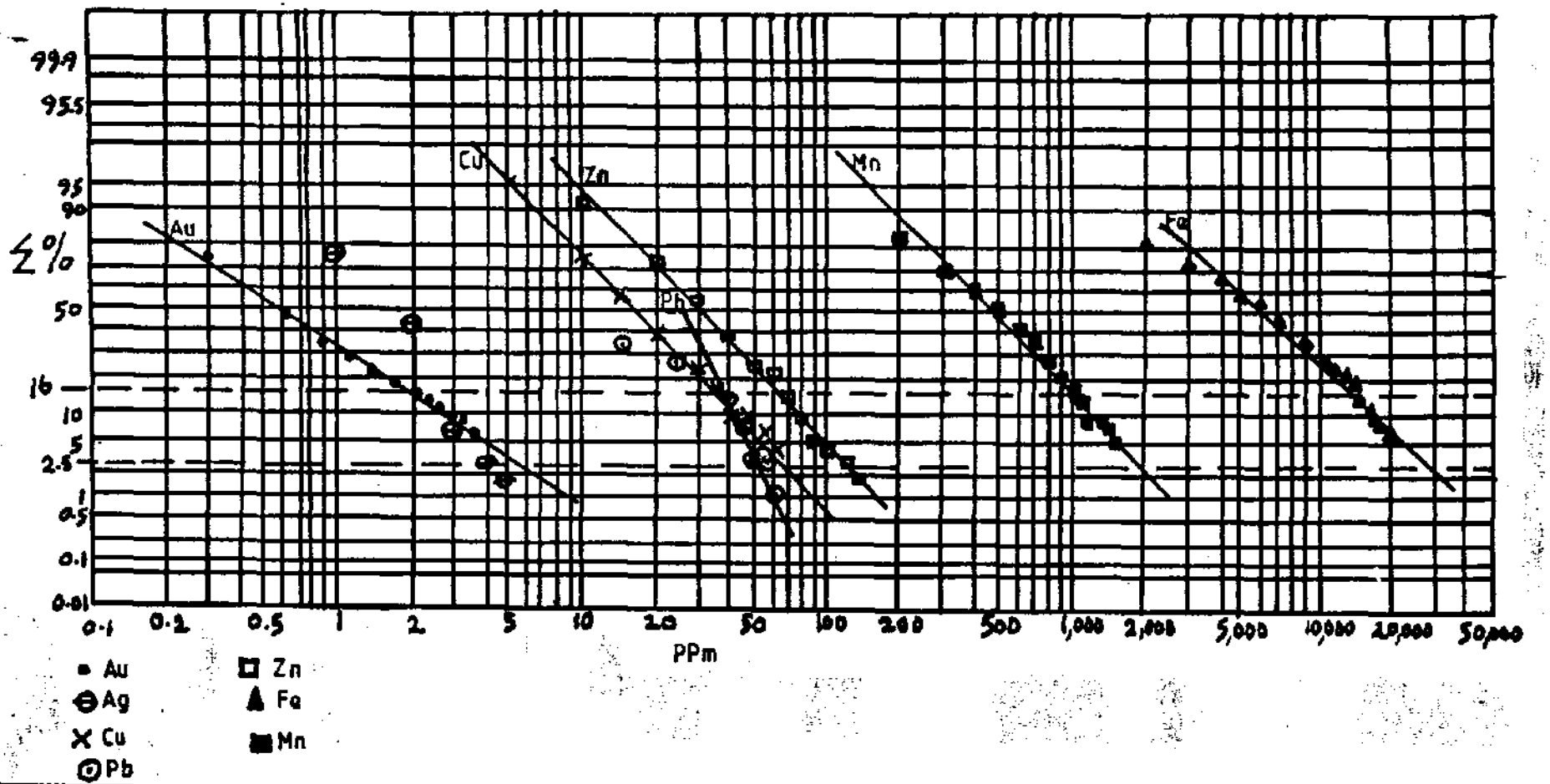


FIG. 14

Cummulative frequency distribution (CFD) for Au, Ag, Cu, Pb, Zn, Fe and Mn in stream sediments (160 Samples) from Areas A and B Combined. (Adopted from Lepeltier, 1969)



elements in Area A, Area B and the two areas combined. The results are expressed, for each pair of elements, as Pearson Correlation Coefficients (r) and the level of significance (s).

Table 4.3.

Correlation Matrix, showing relationships between seven element studied in Area A. (r = Pearson Correlation coefficient; S = level of significance).(for logarithmic values).

Au	Ag	Cu	Pb	Zn	Fe	Mn	
p=1.000	0.110	-0.173	-0.025	0.045	0.109	0.547	Au
s=0.001	0.115	0.030	0.394	0.314	0.120	0.305	
	p=1.000	0.051	0.238	0.085	0.092	0.168	Ag
	s=0.001	0.291	0.005	0.180	0.159	0.034	
		p=1.000	0.305	0.212	-0.002	0.056	Cu
		s=0.001	0.001	0.010	0.491	0.274	
			p=1.000	0.529	-0.209	0.060	Pb
			s=0.001	0.001	0.011	0.257	
				p=1.000	-0.092	-0.029	Zn
				s=0.001	0.150	0.374	
					p=1.000	0.5062	Fe
					s=0.001	0.001	
						p=1.000	Mn
						s=0.001	

Table 4.4

Correlation matrix (for logarithmic values), showing relationships between seven element studied in Area C. (P = Pearson Correlation Coefficient; S = level of significance).

Au	Ag	Cu	Pb	Zn	Fe	Mn	
p=1.000	0.217	0.096	0.167	-0.001	-0.173	0.064	Au
s=0.001	0.086	0.275	0.149	0.499	0.140	0.346	
	p=1.000	0.157	-0.067	-0.148	-0.212	0.027	Ag
	s=0.001	0.163	0.294	0.178	0.091	0.433	
		p=1.000	0.212	0.394	0.260	0.366	Cu
		s=0.001	0.091	0.005	0.050	0.009	
			p=1.000	0.283	-0.414	0.157	Pb
			s=0.001	0.036	0.004	0.163	
				p=1.000	0.024	0.008	Zn
				s=0.001	0.449	0.479	
					p=1.000	0.191	Fe
					s=0.001	0.116	
						p=1.000	Mn
						s=0.001	

Table 4.5

Correlation matrix of logarithmic values showing relationship between seven element studied in Areas A and B combined.

Au	Ag	Cu	Pb	Zn	Fe	Mn	
p=1.00	0.130	-0.102	0.025	0.290	0.062	0.049	Au
s=0.001	0.005	0.099	0.374	0.358	0.218	0.270	
	p=1.00	0.069	0.135	0.023	0.022	0.134	Ag
	s=0.001	0.190	0.044	0.387	0.388	0.045	
		p=1.000	0.278	0.252	0.047	0.106	Cu
		s=0.001	0.001	0.001	0.278	0.091	
			p=1.000	0.459	-0.243	-0.076	Pb
			s=0.001	0.001	0.001	0.169	
				p=1.000	-0.072	-0.022	Zn
				s=0.001	0.182	0.390	
					p=1.000	0.521	Fe
					s=0.001	0.001	
						p=1.000 s=0.001	Mn

4.5. INTERPRETATION AND DISCUSSION

Distribution pattern of the elements considered vary between a near lognormal pattern to an unclear pattern displayed by some of the elements, notably Ag and Pb. Figures 9, 10 and 11 show these features. The lognormal distribution pattern appear to be most applicable to the result of the geochemical survey, as shown in the histograms. Logarithmic values of the metals displayed some sort of a symmetrical forms. From the histograms it can be

observed that Au, Cu, Zn, and Mn displayed a fairly distinct lognormal pattern in the three areas studied (Areas A,B and A+B combined). Pb shows two populations. The pattern of Fe is partly lognormal and partly negatively skewed patterns. The CFD (Cumulative frequency distribution) curves discussed below shed further light on the possibilities. Ag shows a confused (uncertain) pattern and can only be represented by few class limits.

The application of Lepeltier (1969) method using CFD curves has been of great help in defining the distribution patterns of the metals considered. Figures 12, 13 and 14 show the distribution patterns (using the CFD curves) of the elements in the three areas A,B and A+B. The plots are constructed on probability scale. These curves have made the lognormal and otherwise distribution patterns more definite and as such estimation of basic statistical data graphically is possible. It has been found that the use of this method for the data available would be of a greater help in the interpretation than the histograms and are therefore recommended henceforth as the method to be used for the statistical interpretation of the analytical data. However, Ag remain problematic because of its very few classes and has not shown any definite pattern on the CFD curves. Apart from this all others show a sort of pattern. Au (except in B), Cu, Zn, Fe (except in B) and Mn all show single populations lognormally distributed in the CFD curves. Pb shows a sort of two populations.

The CFD curves have been used to estimate background values, deviation coefficients and threshold values (levels) using the Lepeltier (1969) method.

4.5.1. Background.

A straight line on the CFD curves denotes a single population lognormally distributed. Using these curves, the background is estimated graphically by the intersection of the distribution curve (line)with the 50% ordinate. The values are of course rounded off (Figures 12, 13 and 14). In the case of a perfect lognormal curve, the background thus estimated corresponds to the mode and the median and can be taken to be the geometric mean of the set of the values (Lepeltier, 1969). In this study perfect curves have not been achieved and thus the background values estimated are only close to the mode and median (Table 4.2).

4.5.2. Deviation Coefficient

For a lognormal distribution, 68% of the population fall between b - s and b + s(b = background, s = standard deviation) or that 32% are outside these limits. Thus 16% of the values will fall above b+s and 16% below b-s. In the CFD curves (Figures 12, 13, and 14), the values b+s and b-s can be obtained by projecting the intersection of the distribution line (curve) with the ordinates 16% and 84% respectively on the abscissa axes. Therefore the geometric deviation (s^*) which is a factor, is obtained by dividing by the background (b), the value read from the projection

of the intersection of the 16% line with the distribution curve on the 50% ordinate.

4.5.3. Threshold.

In the case of symmetrical distribution (either normal or lognormal), 95% of the individual values fall between b + 2s and b - 2s; that is to say only 2½% of the population exceed the upper limit b + 2s (Lepeltier, 1969). This upper limit is conventionally taken to be the threshold level (t) above which the values are considered as anomalous (Lepeltier, 1969; Sinclair, 1974; Rose, et al, 1979)

Graphically, threshold levels can be calculated from the CFD curves using the formula $t = bxs^{*2}$; or simply the threshold (t) can be estimated directly from the curves (Figures 12, 13, and 14) as the intersection of the distribution line (curve) with the 2½ % ordinate. The calculated threshold (Table 4.6) and the estimated threshold are found to differ slightly due to the rounding off figures and construction scale of the later.

Table 4.6.

Calculated and estimated threshold values for the element (Au, Cu, Zn, Fe and Mn), that show defined lognormal distribution from the CFD curves.

Element	b	s*	t = bxs*^{2} t-calculated	t-estimated	Area
Au	0.6	3.3	6.5	6	
Cu	18	1.7	52	60	
Zn	36	2.1	159	150	A
Fe	8,000	2.0	32,000	30,000	
Mn	500	2.4	2,880	2,300	
Au	0.5	3.0	4.5	5	
Cu	16	2.0	64	60	
Zn	28	2.0	112	100	B
Fe	6,000	3.2	61,440	60,000	
Mn	500	1.8	1,620	1,500	
Au	0.6	3.3	6.5	6	
Cu	17	2.1	71	70	
Zn	30	2.1	132	140	A+B
Fe	600	2.5	37,500	30,000	
Mn	500	2.0	2,000	2,000	

Pb shows a distinct two populations lognormal distribution in the histograms (Figures 9, 10, and 11). It is easier to estimate the threshold values from the histograms using the Rose et al (1979) method for two populations of an element shown by histograms of logarithmic values. The estimated thresholds of Pb in the three areas are shown in Figures 9, 10, and 11 and are as follows:

Area A, t Pb = 4ppm

Area B, t Pb = 8ppm

Area A+B, t Pb = 7ppm.

The threshold values of the elements are by all indications very high considering the range of the data. This is not unusual with the Lepeltier method since only 2½% of the sets of populations will fall above the threshold in a lognormal distribution. It can be observed that in the case of gold only five values in A and one value in B (Appendixes ii and iii)constitute anomalies. It is doubtful that, if these few points (anomalies) are plotted on a map, they will indicate favourable areas worthy of follow-up. If that is done, it would be difficult to ascertain the extent of the influence of such anomalies. Besides, some of the points do not even coincide with known mineralized bodies and some of them may even be due to local drainage features or may even occur by chance. Furthermore, it would be difficult to compare and prioritize such anomalies. In otherwords this is

considered not the best way to make visual presentation of the distribution characteristics of the element populations on the map; in-as-much-as the maps should provide information that are worthy of follow-up survey.

4.5.2. Geochemical Maps.

Another method for selecting thresholds (as described by Rose et al, 1979) is to plot the analytical data on a map and contour or otherwise separate high values from the low values. A cluster of high values has a low probability of occurring by chance (according to Rose et.al., 1979) and may reflect a mineralized area. This method is used by plotting low, medium and high values of the seven elements - Au, Ag, Cu, Pb, Zn, Fe and Mn on the map (Figures, 15, 16, 17, 18, 19, 20, and 21).

It is interesting to observe from the geochemical maps that many clusters of high values of most of the elements are closely associated with known mineral occurrences. Thus, other high values can be related to unknown mineral occurrences which are targets for follow-up survey and these are discussed in section 4.5.7.

4.5.5. Geochemical Characteristics of Element Distributions

Gold (Au). The statistical features and distribution pattern of Au in the three areas have been shown. The most noticeable feature is the generally very high level of Au in the stream sediments. This may be attributed to two factors: (i) samples were collected at sites selected

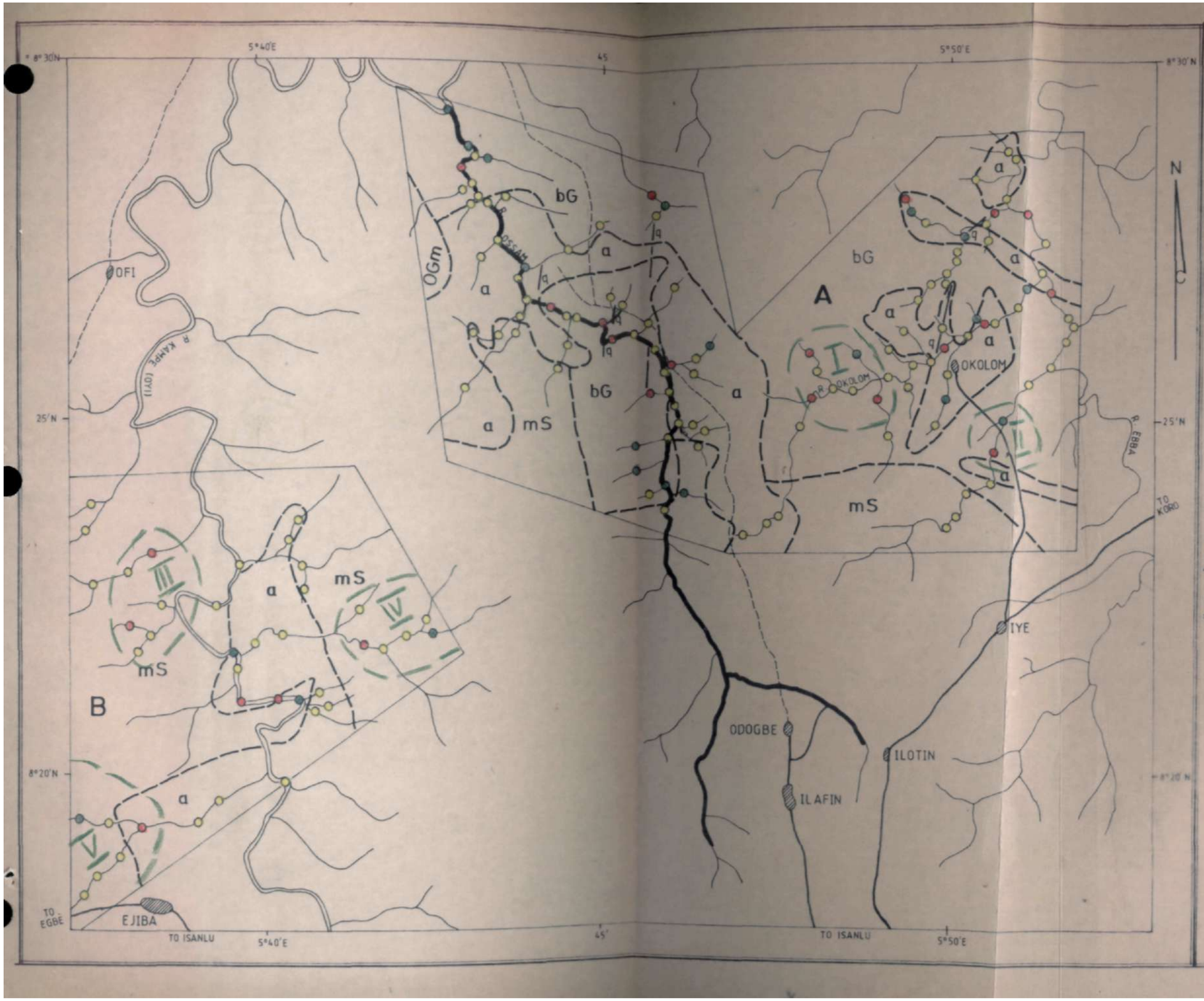

8°30'N
5°40'E
45'
5°50'E
8°30'N
25'N
8°20'N
OFI
R. KAMPE (OYI)
OGm
bG
a
q
mS
A
I
II
R. OKOLOM
OKOLOM
R. EBBA
TO KORO
IYE
B
III
IV
V
ODOGBE
ILOTIN
ILAFIN
EJIBA
TO EGBE
TO ISANLU
N
FIGURE 15
GEOCHEMICAL MAP OF GOLD (Au) DISTRIBUTION IN STREAM SEDIMENTS IN THE TWO AREAS A AND B.
LEGEND
Quartz vein
OGm Older Granite
a Amphibolite
mS Mica Schist
bG Biotite gneiss
AB Areas studied
Geological boundary
River and streams
Road and tracks
HIGH (>2 ppm)
MEDIUM (1—2 ppm)
LOW (<1 ppm)
1 0.5 0 1 2 km
SCALE 1:100,000

FIGURE 16

GEOCHEMICAL MAP OF SILVER (Ag) DISTRIBUTION IN STREAM SEDIMENTS IN THE TWO AREAS A AND B.

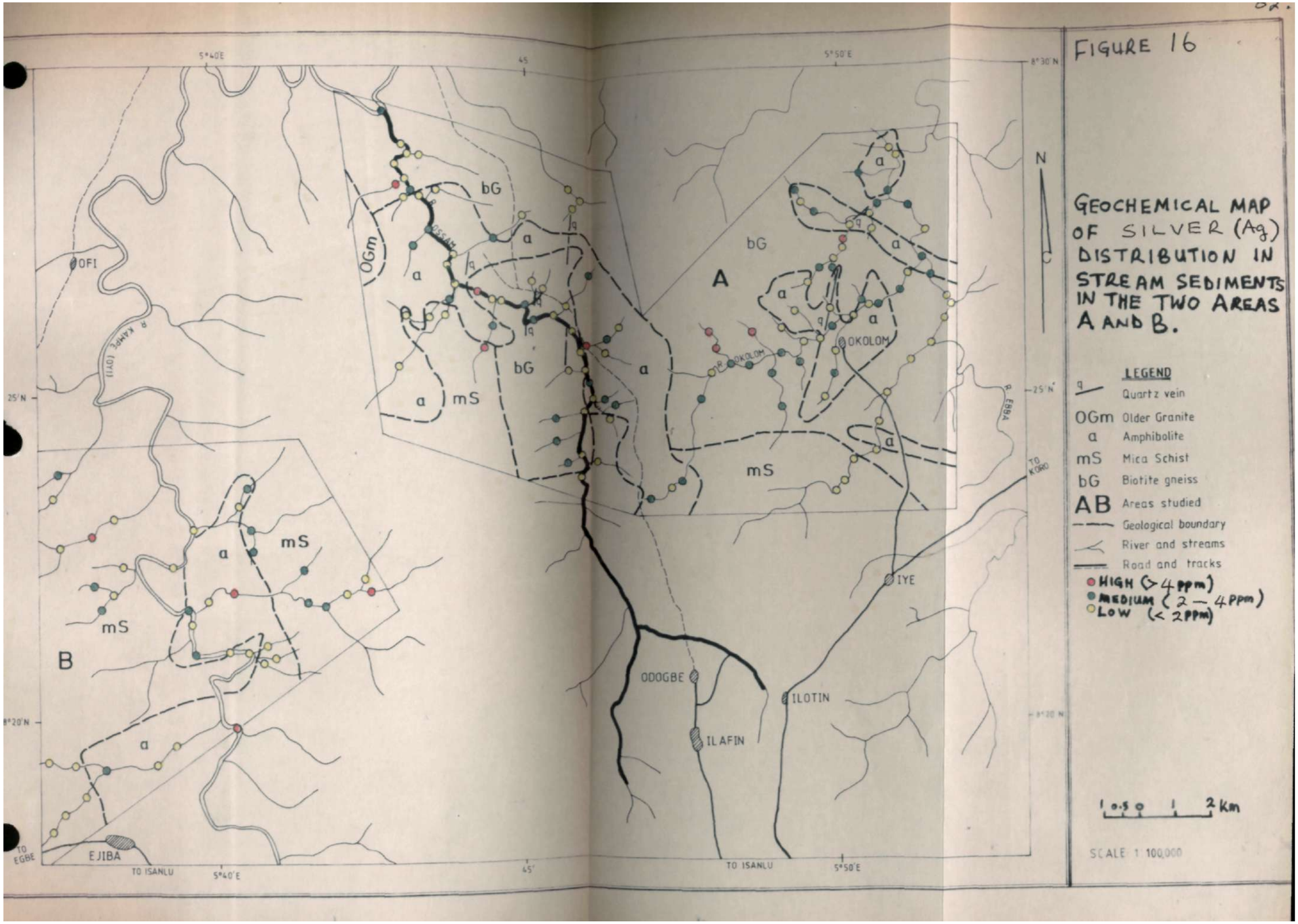
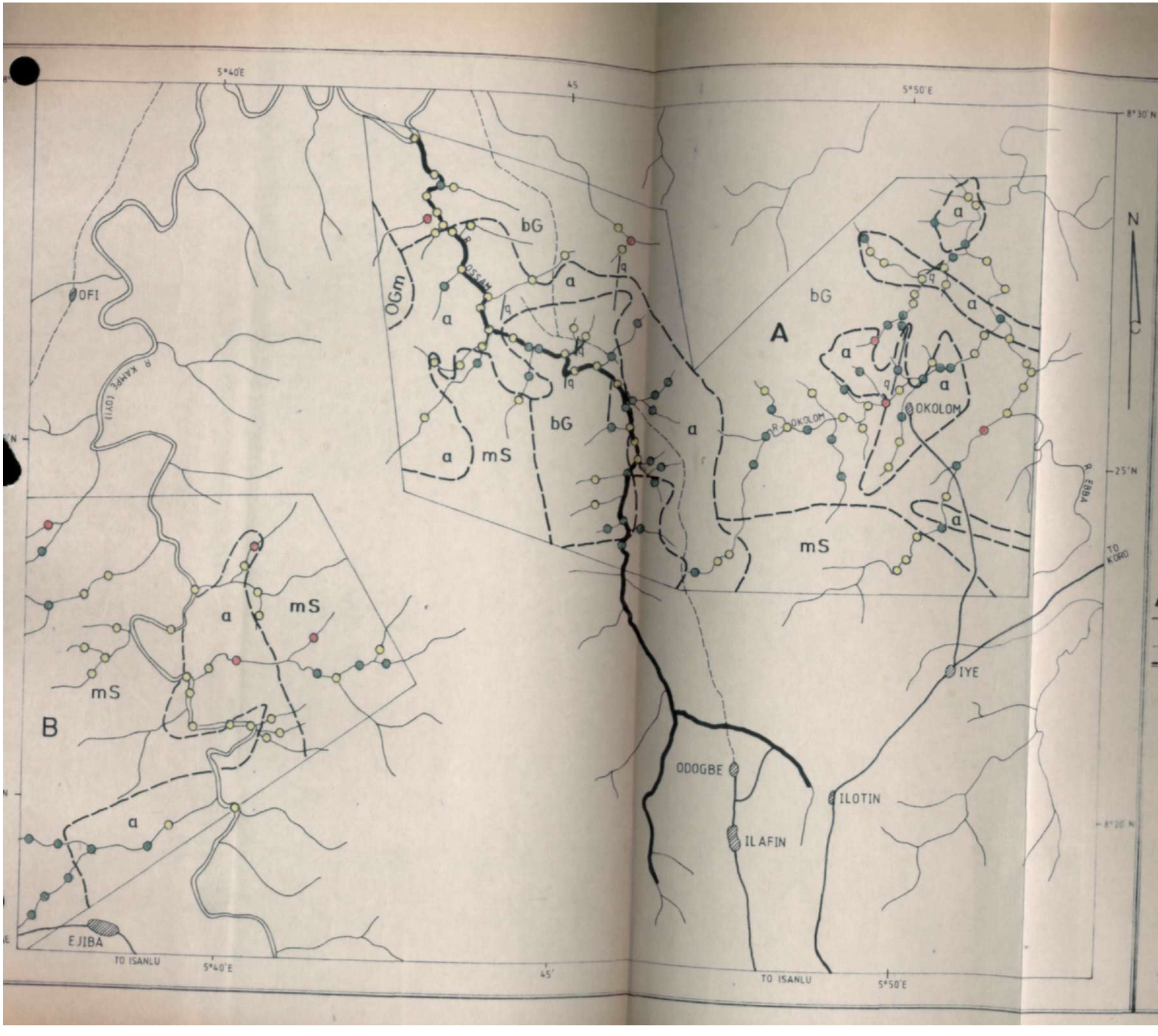
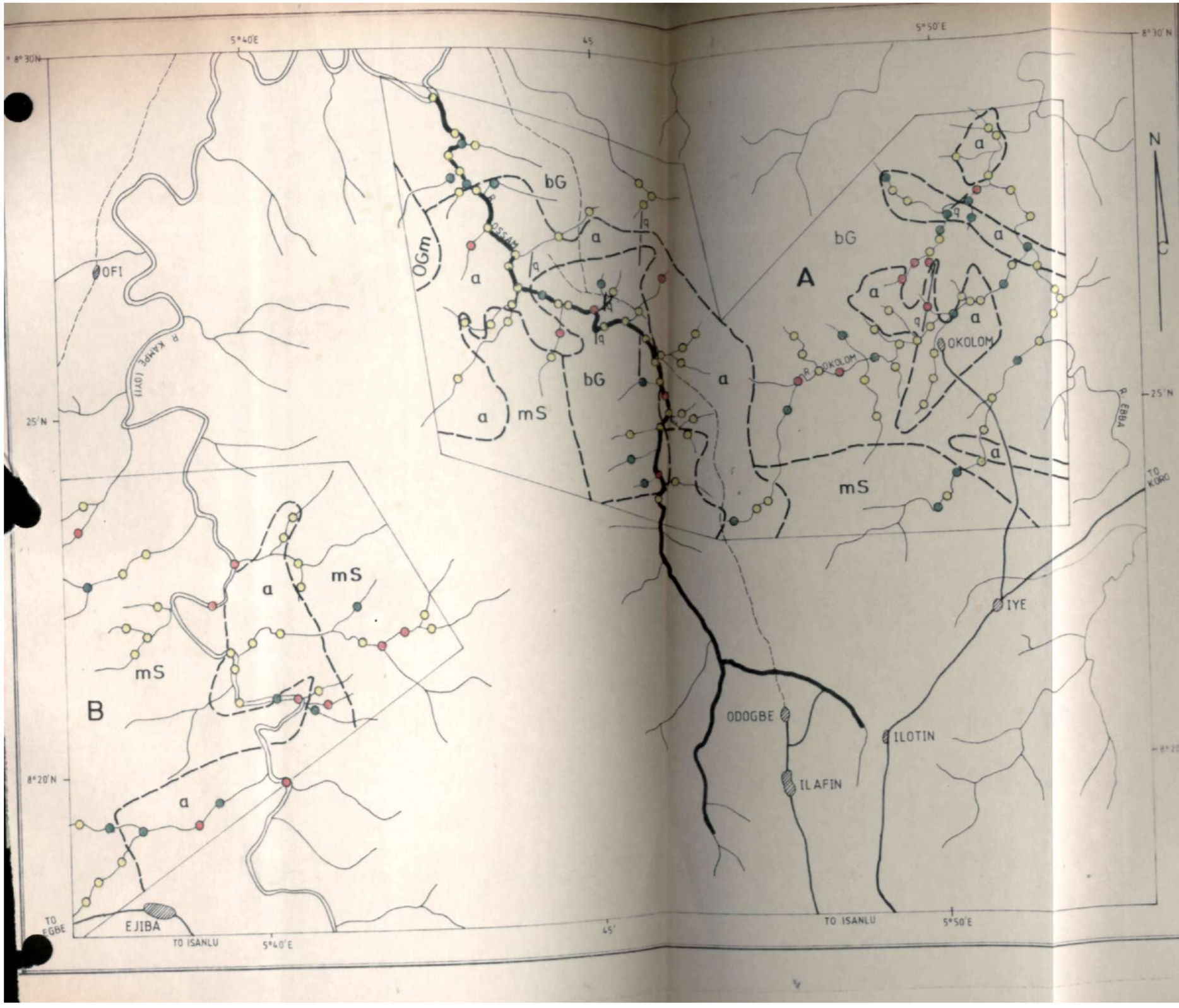


FIGURE 17



GEOCHEMICAL MAP OF COPPER (Cu) DISTRIBUTION IN STREAM SEDIMENTS IN THE TWO AREAS A AND B.

FIGURE 18



GEOCHEMICAL MAP OF LEAD (Pb) DISTRIBUTION IN STREAM SEDIMENTS IN THE TWO AREAS A AND B.

FIGURE 19

GEOCHEMICAL MAP OF ZINC (Zn) DISTRIBUTION IN STREAM SEDIMENTS IN THE TWO AREAS A AND B.

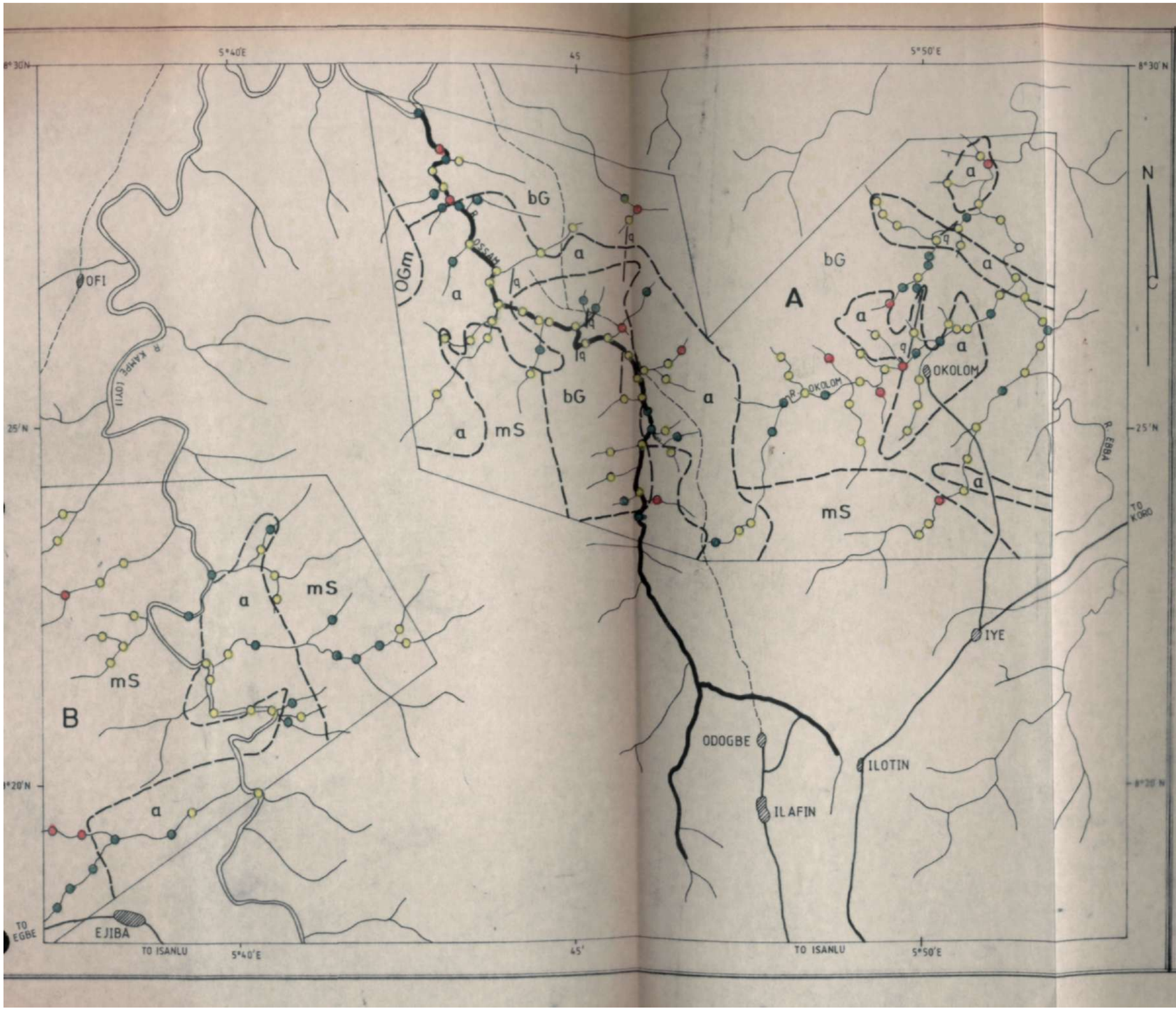
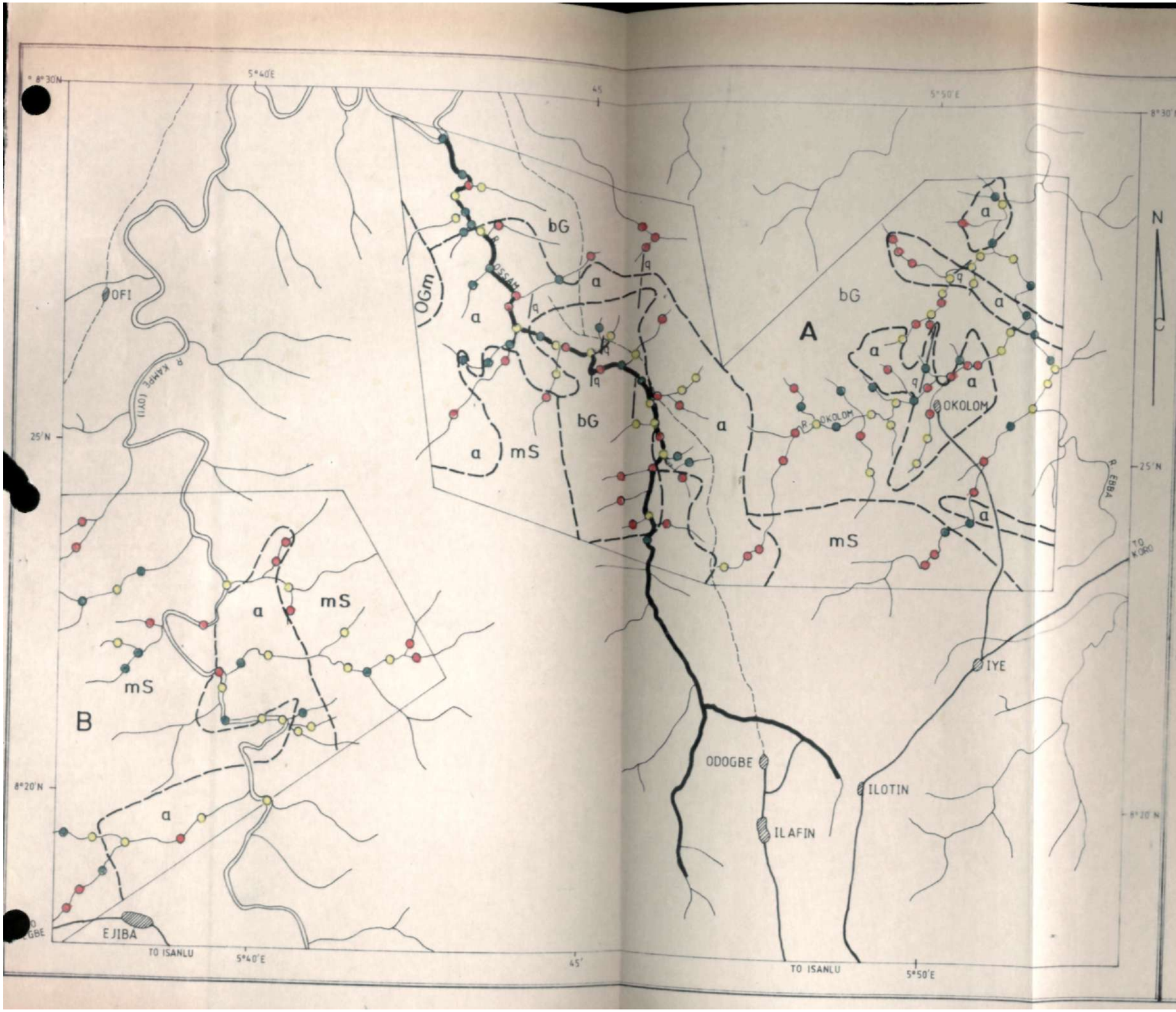


FIGURE 20

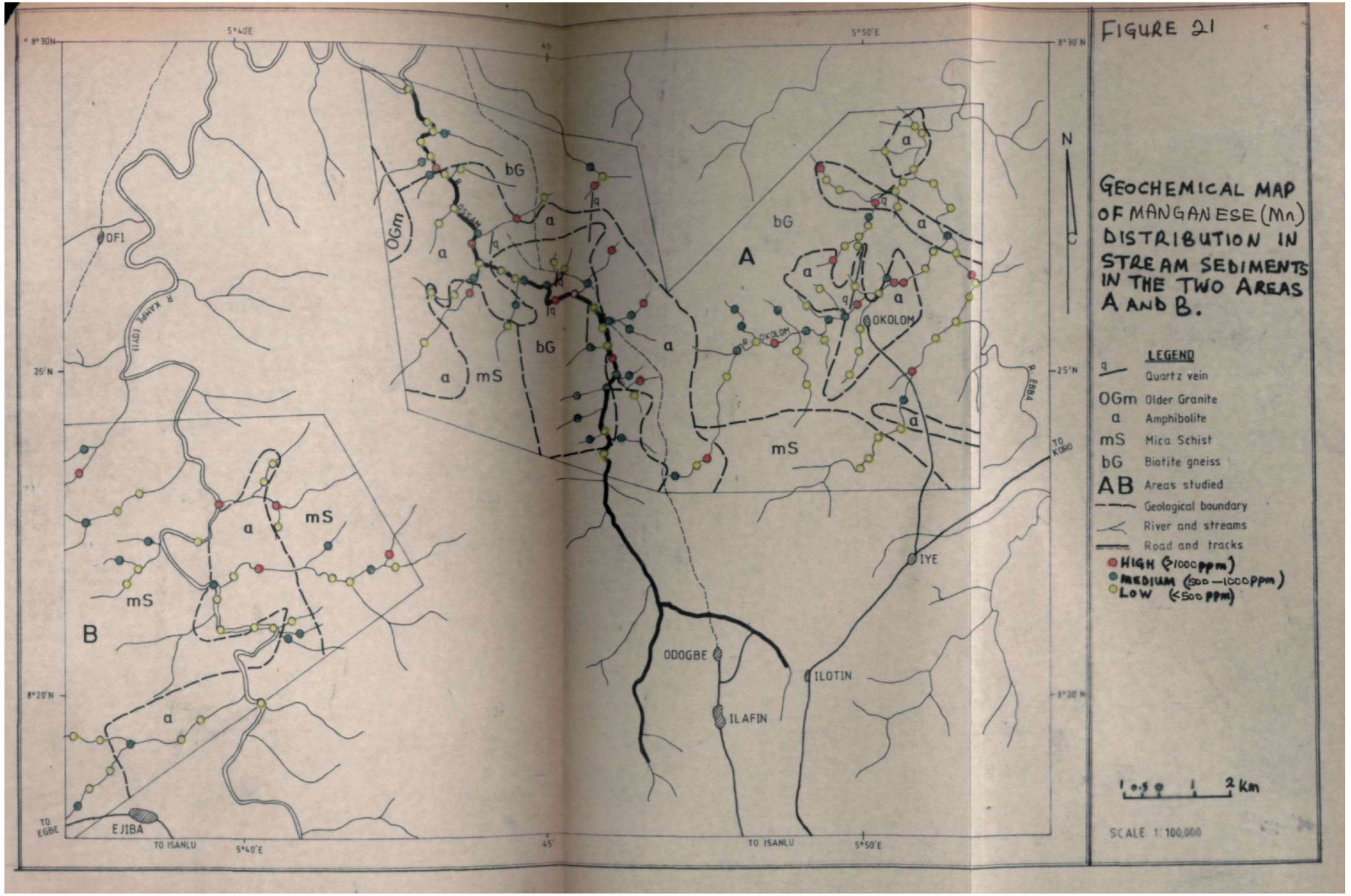


GEOCHEMICAL MAP OF IRON (Fe) DISTRIBUTION IN STREAM SEDIMENTS IN THE TWO AREAS A AND B.

LEGEND

- q — Quartz vein
- OGm — Older Granite
- a — Amphibolite
- mS — Mica Schist
- bG — Biotite gneiss
- AB — Areas studied
- Geological boundary
- River and streams
- Road and tracks
- HIGH (>1% ppm)
- MEDIUM (0.5–1% ppm)
- LOW (<0.5% ppm) < 0.5%

FIGURE 21


GEOCHEMICAL MAP OF MANGANESE (Mn) DISTRIBUTION IN STREAM SEDIMENTS IN THE TWO AREAS A AND B.
LEGEND
q Quartz vein
OGm Older Granite
a Amphibolite
mS Mica Schist
bG Biotite gneiss
AB Areas studied
Geological boundary
River and streams
Road and tracks
HIGH (>1000ppm)
MEDIUM (500–1000ppm)
LOW (<500ppm)
1 0.5 0 1 2 Km
SCALE 1: 100,000
N
A
B
OFI
R. KAHPE (OFI)
OKOLOM
R. OKOLOM
R. EBBA
IYE
ODOGBE
ILOTIN
ILAFIN
EJIBA
TO EGBE
TO ISANLU
TO KOKO
8°30'N
8°20'N
5°40'E
5°50'E
45'
25'N

to maximize heavy mineral concentration, and (ii) both areas A and B are geologically very favourable for Au which is believed to be dispersed through amphibolites (Elueze, 1982) in both areas.

The threshold value of 6.5ppm of A is higher than that of B-1.5ppm. This may be interpreted to indicate more sources of Au in A than B in form of the Au - bearing quartz veins. The extent of Au dispersion train in the stream sediments (as a heavy mineral) has been shown to extend for many kilometers downstream (Boyle, 1979). The concentration level of Au in this survey may be related to suitable conditions for alluvial concentrations being present since most of the samples were collected from sites considered suitable for heavy mineral concentration. Nevertheless, high Au values are found up to one kilometer in the downstream drainage channels from five of the main Au-bearing quartz veins (Figure 15).

High values in the major drainage channels of the Kampe and Ossam are not considered to be indicative of quartz vein mineralization in the immediate civinity (except where the Ossam cuts the Dogon-Daji vein system) but are probably alluvial concentrations whose source may be distant. Several other high and medium values occur without associated known vein mineralization and usually upstream of the known veins. These are marked I to V inFigure 15 and are further discussed in section 4.5.7.

Au shows a lack of significant correlation with any of the other elements (Tables 4.3, 4,4 and 4.5) in the three areas. This may indicate that only Au is carried in discrete grains in the dispersion train in the medium sampled whereas other elements move partially in solution.

Silver (Ag). The general distribution of Ag has been problematic resulting in ill-defined patterns in both histograms and CFD curves. The problem arises from the lack of 'enough' classes of concentration to allow for statistical interpretation. This may be traced to the low concentration level of silver in the medium sampled; which makes detection difficult and problematic. Furthermore, the lack of significant correlation with any of the other elements including Au is difficult to explain. As a result of these problems it seems no reasonable interpretation can be made from Ag in the stream sediments. Even in the map (Figure 16) no individual or group of high values can be related directly to any known mineralized quartz veins.

Copper (Cu). Histograms (Figures 9, 10, and 11) show a sort of bimodal lognormal patterns for Cu. This has not been reflected in the CFD curves (Figures 12, 13, and 14). Instead, the CFD curves for Cu fit well to a lognormal single population pattern. The CFD curves are considered more reliable than the histograms in testing lognormal distribution. Since Cu values show a lognormal single population, Cu is therefore considered to occur as a single

population in the three cases.

Cu values are most likely to be associated with the amphibolites in both areas A and B and the vein mineralization not sufficiently rich in Cu to constitute a second population.

Only two high Cu values can be related to the known mineral occurrences in quartz veins (Figure 17). Many medium values are widespread and cut-across all lithologies and drainage types. This may explain the extreme mobility of Cu with sources in amphibolites and mineralized quartz veins.

Significant correlation exists between Cu and Pb in A and such correlation is lacking in B. However, there is no significant correlation existing between any element pairs in B. The combination of values of the two areas A and B shows a significant correlation between Cu and Zn in addition to the one between Cu and Pb in A. The significant correlation between Cu and Pb and Cu and Zn may indicate a common source consisting of a chalcophile association.

Lead (Pb). Pb shows two distinct populations in both the histograms and the CFD curves, but the histograms show this better and are used to estimate thresholds as discussed in section 4.5.3.

There is a significant correlation between Pb and Cu and Pb and Zn in A and the lack of it in B (Table 4.3, 4.4 and 4.5). The combination of the data in A+B show another

significant correlation between Pb and Fe. The Cu - Pb - Zn association has been reflected in the correlation analysis. This associations are better defined in A which may suggest their role as indicators of the quartz-gold-sulphide vein mineralization typical of the area (A).

In Figure 18, some of the high Pb value can be directly related to the known quartz vein mineralizations. Some of the high values can be due to adsorption by Fe-oxide as indicated by the correlation between Pb and Fe.

Zinc (Zn). A well-defined lognormal distribution pattern in both the histograms and the CFD curves (Figures 9, - 14) in the three areas (A,B and A+B). The significant correlation that exist between Zn and Pb and Zn and Cu (Tables 4.3, 4.4 and 4.5) has been discussed.

Some of the high Zn values (Figure 19) are associated with known, quartz vein mineralizations. The many others may indicate undetected mineralized bodies or due to effects of adsorption by clays and organic matter.

Iron(Fe) and Manganese (Mn). Generally Fe and Mn (except in B) show lognormal pattern (Figures 9 - 14). In B, a distinct two populations of Fe emerge (Figure 13). The correlation that exist between Fe and Mn (Tables 4.3 and 4.5) is a common feature of tropical weathering conditions.

In Figures 20 and 21, it is observed that the high values of Fe and Mn are so widespread that are very difficullt to related to any feature.

4.5.6. Gold in Heavy Mineral Concentrate.

The heavy mineral survey was restricted to Au as a heavy mineral. The purpose of the method has been briefly discussed earlier in this Chapter. Figure 8 shows the distribution of Au in the heavy minerals in the area of study. Since most heavy mineral and stream sediment samples were collected from the same sites, this method of survey will be useful in confirming or otherwise of patterns of Au distribution obtained in the drainages by either method.

Figures 8 and 15 show that spatial distribution of Au in heavy minerals and stream sediments respectively. Many areas of high Au value coincide in both figures and these are the ones associated with known Au-bearing bodies and other areas that are favourable for Au occurrence. For example, the three Au-bearing quartz veins drained by River Ossam are associated with high Au values in both Figures 8 and 15, so also the yicinity of Okolom Reef. The area marked I in Figure 15 which shows consistent high Au and other metal values have been picked-up as an area of high Au-values in the heavy mineral survey. Infact many other areas such as I to V in Figure 15 of high Au values not related to known Au-bearing veins coincide in both Figures 8 and 15. However, most of these are not unexpected as the media sampled are all favourable for the mechanical accummulation of Au in the drainage.

This shows that either methods (stream sediment or heavy mineral survey) despite their short-comings can be used effectively for Au at reconnaissance stage to outline areas worthy of follow-up survey. But the heavy mineral survey is a more effective exploration tool for Au in this case as it is cheaper, quicker and gives results in the field.

One particular feature observed in the heavy mineral survey using the amalgamation process is the ultra-sensitivity of the weighing instrument compared to the stream sediment AAS method. It can be observed that up to $0.001g/m^3$ (equivalent of 0.04 ppm) can be detected by the amalgamation method, whereas such sensitivity (detection) cannot be achieved by the AAS used.

4.5.7. Summary.

The geochemical patterns of the element distribution have been enumerated. Many features may be useful in the application of the geochemical patterns described to the prospecting for Au deposits.

The primary Au-quartz vein mineralization are reflected by high Au values in stream sediments and heavy minerals though the widespread nature of the values indicate a long dispersion train of Au.

Lognormal distribution pattern appears to be the one most applicable to most of the element studied in the three areas. The unclear patterns of some elements

observed in B may be due to the small number of samples considered compared to those for A. However, this "barren" area (B) (with regards to primary Au-quartz veins) has a lower threshold value of Au (4.5 ppm) and other elements than A (6.5 ppm) known to include mineralized veins.

Several areas (marked I - V) of high Au values including the Ossam Valley in Figures 8 and 15 have no mineralized vein outcrops and therefore need further investigations.

The Pb/Cu and Pb/Zn correlation may be significant in outlining areas of vein mineralization since the lack of it characterise the "barren" area (B).

The overall high Au background values is indicative of a metallogenetic area favourable for Au.

CHAPTER 5

5. EVALUATION OF PROSPECTS

Following the combined geological and geochemical investigation some gold prospects have been delineated in the study area for necessary attention. These prospects include primary vein deposits and eluvial and alluvial placer deposits located during the investigation. Preliminary evaluation of the potentials of these prospects has been attempted to examine their characteristics to determine if they could be worth follow-up work.

Several areas are also indicated by stream sediment and heavy mineral survey to be potential sources of gold notably some primary vein-type mineralization as yet unfound (and there may also be secondary mineralization) that require detail follow-up.

5.1. OKOLOM REEF.

The Okolom Reef (as discussed in Chapter 2 and 3) is the most prominent of all the quartz veins mapped in the study area. It carries a gold - sulphide mineralization and is associated with mineralized minor quartz lenses and stringers in the wallrocks. The main zone of the Reef extends for about 800m along strike length and contains significant values of gold and minor values of silver, cadmium, copper, lead and zinc.

Past mining activities were concentrated mainly in the weathered altered wall-rocks which evidently are decomposed

and enriched by secondary processes. What is seen today of Okolom Reef is a block of vein quartz flanked by deep excavations usually on both sides representing the zone of the enriched altered wallrocks (Plate XVII). The evaluation of the Okolom Reef from the present work was hindered by lack of continous exposure due to past mining activity and also lack of sub-surface sample materials. Much of the vein and wallrock material which could reveal the necessary geologic information were removed or displaced by past miners. The present evaluation was done utilizing only the vein quartz. This handicap should be taken into consideration while assessing the potentials of the Reef.

5.1.1. Evaluation of Metal Content.

The sampling and analysis of the vein samples (as discussed in Chapter 3) has enabled the identification of the main metal-rich zone (ore shoot) of the Okolom Reef. This zone can also be outlined from the concentration of past mining activity (See Figure 3). These indicated that the zone extends continously for about 800m along strike length. The following average grades of metals have been calculated:

Au = 2.34g/tonne

Ag = 1.5g/tonne

Cu = 0.005%

Pb = 0.003%

Zn = 0.002%

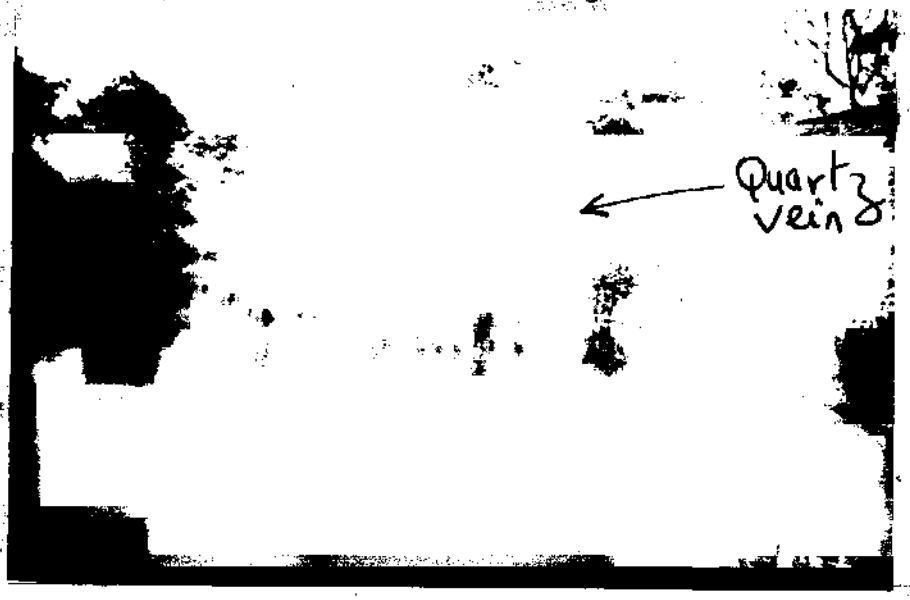


Plate XVII.

Pattern of past mining in Okolom Reef. Excavations were concentrated in the altered wallrock of the Reef.

It can be observed that only the grade of Au is significant and possible mineable, and is the only one to be evaluated in this exercise.

The only record of subsurface geology has been reported in the Quarterly Reviews of the Mines Inspectorate of Northern Nigeria (1948 - 1956). It was reported that two shafts were sunk in the altered wallrock and one shaft in the main vein quartz. It was reported that the maximum depth attained was 55 feet (16.76m). The zone of oxidation and secondary enrichment was reported to persist up to 30 feet (~ 9.0m) level which marked the boundary between altered and unaltered ores. The Mines Inspectorate Review further reported that gold values of over 1oz per ton were mined from the oxidized zone but only few dwt. of gold were obtained from the unaltered zone.

The past miners have had great limitations to the extent of mining due to lack of equipment and the mining of such primary deposits were abandoned due to the emergance of the Ilesha alluvial deposits of late 1940s. Personal comments from some of the Old miners indicated a widespread lack of safety in the mines leading to mine accidents prior to the movement to the Ilesha fields.

In the present evaluation, gold metal content has been estimated for the block of the vein quartz only. This block is about 800m long with average width of 2m and extends to 9m depth representing the portion of the

Reef within the zone of oxidation and secondary enrichment.

Volume of block of vein quartz = 14,400m^3 (800x2x9)

Specific gravity of quartz = 2.6

Average grade of gold = 2.34g/tonne

Tonnage (Volume x S.G) = 37,440 tonnes

Gold content (Tonnage x grade) = 87,610g Au

= 2,817oz. Au.

This estimation indicate that about 2500 troy ounces of gold might be won from the block of vein quartz above the 9m level (mining involves losses of metal). In addition some secondarily enriched wallrock material might be mined but this cannot be quantified at this stage.

5.2. OKOLOM ELUVIAL DEPOSIT

Most of the mineralized quartz veins and slicified zones are associated with eluvial gold deposits in form of metal-rich weathered residue in their immediate vicinities. The most extensive developments of such deposits are centred around the Okolom Reef and the Dogon-Daji-Kachakacha zones which carry numerous mineralized veins, lenses and stringers of quartz. In these two areas, the eluvial deposits occur as a blanket-like deposits on a relatively flat-lying terrain; and have been mined for gold in the past. Mining in the past was evidently on a small scale in pockets which indicate selective mining of the pay streaks.

During the present work, the Okolom eluvial deposit has been investigated. Systematic pitting was carried out in an area of about 250,000m^2 within the immediate vicinity of the main zone of the Reef (Figure 3). Twenty nine pits were sunk to the bedrock in the eluvium and were spaced at a regular interval of 100m. One sample each was collected from the pits, with two headpan-volumes of pit material (~ 0.016m^3) collected as representative as possible to represent one sample. Usually, a sort of channels were cut in the walls of the pits from the surface to bedrock. The sampled material was then panned to obtain the heavy fractions which were analysed by amalgamation process (Chapter 4) and the result expressed in g/m^3 (Table 5.1).

It has been found that the average thickness (depth to bedrock) of the eluvium is about 0.8m. The pitting, however, revealed that the gold is not uniformly distributed in the eluvium but the gold values are restricted to some pockets in the eluvium. The majority of the pits showed no gold value. This may mean that either such places are barren or they have been extracted by past mining. The indications of widespread past mining may mean that most of the gold in the Okolom eluvium had been mined and the few values obtained in some pits may be waste tailings of the past mining.

Table 5.1.

Data obtained from pits in Okolom Eluvial deposit.

PIT AND SAMPLE NO.	THICKNESS DEPTH (M)	GOLD VALUE g/m^3
PTK 4100E	1.0	0.025
PTK 4101E	0.8	0.031
" 4102E	0.8	0.003
" 4103E	1.04	Nil
" 4104E	0.5	"
" 4105E	0.7	"
" 4106E	0.8	"
" 4107E	0.8	"
" 4108E	0.7	"
" 4109E	0.5	"
" 4110E	0.7	"
" 4111E	0.6	"
" 4112E	0.7	0.031
" 4113E	0.8	Nil
" 4114E	0.7	0.025
" 4115E	0.7	0.025
" 4116E	0.7	Nil
" 4117E	0.8	Nil
" 4118E	0.6	0.003
" 4119E	0.8	Nil
" 4120E	1.2	"
" 4121E	0.8	"
" 4122E	0.7	"
" 4123E	1.0	0.062
" 4124E	0.4	Nil
" 4125E	1.0	"
" 4126E	1.0	0.062
" 4127E	0.7	Nil
PTK 4128E	1.0	Nil

238055

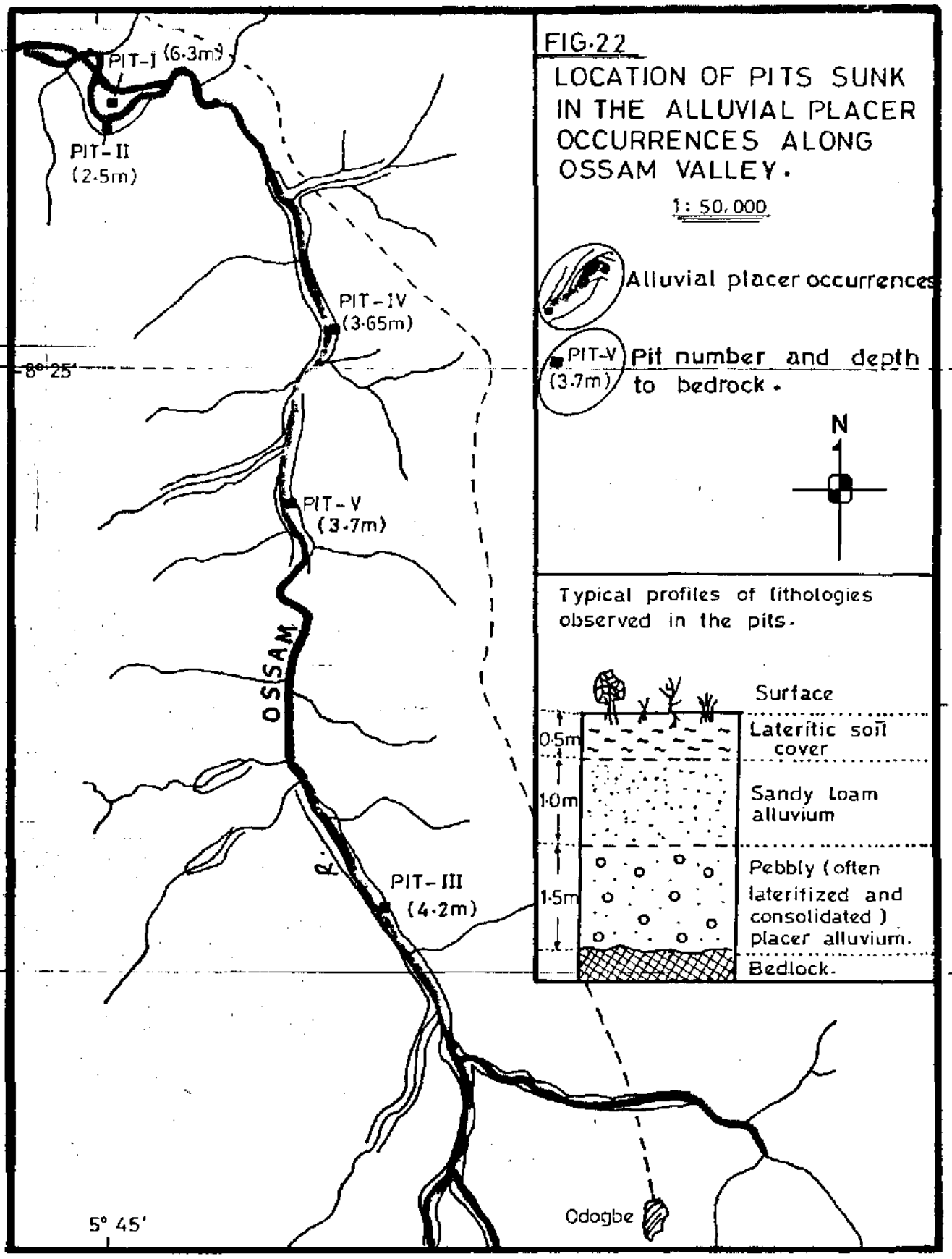
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5.3. ALLUVIAL PLACER DEPOSITS

Alluvial placer occurrences are developed in the present water courses along the valleys of most major streams and rivers; the most prominent being along the valleys of River Ossam and its tributaries. The alluvial placer occurrences within the Ossam Valley are extensive in some places, but are generally erratic in their occurrence (Figures 2 and 22). These alluvial placer occurrences are found to be gold-bearing wherever they were studied.

To study these alluvial placers, five pits were sunk in locations within the occurrences along the Ossam Valley (Figure 22). Pits were sunk to the bedrock and sampling was carried out such that all lithologic units were sampled separately and a representative channel sample was collected also from each pit. This was to study the nature of the gold occurrences with respect to the lithologic layers constituting the placers. Each sample was collected as two headpan-volumes (~0.016m^3) of alluvial material. This was then panned and analysed by the Amalgamation process.

At the points of pitting, pits were located 30m from the stream bank up-slope. This was done to check whether the alluvial successions, which are seen on the banks, extend up to 30m away from the stream channels. It was observed that at the points of pitting, the alluvial placer thickness varies from 2.5 to 4.2m with average thickness of about 3.5m. It is reasonable to assume that


PIT-I (6.3m)
PIT-II (2.5m)
PIT-IV (3.65m)
PIT-V (3.7m)
PIT-III (4.2m)
OSSAM R.
8° 25'
5° 45'
Odogbe
FIG.22
LOCATION OF PITS SUNK IN THE ALLUVIAL PLACER OCCURRENCES ALONG OSSAM VALLEY.
1: 50,000
Alluvial placer occurrences
PIT-V (3.7m) Pit number and depth to bedrock.
N
Typical profiles of lithologies observed in the pits.
Surface
0.5m
Lateritic soil cover
1.0m
Sandy loam alluvium
1.5m
Pebbly (often laterifized and consolidated) placer alluvium.
Bedlock.

the alluvial placer occurrences maintain this thickness for about another 20 to 30m up-slope. It has therefore been estimated that the alluvial placers extend for approximately 50m on both sides of the stream channels (Figure 22).

It was observed that the lower quartz-pebble alluvial placer (wash) carries most of the gold values. Therefore, the gold content tends to increase from the surface downwards to the bedrock. The lower layer near the bedrock carries the highest values as is usual in alluvial deposits (Boyle, 1979).

From the analysis of the five pits dug, average grade of the alluvial placers was estimated to be about 0.15 g/m^3 (approximately 0.1 dwt.).

Other potential alluvial gold placer occurrences are widespread in other stream and river valleys in the area (Figure 2) but have not been investigated during the present work.

The indicated average gold grade of 0.15g/m^3 is not rich, but the consistent and widespread occurrence of gold in an extensive area like this does require further work to locate higher grade sections for development.

5.4. ECONOMIC CONSIDERATIONS.

It will be pramature to conclude on the economic viability of the gold deposits studied. However, the work done has been successful in delineating some potential gold resources in the area studied and their viability or otherwise can be determined with some follow-up work.

5.4.1. Okolom Reef.

The Okolom Reef vein quartz has been estimated to average 2.3dwt/tonne and contains some 37,000 tonnes to a depth of 9m with a total contained gold of about 2,600 troy ounces. In addition some additional mineralization may be available during any open pit mining operation from the secondarily enriched wallrocks. Some diamond drilling is essential to properly evaluate the potential of this deposit. However, even for open pit operations the grade seems low and any exploitation may be dependent on a considerable increase in available tonnage or the use of a mobile treatment plant. At such grades any operation is very dependent on World gold prices, currently at a record low level.

5.4.2. Okolom Eluvial Deposit.

It seems the gold in the eluvium around the Okolom Reef had been exploited by past miners and there doesn't seem to have any valuable gold occurrences left in it. As such it is doubtful whether any further investment on it may yield any favourable result.

5.4.3. Ossam Valley Placer Deposits.

The Ossam Valley alluvial placers have been assessed only using five irregularly spaced pits. The average grade of the gold placers was estimated to be about 0.1dwt. which is comparable to the Ilesha placers that are considered economically viable by the Nigerian Mining Corporation and are currently operated at a pilot scale.

A simple comparison is shown in Table 5.2 below between the Ossam Valley placer deposits and the Ilesha Phase I placer deposits which are being operated by the N.M.C. It must be stressed that the Ossam Valley figures are based on minimal data and at best only indicate a potential, whereas the Ilesha Phase I data are the result of extensive work.

Table 5.2.

Comparison between Ossam Valley and Ilesha Phase I placer deposits.

	Ossam Valley	Ilesha Phase I
Area (m^2)	1,500,000	3,201,318
Average depth (m)	3.5	2.5
Volume (m^3)	5,250,000	8,153,295
Average grade (dwt/m^3)	0.1	0.1
Estimated gold content (oz)	26,250	40,766

By rough comparison the Ossam Valley and Ilesha Phase I can be similar in gold resources, though a less accurate method of evaluation was used for the Ossam Valley. If a more accurate method of evaluation similar to the Ilesha Phase I bank, drilling programme can be used for the Ossam Valley, the grade estimated may be confirmed or even enhanced.

CHAPTER 6

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. CONCLUSIONS.

The geologic framework of the area studied has been fairly understood. The general geologic set-up is comparable to the Ilesha schist belt, both consist of metavolcano - sedimentary rocks and widespread gold mineralization similar to greenstone belts. The area of the present study is certainly one of the schist belts of the Southwestern Nigeria Basement Complex and has not been given the necessary attention by many workers. It has been found that the belt is more extensive than hitherto considered. A problem remains with age relationships of the different rock units mapped. Many tectonic aspects too, remain obscured.

Mineralization is evidently two types: the vein-type and disseminated type in amphibolites where gold and sulphides are the principal components. Derived from these, are products of secondary processes which are mainly metal rich (mainly gold) eluvial and alluvial deposits. The origin of the gold mineralization is uncertain: however, the structural controls of the mineralization has been understood. Whether the amphibolites are the source rocks or are mineralized like the quartz veins is not understood. However, recent models of gold mineralization as discussed earlier, favour the influence of granitic intrusions with the fractures and shear zones

acting as structural controls of the mineralization. Both the granitic bodies, fractures and shear zones occur in the study area.

The method of concurrent sampling of stream sediments and heavy mineral fractions used in the geochemical prospecting was found to be useful in maximizing field opportunities but is not cost-efficient. The usefulness of using stream sediments and heavy minerals as exploration tools at reconnaissance stage for gold have been assessed. It was found that the heavy mineral survey is a better exploration tool because it is quicker, cheaper and gives result in the field to guide fieldwork.

The usefulness of the stream sediment in geochemical prospecting has been realised but was characterized by liritations due to costs and sampling errors. Due to costs only few sample could be analysed for so few elements. Sampling and analytical methods must sacrifice precision for speed due to the nature of the prospecting and appropriate attention has not been given to achieve a homogeneous collection of samples from the many types of streams and lithological units. Since statistical interpretation is a key to geochemical prospection, a reliable statistical interpretation requires that a great quantity of data be treated and that these data be homogeneous (Lepeltier, 1969).

Lognormal distribution pattern appears to be the one most applicable to the results of the stream sediment survey. The unclear patterns shown in Area B

may be due to the small number of samples considered. The most noticeable feature is the generally very high level of gold in the stream sediments and heavy minerals, suggesting that the area is favourable for gold occurrences. The higher threshold level of gold in Area A than Area B and the existence of significant correlation of Pb/Cu and Pb/Zn only in the former has been interpreted to indicate the presence of gold-bearing quartz veins in Area A relative to B. The threshold level of gold in Area B is attributed to the gold mineralization in the amphibolites. Area B has been found to be "barren" only to gold-quartz veins. Gold in the stream sediments shows no significant correlation with any of the other elements studied. This may be due to the different media of dispersion, where gold is carried into dispersion train as discrete grains whereas the other base metals are taken chemically into the train.

The survey has ended up in delineating some prospective targets for gold deposits. These include the Okolom Reef, Ossam Valley and the areas with anomalous metal values (particularly gold) revealed by stream sediment geochemical survey and also confirmed by the heavy mineral survey. All these coupled with the favourable geology makes the area of great potential value for gold. If these targets are further assessed they may end up meeting the objectives of the programme.

6.2. RECOMMENDATIONS.

1. The vast area north of the present study area remain unexplored as was not covered by the present work. It may be that similar geological and geochemical features continued northwards. Therefore, a reconnaissance survey is diserable to cover the area. From the result of the present work, a combined geological and heavy mineral survey is strongly recommended.

2. It is hoped that the potentials of the area studied for gold will not be over emphasied. Even Dr. R.W. Boyle during his visit to Nigerian Mining Corporation's Gold Projects in 1933 remarked: "In priority I would rank the Iperindo and Okolom deposits for equal attention, followed by the Dukki Mines, Kwali Prospects and the shear zones northwest of Okolom Mines".

3. The Okolom Reef deserves more detailed exploration, the most appropriate method should be diamond drilling.

4. Soil geochemistry and diamond drilling are recommended to adequately cover and assess the Dogon-Daji-Kachakacha shear zones.

5. Close grid banks drilling is required to further evaluate the Ossar Valley alluvial gold deposits. Reconnaissance pittings can be done to study the other alluvial occurrences not studied in this work.

6. Detailed investigations involving soil geochemistry should be carried out in the high gold value areas marked I - V in Figure 15.

7. Finally, the economic potentials of the widespread talc deposits should be investigated to compliment the Country's current drive towards local industrial raw materials.

REFERENCES

1. Ajibade, A.C., 1976. Provisional classification and correlation of the schist belts of NW Nigeria. In Geology of Nigeria, Kogbe (Ed) P. 85 - 90. Elizabethan Pub. Co., Lagos.

2. Ajibade, A.C., 1982. The cataclasic rocks of the Zungeru region and their tectonic significance. Journ. Min. Geol. 18(2)P. 29 - 41.

3. Antweiler, J.C., and Campbell, W.L., 1982. Gold in Exploration Geochemistry. Precious metals in the Northern Cordillera. The Association of Exploration Geochemists. Levinson (E d).

4. Arogundade, C.O., 1973. Geology of the Isanlu Area, Sheet 225 (Isanlu) 1:100,000. Unpubl. Geol. Surv. Nig. Rpt.

5. Befor, B.E., 1979. Volcanogenic - sedimentary formations in parts of SW Nigeria. Unpub. Ph.D. Thesis, Univ. of Belgrade.

6. Befor, B.E., 1981. The occurrences of sulphide mineralization in the Egbe Area of SW Nigeria. Journ. Min. Geol. 18(1)P. 175 - 179.

7. Boyle, R.W., 1979. The Geochemistry of Gold and its deposits. Geol. Surv. Can. Bull. 280 PP. 584.

8. Boyle, R.W., 1983. Brief Summary of Consultancy to Nigerian Mining Corporation on Gold (Unpubl.)

9. Cooray, P.G., 1974. Some aspects of the precambrian of Nigeria - A review. Journ. Min. Geol. 8(1) and (2) P. 17 - 43.

10. Demspter, A.N., 1967. Geol. Surv. Nig. Sheet 61 Akure. 1: 250;000.

11. DeSwardt, A.M., 1953. The ge ology of the country around Ilesha, Nigeria. Geol. Surv. Bull. No. 23 PP. 54.

12. Elueze, A.A., 1981. Geochemistry and tectonic setting of metasedimentary rocks of the schist belt of Ilesha Area of SW Nigeria. Jour. Min. Geol., 18(1)P. 194 - 197.

13. Elueze, A.A., 1982. Metallograp hic studies of ore minerals in the amphibolities of Ilesha schist belt, SW Nigeria. Jour. Min. Geol. 18(2)P. 53 - 58.

14. Elueze, A.A. and Olade, M.A., 1977. Geology of the Ilesha Area and relationship to gold mineralization. Jour. Min. Geol. 14(2)P. 60.

15. Harris, J.F., 1982. Sampling and analytical requirements for effective use of Geochemistry in Exploration for gold. In: Precious metals in the Northern Cordillera. The Association of Exploration Geochemists. Levinson (d).

16. Higgins, M., 1971. Cataclastic rocks. Prof. pap. U.S. Geol. Surv. 687 PP. 97.

17. Jaques, E.H., 1945. The geology of the Egbe District, Kabba Province, Geol. Surv. Nig. Rept. No. 1198 (Unpubl.)

18. Jeje, L.K., Adejuwon, J.O., and Ojo-Atere, O.J., 1982 Physico - Chemical changes in soils subject to sheet wash erosion, Oyi, L.G.A., Kwara State. Jour. Min. Geol. 18(2)P. 132 - 139.

19. Klemm, D.D., Scheneider, W., and Wagner, B., 1984 The Precambrian metavolcano-sedimentary sequence east of Ife and Ilesha SW Nigeria. A Nigerian 'green - stone belt' Journ. Afri. Earth Sc. 2(2)P. 161 - 176.

20. Kreiter, .V.M., 1968. Geological prospecting and exploration. MIR Publ. MOSCOW.

21. Lepeltier, C., 1969. A simplified statistical treatment of geochemical data by graphical presentation. Econ. Geol. 64P. 538 - 550.

22. MacLeod, W., 1963. Memorandum on the Isanlu Makutu talc deposit. Geol. Surv. Rept. No. 1198 (Unpubl.).

23. Mathels, G., and Caen-Vachette, M., 1983. Rb - Sr isotopic study of rare-metal bearing and barren pegmatites in the Pan-African reactivation zone of Nigeria. Jour. Afri. Earth Sc. 1(2) P. 35-40.

24. Milovsky, A.V., 1982. Mineralogy and patrology. PP. 439, MIR Publ., MOSCOW.

25. Mines Inspectorate of Northern Nigeria, 1941-1956. Rept. No. C.196, C.182, C.832, C.194 and AR 1/29. In the National Archieves, Kaduna.

26. Olade, M.A. and Elueze, A.A., 1979. Petrochemistry of the Iiesha amphibolites and Precambrian crustal evolution in the Pan-African domian of SW Nigeria. Precamb. Res. 8, P. 303-318.

27. Oyawoye, M.O., 1964. The geology of the Nigerian Basement Complex. Jour. Nig. Min. Geol. Metall. Soc. Vol. 1.

28. Oyawoye, M.O. 1972. The Basement Complex of Nigeria. In African Geology, Ibadan. Dessauvegie and Whiteman (Eds.). Geol. Dept. Univ. Ibadan, Nigeria. P.67-99.

29. Pargeter, R.C., 1958. The auriferous quartz veins near Diko, Abuja Division, Niger Province. Geol. Surv. Nig. Rept. No. 1173.

30. Rahaman, M.A., 1976. Review of the Basement Geology of SE Nigeria. In Geology of Nigeria. Kogbe (Ed.) P. 41-58. Elizabethan Publ. Co. Lagos.

31. Rose, A.W., Hawkes, H.E., and Webb, J.S., 1979. Geochemistry in mineral exploration (2nd Ed.) PP.657. Academic Press.

32. Russ, W., 1957. The geology of parts of Niger, Zaria, and Sokoto Provinces with special references to occurrences of gold. Geol. Surv. Nig. Bull. No.27. PP. 42.

33. Sibson, R.H., 1977. Fault rocks and fault mechanisms. Geol. Soc. Lond., 133(3)P. 191 - 214.

34. Sinclair, A.J., 1974. Selecting of threshold values in geochemical data using probability graphs. Jour. Geochem. Explor. 3 P. 129 - 149.

35. Smirnov, V.I., Ginzburg, A.I., Grigoriev, V.M., and Yakovlev, G.F., 1983. Studies of mineral deposits. PP. 288. MIR Publ., MOSCOW.

36. Tennant, C.B., and White, M.L., 1959. Study of the distribution of some geochemical data. Econ. Geol. 54. P. 1281 - 1290.

37. Turner, D.C., 1983. Upper Proterozonic schist belts in the Nigerian sector of the Pan-African Province of West Africa. Precambrian Research, 21. P. 55 - 79.

38. Woakes, M., and Befor, B.E., 1982. Primary gold mineralization in Nigeria. In Gold 82: The geology, geochemistry and genesis of gold deposits. Foster (Ed.). Geol Soc. Zimbabwe, Spec. Publ. No. 1.

39. Wright, J.B., and McCurry, P., 1970. A reappraisal of some aspects of Precambrian shied geology: Discussion. Geol. Soc. Amer. Bull., 81. P. 3491 - 3492.

APPENDIX (i)

Analytical results (in ppm) of 44 rock samples from Okolom Reef.

Serial No.	Sample No.	Au	Ag	Cd	Cu	Pb	Zn
1.	ROK/4050	0.05	3	3	132	1	22
2.	" 4051	0.05	1	3	112	1	7
3.	" 4052	0.05	2	1	40	1	3
4.	" 4053	0	0	3	12	0	3
5.	" 4054	0.10	2	2	5	0	2
6.	" 4055	0	0	3	22	0.7	5
7.	" 4056	0.1	0	3	24	4	2
8.	" 4057	2.65	4	3	12	34	4
9.	" 4058	0	0	0	21	2	4
10.	" 4059	0.27	2	2	74	14	13
11.	" 4060	0.17	2	2	8	0.5	4
12.	" 4061	2.75	1	4	87	13	55
13.	" 4062	0.10	0	2	11	10	4
14.	" 4063	0.40	1	3	11	3	6
15.	" 4064	3.34	2	0	53	16	50
16.	" 4065	16.85	3	3	41	3	8
17.	" 4066	2.20	1	3	29	8	22
18.	" 4067	3.37	2	1	40	9	4
19.	" 4068	13.25	7	4	268	327	117
20.	" 4069	0.46	1	3	31	2	50
21.	" 4070	0.05	1	3	38	2	62
22.	" 4071	4.75	0	2	9	3	3

APPENDIX (i) CONT'D

Serial No.	Sample No.	Au	Ag	Cd	Cu	Pb	Zn
23.	ROK/4072	0.17	0	1	126	1	24
24.	" 4073	0.23	2	3	25	6	43
25.	" 4074	2.85	0	1	42	7	5
26.	" 4075	0.32	2	1	30	1	47
27.	" 4076	0.28	0	2	8	1	7
28.	" 4077	0.10	2	2	54	26	5
29.	" 4078	1.15	1	0	42	1	3
30.	" 4079	0.80	0	0	11	9	10
31.	" 4080	4.90	0	1	17	2	8
32.	" 4081	0.28	1	1	8	1	7
33.	" 4082	0.40	1	2	64	1	3
34.	" 4083	0.50	2	4	19	10	31
35.	" 4084	0.32	1	3	46	0	14
36.	" 4085	0.23	0	2	5	4	16
37.	" 4086	0.23	2	3	3	1	10
38.	" 4087	0.23	2	2	11	0	4
39.	" 4088	56.90	9	4	15	48	6
40.	" 4090	5.95	1	2	33	20	6
41.	" 4091	0.23	2	4	58	5	12
42.	" 4092	0.90	0	0	9	4	4
43.	" 4093	0.28	0	1	8	0	6
44.	ROK/4094	0.15	2	2	186	1	9

APPENDIX (ii)

Analytical results (in ppm) of 119 stream sediment samples from Area A. [MV = missing value].

A

S/No.	Sample No.	Au	Ag	Cu	Pb	Zn	Fe	Mn
1.	GK/1152	0.80	3	9	1	256	3650	250
2.	" 1154	1.80	4	20	36	266	9600	800
3.	" 5189	0.00	2	14	15	26	4554	960
4.	" 2208	0.80	1	9	2	21	5462	200
5.	" 2212	0.30	1	15	2	19	12594	590
6.	" 2213	1.25	3	16	1	32	21600	900
7.	" 2214	0.50	3	24	1	33	21700	500
8.	" 2218	0.30	2	18	1	24	8330	180
9.	" 2220	1.90	3	12	21	24	12400	900
10.	" 2224	3.60	2	20	2	64	11924	580
11.	" 4049	5.20	5	25	2	16	11188	520
12.	" 4051	0.30	2	36	5	22	MV	MV
13.	" 4053	0.04	3	16	2	8	10,000	12500
14.	" 4054	0.15	2	28	14	36	12594	590
15.	" 4055	0.55	2	21	14	16	2772	1600
16.	" 4056	0.60	0	12	2	17	5320	180
17.	" 4058	MV	1	20	1	12	8264	260
18.	" 4059	1.25	0	11	2	11	10396	520
19.	" 4060	1.50	3	20	8	19	21200	1200
20.	" 4063	0.80	2	20	2	13	14900	MV
21.	" 4065	0.35	3	22	8	20	2858	720
22.	" 4068	0.45	2	10	8	46	3234	560

APPENDIX (ii) CONT'D

A

S/No.	Sample No.	Au	Ag	Cu	Pb	Zn	Fe	Mn
23.	GK/4069	0.40	3	24	1	12	7848	600
24.	" 4071	0.30	0	26	1	28	20800	500
25.	" 4072	0.50	3	21	14	48	6534	1520
26.	" 4074	16.25	2	24	21	40	1132	920
27.	" 4075	0.80	2	17	1	8	9188	340
28.	" 4076	0.30	3	29	61	49	27600	1500
29.	" 4078	0.15	2	30	1	24	11188	730
30.	" 4080	0.25	1	13	14	30	1914	940
31.	" 4083	1.50	2	21	48	36	2460	450
32.	" 4084	0.30	3	24	21	62	19200	800
33.	" 4087	7.10	3	20	28	36	5800	500
34.	" 4090	0.30	3	8	1	6	5800	300
35.	" 4091	0.30	2	34	4	22	28000	1500
36.	" 4093	0.80	0	13	2	21	8056	130
37.	" 4108	1.80	3	20	1	73	5518	380
38.	" 4109	1.25	1	19	2	104	9264	500
39.	" 4110	1.70	2	20	14	40	2660	810
40.	" 4111	0.30	2	33	36	70	10990	220
41.	" 4112	37.50	0	11	1	23	7848	220
42.	" 4114	0.80	2	5	1	30	7716	160
43.	" 4115	0.35	4	332	28	49	4666	820
44.	" 4116	0.35	3	24	28	92	6193	1840
45.	" 4117	0.30	2	8	1	71	9200	800
46.	" 4120	0.30	2	20	44	41	12330	280

APPENDIX (ii) CONT'D

A

S/NO.	Sample No.	Au	As	Cu	Pb	Zn	Fe	Mn
47.	CK/4121	0.30	3	15	1	38	6120	210
48.	" 4122	0.30	3	49	42	64	7050	230
49.	" 4125	0.75	7	24	34	64	4200	720
50.	" 4128	0.15	2	4	31	62	6528	120
51.	" 4129	0.45	2	9	1	70	4196	80
52.	" 4130	2.50	3	14	46	80	4648	730
53.	" 4132	0.15	2	25	2	65	8584	200
54.	" 4169	0.90	3	36	48	46	15650	240
55.	" 4170	0.40	2	4	2	76	15650	160
56.	" 4171	2.75	2	24	56	76	2460	360
57.	" 4240	0.95	3	21	64	44	4556	680
58.	" 4242	3.00	5	14	1	14	12000	400
59.	" 4243	0.90	1	11	1	7	12300	440
60.	" 4248	0.20	0	8	1	15	21400	1600
62.	" 5179	0.35	3	29	38	56	4330	560
63.	" 5180	0.30	0	15	2	22	14924	240
64.	" 5181	0.30	3	12	1	3	18800	1200
65.	" 5182	0.90	2	21	44	38	7200	500
66.	" 5184	1.75	3	11	2	8	8264	650
67	" 5186	0.08	0	34	1	7	12400	500
68.	" 5187	0.55	3	13	36	36	1518	120
69.	" 5188	0.55	2	20	28	32	4554	960
70.	" 5190	0.75	3	36	1	17	6528	330
71	" 5194	0.30	3	24	14	34	1300	800

APPENDIX (ii) CONT'D

A

S/No.	Sample No.	Au	Ag	Cu	Pb	Zn	Fe	Mn
72.	GK/5196	1.20	4	31	1	23	9188	640
73.	" 5197	30.00	4	4	1	22	10990	400
74.	" 5198	2.40	2	25	44	49	15940	600
75.	" 5199	0.30	3	32	21	46	12396	280
76.	" 7002	1.25	2	20	28	37	3234	1460
77.	" 7004	0.50	3	36	1	36	9056	100
78.	" 7005	2.30	3	10	14	27	1396	360
79.	" 7027	8.80	3	9	6	50	11386	1560
80.	" 7031	0.30	3	25	25	79	12264	170
81	" 7033	2.25	1	30	1	14	25200	1200
82.	" 7034	0.80	3	26	2	8	18400	1400
83.	" 7036	0.30	3	14	21	72	7000	500
84.	" 7039	0.35	3	33	21	40	7848	600
85.	" 7040	0.50	2	20	21	35	8462	240
86.	" 7049	0.50	3	9	28	41	2330	840
87.	" 7052	0.45	3	24	40	42	7722	3320
88.	" 7054	0.45	4	13	30	74	4660	800
89.	" 7058	0.45	2	64	48	124	4884	1080
90.	" 7059	0.70	3	40	44	44	17452	330
91.	" 7060	0.45	1	38	2	26	3926	250
92.	" 7063	0.30	3	13	1	16	12500	400
93.	" 7064	1.20	1	8	1	12	12100	900
94.	" 7065	3.60	3	21	32	39	14800	1100
95.	" 7067	5.32	3	11	1	17	7716	280

APPENDIX (ii) CONT'D'

A

S/No.	Sample No.	Au	Ag	Cu	Pb	Zn	Fe	Mn
96.	GK/7037	1.60	1	9	1	12	4792	220
97.	" 7069	0.30	0	17	1	19	9300	3500
98.	" 7070	0.70	2	7	1	60	4000	400
99.	" 7071	0.60	2	8	14	40	728	120
100.	" 7074	3.00	2	20	3	20	18200	900
101.	" 7076	0.40	2	33	2	28	0528	360
102.	" 7078	0.45	1	5	21	82	5254	209
103.	" 7080	0.80	1	21	2	22	12502	340
104.	" 7081	0.30	1	20	21	28	MV	MV
105.	" 7082	1.90	2	38	3	23	14500	1100
106.	" 7087	0.10	2	52	36	43	5780	330
107	" 7091	0.30	2	7	1	12	6400	400
108	" 7093	1.15	3	11	1	11	8800	500
109.	" 7095	0.30	0	29	1	29	27452	330
110	" 7105	0.40	4	24	2	18	10132	330
111	" 5191	2.40	3	22	3	33	21500	500
112.	" 5195	0.30	3	15	2	19	1800	500
113.	" 2223	2.05	2	54	20	125	19240	220
114.	" 2217	0.35	2	19	14	90	2000	480
115.	" 4067	1.50	0	39	8	95	2528	1050
116.	" 4086	1.50	2	35	4	85	14000	520
117.	" 4118	1.00	0	13	14	65	3848	180
118.	" 4123	0.85	0	39	8	270	3650	650
119.	" 7028	0.70	0	88	8	107	5320	570

APPENDIX (iii)

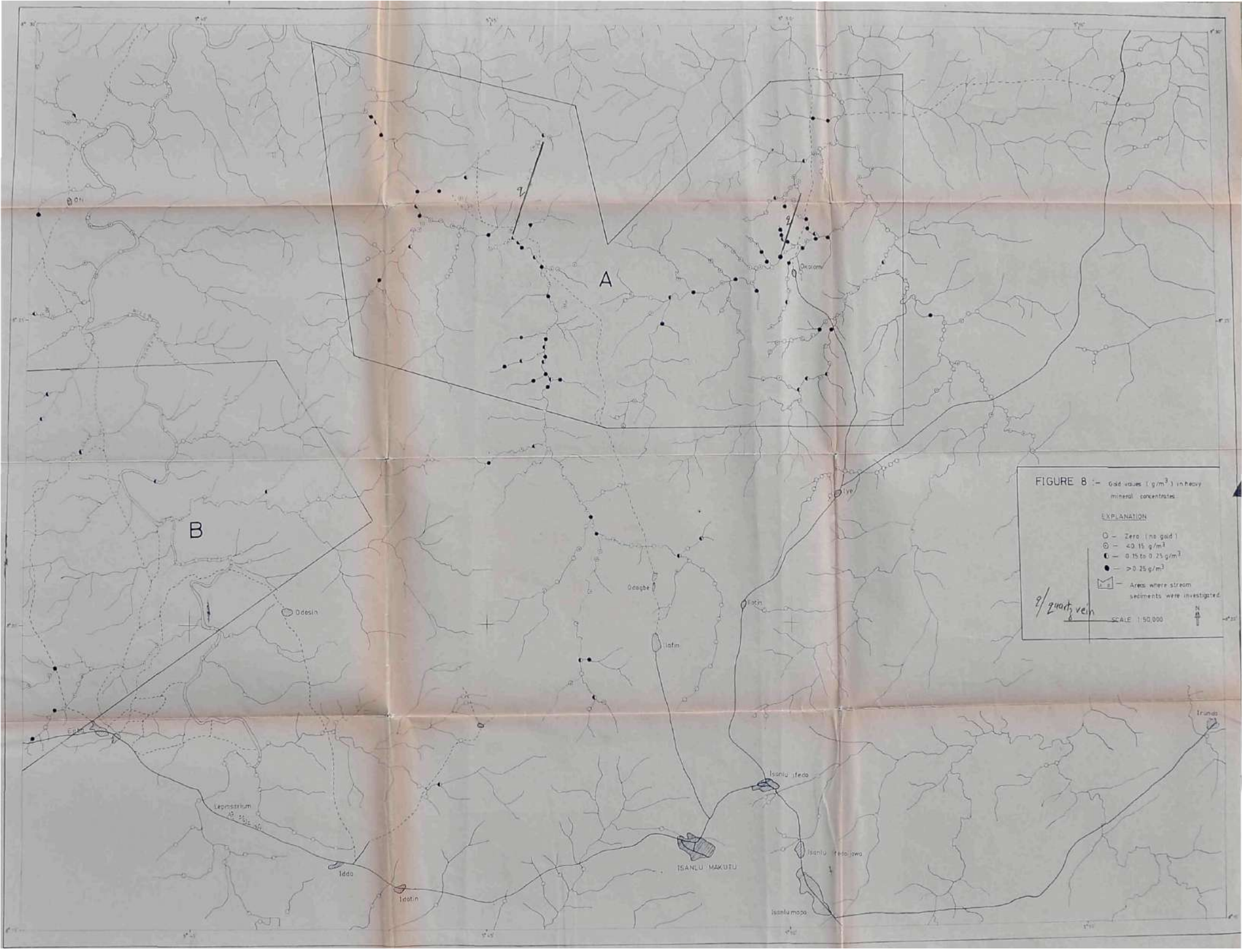
Analytical results (in ppm) of 41 stream sediment samples from Area B.

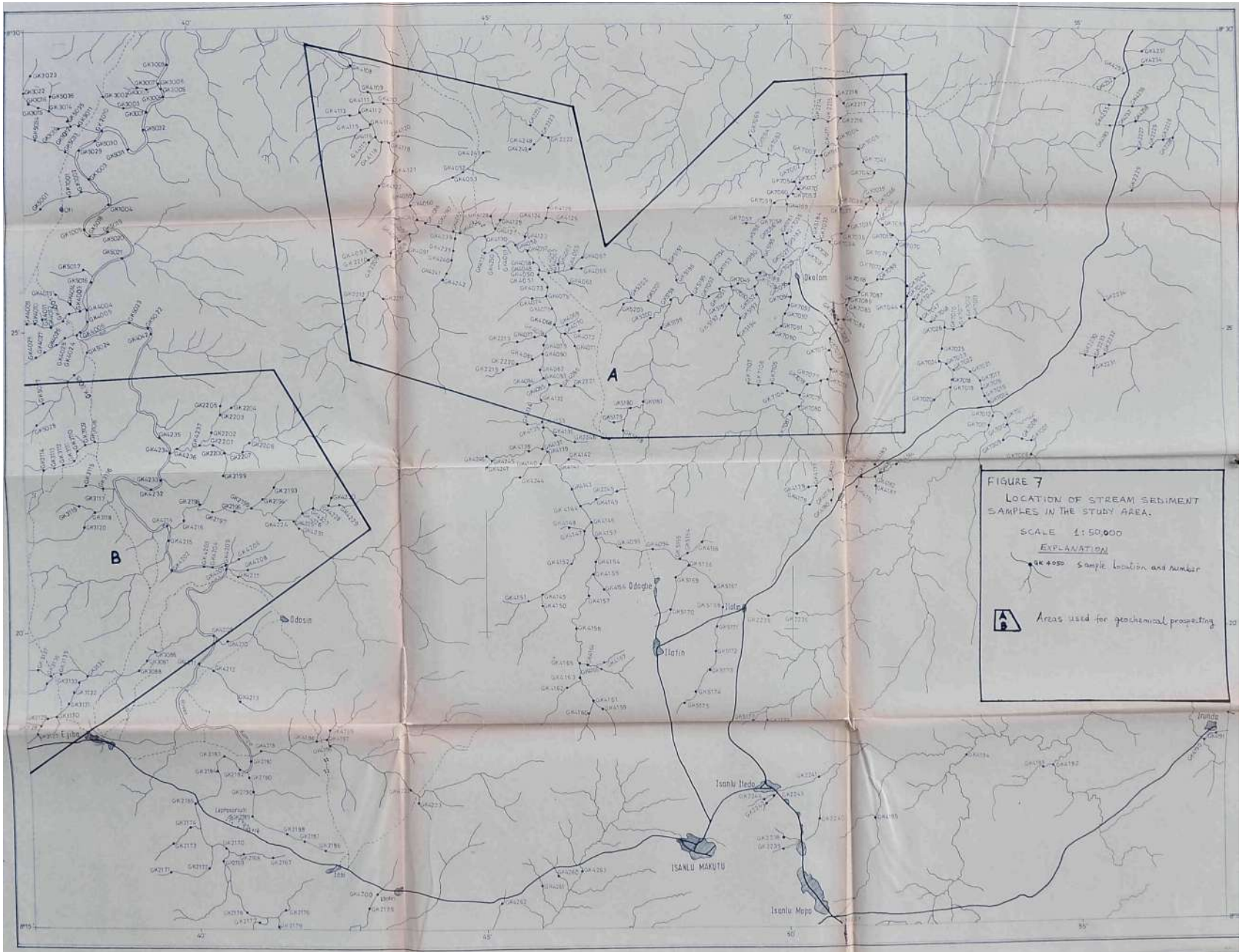
S/No.	Sample No.	Au	Ag	Cu	Pb	Zn	Fe	Mn
1.	CK/2193	0.55	3	54	26	49	3188	600
2.	" 2199	0.20	3	12	1	13	16000	900
3.	" 2200	0.60	3	6	1	38	764	950
4.	" 2202	0.40	2	17	1	27	10396	570
5.	" 3086	0.45	3	20	28	18	2066	240
6.	" 3088	0.60	2	24	48	48	10990	440
7.	" 3108	2.75	2	12	8	25	6330	200
8.	" 3111	0.60	16	8	1	30	4792	200
9.	" 3114	0.20	1	24	28	296	7510	520
10.	" 3116	0.50	1	11	2	30	12500	800
11.	" 3118	0.30	0	14	1	24	6926	170
12.	" 3119	0.60	3	18	2	28	14800	900
13.	" 3120	0.90	3	16	1	33	7188	140
14.	" 3127	0.30	2	30	2	82	13452	570
15.	" 3129	0.20	2	11	1	42	16200	500
16.	" 3131	0.50	2	29	2	56	8594	230
17.	" 3135	0.45	2	22	28	392	4858	250
18.	" 3137	1.10	0	21	4	240	7648	130
19.	" 4202	3.60	3	9	1	7	5188	200
20.	" 4203	2.50	2	4	36	20	924	200
21.	" 4205	1.60	2	20	44	22	1650	240
22.	" 4206	0.60	2	16	1	17	6462	200

APPENDIX (iii) CONT'D

B

S/No.	Sample No.	Au	Ag.	Cu	Pb	Zn	Fe	Mn
23.	GK/4208	0.70	2	20	44	22	2904	960
24.	" 4209	0.70	7	12	44	17	1132	280
25.	" 4214	1.50	3	8	1	21	13200	800
26.	" 4215	0.03	2	4	1	22	3186	160
27.	" 4216	0.00	2	6	1	8	5386	250
28.	" 4217	0.15	2	20	36	72	3188	840
29.	" 4224	2.65	3	22	4	42	2200	500
30.	" 4225	0.50	3	10	49	41	16600	250
31.	" 4227	0.75	2	24	56	46	3716	680
32.	" 4229	1.25	5	22	1	39	13452	260
33.	" 4230	0.30	1	19	2	8	15600	1100
34.	" 4232	0.25	2	14	56	42	2772	240
35.	" 4233	0.50	2	8	1	41	10132	380
36.	" 4234	0.76	2	10	44	56	2316	1240
37.	" 5027	0.30	3	43	2	24	18528	920
38.	" 5028	0.75	2	36	48	39	16600	3800
39.	" 2197	0.70	10	54	4	75	2904	1640
40.	" 2203	0.50	3	50	2	55	14924	690
41.	" 3134	4.40	3	25	32	57	3234	720


A
B
Okolomu
Ode
Odesin
Odagbe
Ilafin
Eotin
Iye
Iruwa
Isanlu Ifeda
Isanlu Ifetoijawa
ISANLU MAKUTU
Isanlu mopo
Iddo
Idotin
Lepmastrium
FIGURE 8 :- Gold values (g/m³) in heavy mineral concentrates
EXPLANATION
O — Zero (no gold)
⊙ — <0.15 g/m³
◐ — 0.15 to 0.25 g/m³
● — >0.25 g/m³
— Areas where stream sediments were investigated
q/ quartz vein
SCALE 1:50,000
N


A
B
Okolom
Odosin
Odoghe
Ilatin
Isanlu Ifedo
ISANLU MAKUTU
Isanlu Mopo
Iruntu
FIGURE 7
LOCATION OF STREAM SEDIMENT SAMPLES IN THE STUDY AREA.
SCALE 1:50,000
EXPLANATION
GK 4030 Sample location and number
A B Areas used for geochemical prospecting

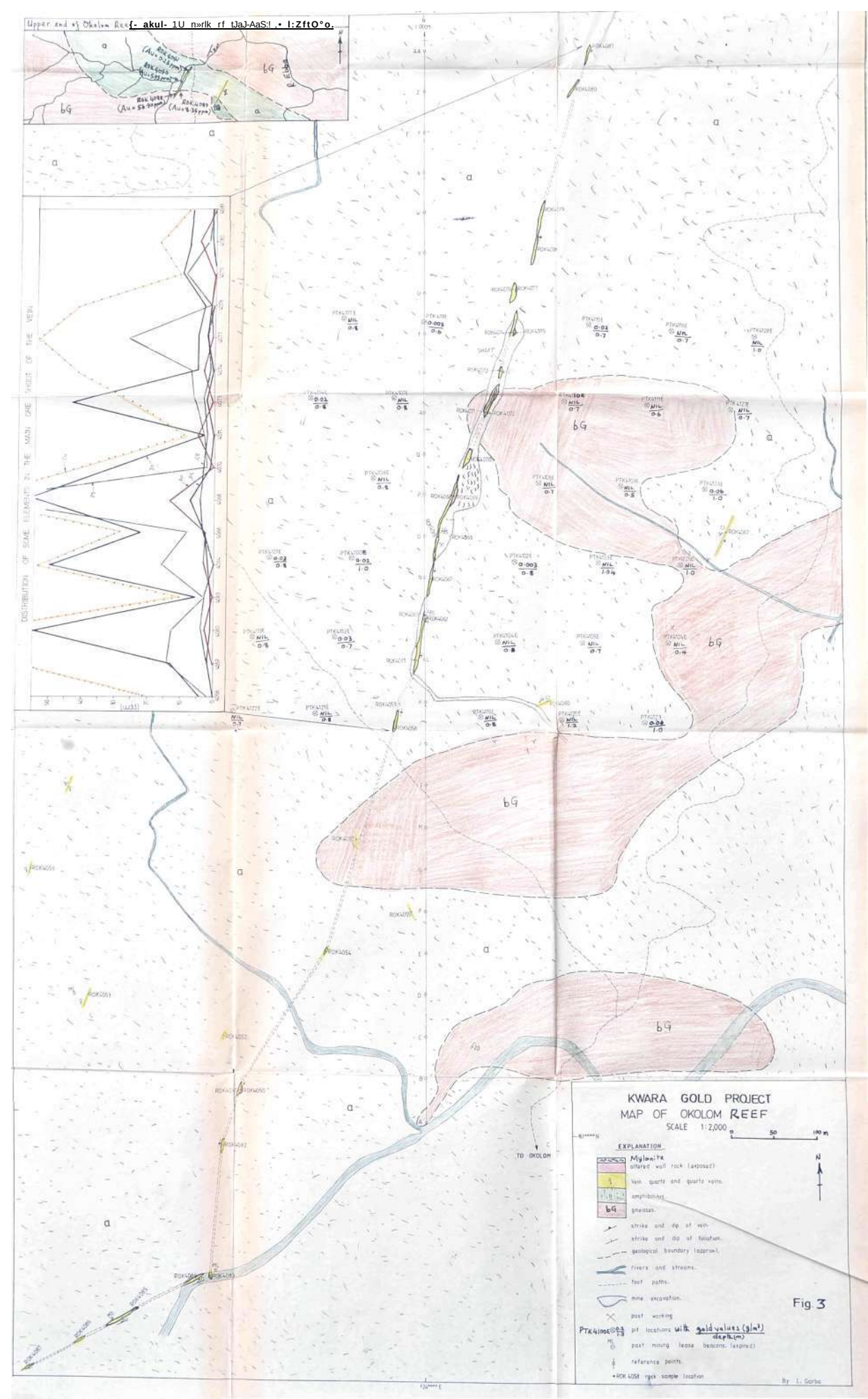
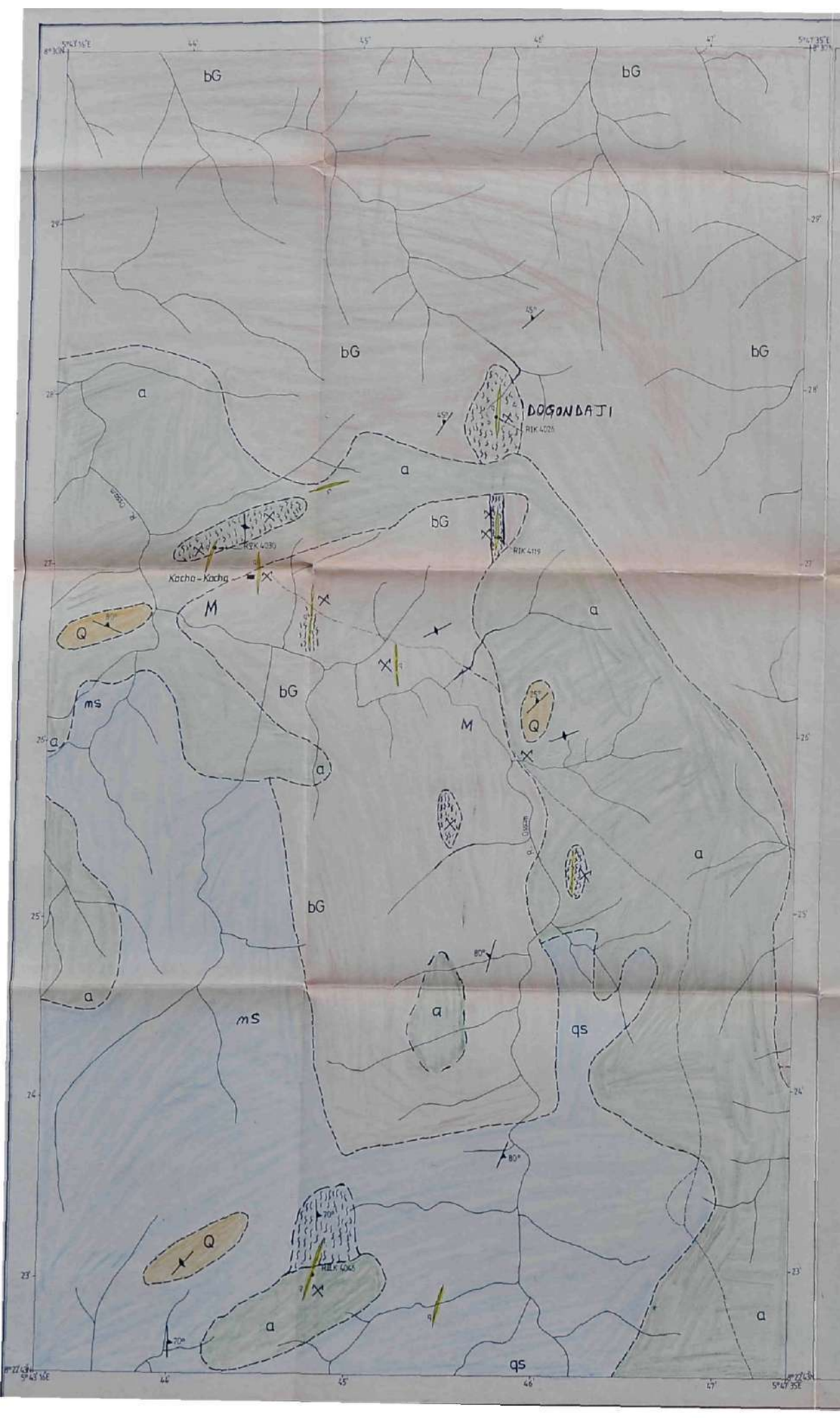

Upper end of Okolom Reef
DISTRIBUTION OF SOME ELEMENTS IN THE MAIN ORE SHOOT OF THE VEIN
KWARA GOLD PROJECT
MAP OF OKOLOM REEF
SCALE 1:2,000
0 50 100 m
EXPLANATION
Mylonite altered wall rock (exposed)
Vein quartz and quartz veins.
amphibolites
bG gneisses.
strike and dip of vein
strike and dip of foliation.
geological boundary (approx).
rivers and streams.
foot paths.
mine excavation.
past working
pit locations with gold values (g/m³) depth (m)
past mining lease beacons (expired)
reference points.
• ROK 4058 rock sample location
TO OKOLOM
By L. Garba

Fig. 3



SECTIONS ALONG "A-A" AND "B-B" SHOWING GEOLOGIC AND GEOMORPHIC FEATURES



NIGERIAN MINING CORPORATION

KWARA GOLD PROJECT

DOGONDAJI — KACHAKACHA SHEAR ZONE

SCALE 1:25,000

EXPLANATION

- = Mylonites
- bG = Biotite gneiss
- M = Migmatite
- a = Amphibolite
- qs_{ms} = Quartz schist, mica schist
- Q = Quartzite
- = Vein quartz and quartz vein.
- = Geological boundary (definite)
- = " " (approx.)
- = Strike and dip of foliation.
- = Strike of vertical foliation
- = Old workings
- = Streams
- = Tracks
- RIK 4026 = Rock sample location

By I. GARBA

ANALYTICAL RESULTS

SAMPLE No	Au (ppm)	Ag (ppm)	Cd (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)
RIK 4026	72.00	1.00	3.00	26.00	3.00	7.00
RIK 4119	0.05	3.00	1.00	16.00	1.00	12.00
RIK 4046	0.10	2.00	2.00	9.00	0.00	8.00
RIK 4030	2.45	3.00	2.00	20.00	0.00	8.00

1 0 1

Fig. 4

N