No. 301

REPORT
ON
THE MINERAL EXPLORATION
IN
THE MARONET AREA,
THE REPUBLIC OF ZAMBIA
PHASE II

MARCH 1994

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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Preface

In response to the request by the Government of Zimbabwe, the Japanese Government decided to conduct a Mineral Exploration Project in the Makonde Area Project and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ). The JICA and MMAJ sent to Zimbabwe a survey team headed by Mr. Yoshioki Nishitani from 5 July to 26 September, 1993.

The team exchanged views with the officials concerned of the Government of Zimbabwe and conducted a field survey in the Makonde area. After they returned to Japan, further studies were made and the present report has been prepared.

We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of Zimbabwe for their close cooperation extended to the team.

February 1994

Kensuke YANAGIYA
President
Japan International Cooperation Agency

Takashi ISHIKAWA
President
Metal Mining Agency of Japan

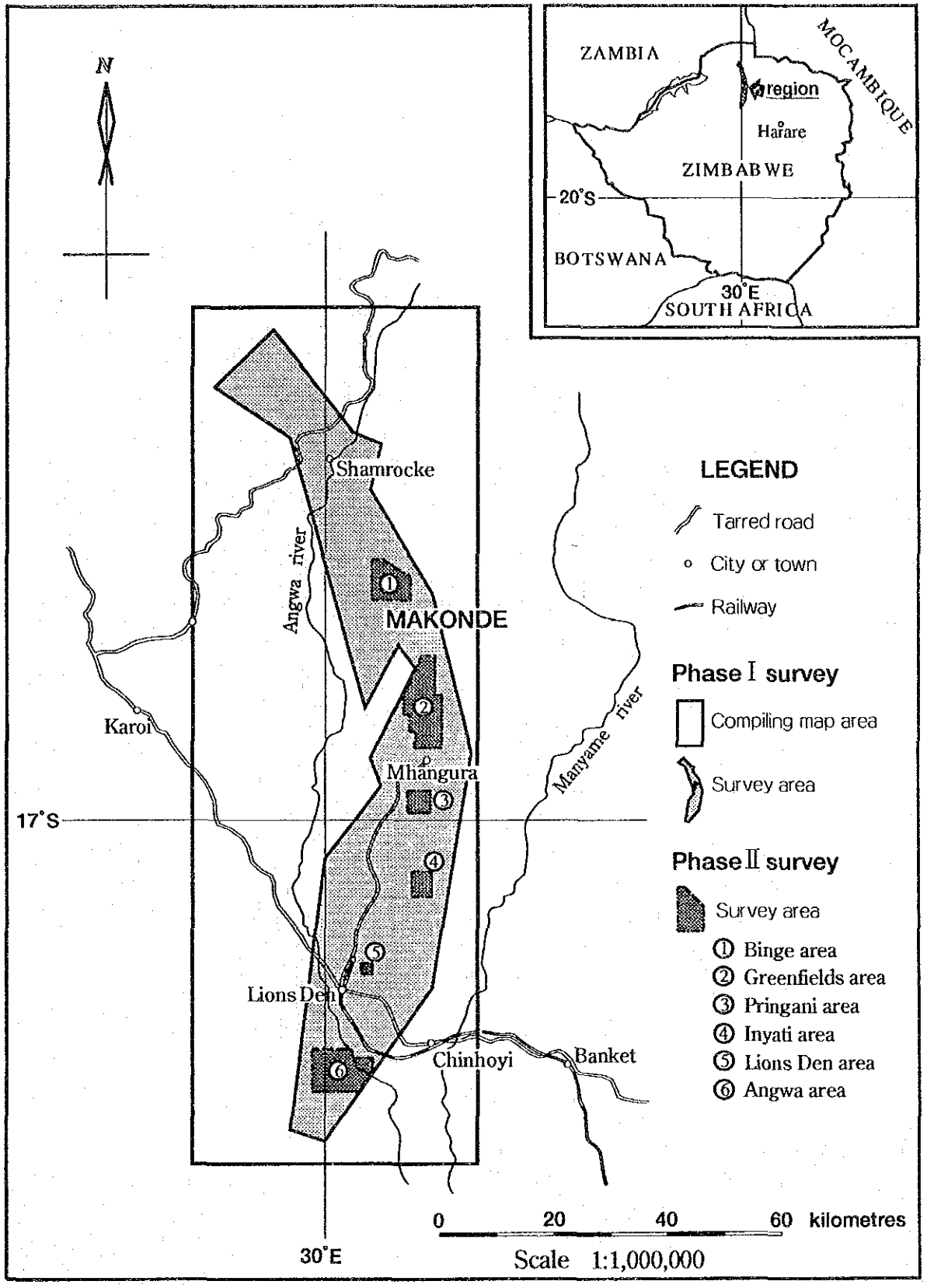

Fig. I-1-1 Locality of the Survey Area

Abstract

This survey was carried out in order to find out new ore deposits through the study of the geological setting and ore deposits of this area. At the same time, technological transfer from Japan to the related organisation of Zimbabwe is one of the important purposes of this project.

The analyses of previous geochemical data (five areas, 110km^2) and IP geophysical survey were carried out as Phase II of this project 1993.

Analyses of previous geochemical data:

The following geochemical anomalous sites were extracted by the computer analysis of the soil geochemical data of the related areas.

1. Tchetchenini~Binge~Redwing site
2. Wilden~Chimusenga~Greenfields site
3. Chironbozi~Brenville site
4. Piringani site
5. Inyati site
6. Around Old Alaska Mine site
7. South of Alaska smelter site
5. The Angwa mine~The Hans mine site

Geophysical survey:

IP geophysical reconnaissance and IP Semi-detailed surveys were carried out to detect sulphide mineral ore deposits in the geochemically anomalous sites detected by 1992's survey. As a result, the following sites were selected as the promising sites.

1. Chironbozi site (L line No.18-19 stations)
2. Brenville A site (Za line No.-3 station)
3. Brenville B site (Za line No.2 station)
4. Inyati site (Os line No.9~Oss line NO.9)
5. Blackwood A site (Ys line No.9 station)
6. Blackwood B site (Y line No.13~14 station)

Based on results of Phase I and Phase II surveys, 6 sites with encouraging IP anomalous bodies were identified in the geochemical anomalous areas. These IP anomalous bodies must be confirmed by drilling.

The minimum amount of drilling and priority is as follows;

Priority;

1) Blackwood A	600m
2) Blackwood B	500m
3) Brenville A	300m
4) Brenville B	400m
5) Inyati	200m
6) Chirobozi	200m

In the case of potential ore deposits revealed by the above drilling, detailed drilling will be necessary to explore the extend of mineralisation and to calculate the ore–reserves and grade.

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Part I General Remarks

Chapter 1 Introduction

1-1 Background and Purpose of the Survey

This survey will be carried out within a period of three years commencing from 1992. This year,1993, is the phase II of this project. In the Makonde area, the target area of this survey, there are major Cu-Ag-Au deposits of Zimbabwe such as the Mhangura Mine and the Shackleton Mine. There are the high potentialities of the existence of the same type deposits which are undeveloped. As the production of ore in these mines has been decreasing in recent years, the discovery of new deposits is urgently expected. Therefore, the Government of the Republic of Zimbabwe requested to conduct the Technical Cooperation for a Mineral Exploration to the Government of Japan. The Government of Japan responded to the request and conducted analyses of previous data, and IP method of geophysical surveys. Through these surveys, the survey team was dispatched and carried out the survey in order to explore new deposits.

1-2 Conclusion and recommendations of the Phase I survey

1-2-1 Conclusion of the phase I survey

The literature search covering the area of 7,500 km^2, geological survey covering the area of 2,250 km^2, and geochemical soil sampling covering the area of 919 km^2 were carried out as the Phase I of this project. The results are summarised below.

The literature search was carried out in order to understand the characteristics of geology and mineralisation of this area, and made geological map by the data compiling.

Actual geology was examined by the field survey. As the result, there are Archaean granites of the basement rock in the eastern area, and conglomerate, arkose, dolerite and slates of Proterozoic era in the western area. The distribution of these sedimentary rocks shows typical occurrence according to the extension of the rift valley.

From the result of the survey of the mines and mineralisation zone, the main ore deposits of this area are stratabound copper deposits. In addition to these ore deposits, small amounts of quartz-copper vein type deposits, bedded iron ore deposits and dolomite deposits can be recognised. All the big economical ore mineral deposits such as the Mhangura Mine, the Shackleton Mine including Avondale ore deposit, are stratabound copper deposits. These ore deposits occur within arkose or conglomerate of Deweras Group of Proterozoic era, and have close relationship to local folding structure and fault.

On the measurement of physical properties of rocks and ore samples, the chargeability method (e.g. IP survey) which detect the difference of the sulphide mineralisation from the other is more expectative in case of application of geophysical survey in this area.

On the soil geochemical survey, the following places are extracted as the high potential areas for the existence of ore deposits ;

1) The Angwa to Hans area
2) The south-west Old Alaska area
3) The Inyati area
4) The Piringani area
5) The Greenfields area
6) The Wildene area
7) The Chipiri area
8) The Binge area

1-2-2 Recommendations for the Phase II survey

The following recommendations are proposed based on the results and examination of the phase I.

1. The detailed data analyses

The detailed analyses of the previous soil geochemical data of the target areas which are kept in the ZMDC must be carried out in addition to the data which were examined in this year.

2. The detailed geological survey

Detailed geological survey including trenching must be carried out in order to study the situations of the mineralisation and geological structure of the target area.

3. The geophysical survey

Geophysical survey by the difference of the chargeabilities of rocks from sulphide ores must be carried out in order to study the possibility of occurrences of ore deposits in the target areas.

4. Drilling

Drilling in the most expectative areas based on the detailed data analyses, detailed geological survey and the geophysical survey must be carried out in order to recognize the existence of the sulphide mineralisation.

1-3 Outline on the works of the phase II surveys

1-3-1 The Survey Area

The Makonde area is located in the northern part of Zimbabwe. The distance and travel time by car from Harare are as follows.Locality of survey area is shown to Fig.I-1-1.

HARARE —(1.5 hours / 130 kilometres)— CHINHOYI —(0.8 hours / 70 kilometres)— MHANGURA

CHINHOYI —(10 minutes / 12 kilometres)— ALASKA

There are paved national roads and local roads from the Capital to the survey area. Even during the rainy season of November to March, it is possible to access to the survey area.

Survey areas that are selected by the phase I survey are as fellows.

1.Binge area 2.Greenfields area 3.Piringani area 4.Inyati area 5.Lions Den area 6.Angwa area

During the field survey, Japanese engineers stayed in Chinhoyi. The counterpart stayed in the base camp in the Alaska Smelter during the field surveying. Labors were employed in the survey area.

1-3-2 Purpose of the survey

This survey was carried out in order to study the soil geochemical anomaly and geophysical anomaly related to mineralisation and explore new ore deposits in the Makonde area, the Republic of Zimbabwe.

1-3-3 Method of the survey

1. The existing data analysis

Chemical analysis data of soil geochemical survey which kept in the Geological Survey Department, Ministry of Mines (hereinafter called GSD) and Zimbabwe Mining Development Corporation (hereinafter called ZMDC) were reanalysed by computer. The results of this study and phase I geochemical survey were compiled in geological map.

2. Geophysical Survey

IP reconnaissance survey and semi-detailed IP survey were done for the target area where selected by phase I geochemical survey. Potentiality of new ore deposit were studied.

Outline of the survey are shown in Table I-1-1.

TableI-1-1 Outline of the survey

Specification of the survey	Numbers of survey
Existing data analysis	Green fields area 47 km^2 Piringani area 5 km^2 Inyati area 6 km^2 Lions Den area 2 km^2 Augwa area 50 km^2 Total 110 km^2
Geophysical survey	Survey area : Binge area, Green fields area, Piringani area,Inyati area, Lions Den area, Angwa area General survey : Line km 51 km Number of operation 656 Detail survey : Line km 23.2 km Number of operation 366 Laboratory Test : Resistivity and Chargeability 60 samples

1-3-4. Members of the survey team

The following members were organised as the survey team, who negotiate the survey planning, conducted and actual survey.

Planning and Field Supervisor:

(Japanese Members)

Mr.Haruhisa MOROZUMI :MMAJ

(Zimbabwean Members)

Mr.Surrender Mdunyiswa Nyahwa NCUBE :Deputy Director of GSD

Mr.Edson MUSHAYABASA :GSD

Mr.Fadzanai Bornwell MUPAYA :GSD

Mr.Jameson RUSHWAYA :GSD

Field Survey

(Japanese)

Yoshioki NISHITANI :DOWA Engineering.,Ltd.

Hirohide KONNO :DOWA Engineering.,Ltd.

Hiroshi JINGU :DOWA Engineering.,Ltd.

Michio TANAHASHI :DOWA Engineering.,Ltd.

Kuraei IWAKI :DOWA Engineering.,Ltd.

Tadashi NYUI :DOWA Engineering.,Ltd.

(Zimbabwean)

Fadzanai Bornewell MUPAYA :GSD

Jameson RUSHUWAYA :GSD

Cheneso MUPFUMI :GSD

Joseph MADEKENI :GSD

1-3-5. Term of the Survey

Field survey was carried out as follows:

Field survey	; from	5	July	to	26	September	, 1993
Analyses of previous geochemical data	; from	9	July	to	17	August	, 1993
Geophysical survey	; from	10	July	to	30	August	, 1993
Conclusion	; from	31	August	to	23	September	, 1993

Chapter 2 Physical features

2-1 Topography and Drainage System

The topography of the survey area shows peneplain like a moderate swell of the elevation of 1,000 metres to 1,250 metres.

The mountain system is controlled by the geology in the area. The mountains stretch the direction of the NNE to the SSW in the southern part and NNW to SSE in the northern part.

Rivers flow to the direction of the west or the north, and flow into Angwa river which runs in the western part of the area. Angwa river runs to the north to flow into Zambezi river which make the northern border of Zimbabwe with Zambia.

All the rivers flow only in the rainy season. There is no water in the river except some pools in the dry season.

2-2 Climate and Vegetation

The climate of the survey area is divided into the dry season (from April to October) and the rainy season (from November to May). Maximum temperature is constant of 25 to 28 degree centigrade through the year. Minimum temperature shows 17 degree centigrade in rainy season and from 5 to 10 degree centigrade in dry season. Rainfall of each month shows about 180 mm par month in the rainy season and from 1 to 5 mm par month in dry season. No rainfall is recognised in dry season.

As regards vegetation, except short broad-leaved tree as oaks which distributes in the mountainous district, the vegetation is generally thin in the survey area. Tall legume as acasias is usually distributed in the mountain skirts and in the plain, Many coconut palms and cycads characteristically grow along the river. No coniferous trees are generally seen except few in the pasture and afforested area.

The plain extended from the southern part of the survey area to the north of the Mhangura Mine is owned by large-scale farmers to grow wheat, corn and grass, and pastures.

Chapter 3 General geology

3-1 General geology

Geology of this area consists of gneiss, green rocks and granites of Archaean era which forms the basement, and ssedimentary rocks and volcanic rocks of Proterozoic era callsed Magondi Supergroup. Geologocal map is shown in Fig.I-3-1. Shematic geologic column is shown in Fig.I-3-2.

The basement rock consists of gneiss, green rocks and granites. Gneiss is distributsed in the northern part. Green rocks are distributsed in the southern part and are compossed of mafic rock and felsic sandstone. Granite is distributsed in the eastern side of the Mhangura Mine and the southern part of the survey area.

Magondi Supergroup is dividsed into Deweras Group, Lomagundi Group and Piriwiri Group from the lower to the upper horizon.

Deweras Group mainly consists of alluvial fan ssediments such as conglomerate, arkose with cross-bsedding and grading, and pelitic schist partly associatsed with chemical ssedimentary rocks. It shows the structure of repeatsed ssedimentation of the unit of Playa. This Group is distributsed in the central part of the area successively from the north to the south, and includes strata-bound copper deposits.

Lomagundi Group can be dividsed into the lower formation which mainly consists of dolomite and poke-marksed quartzite and the upper formation which mainly consists of strippsed slate.

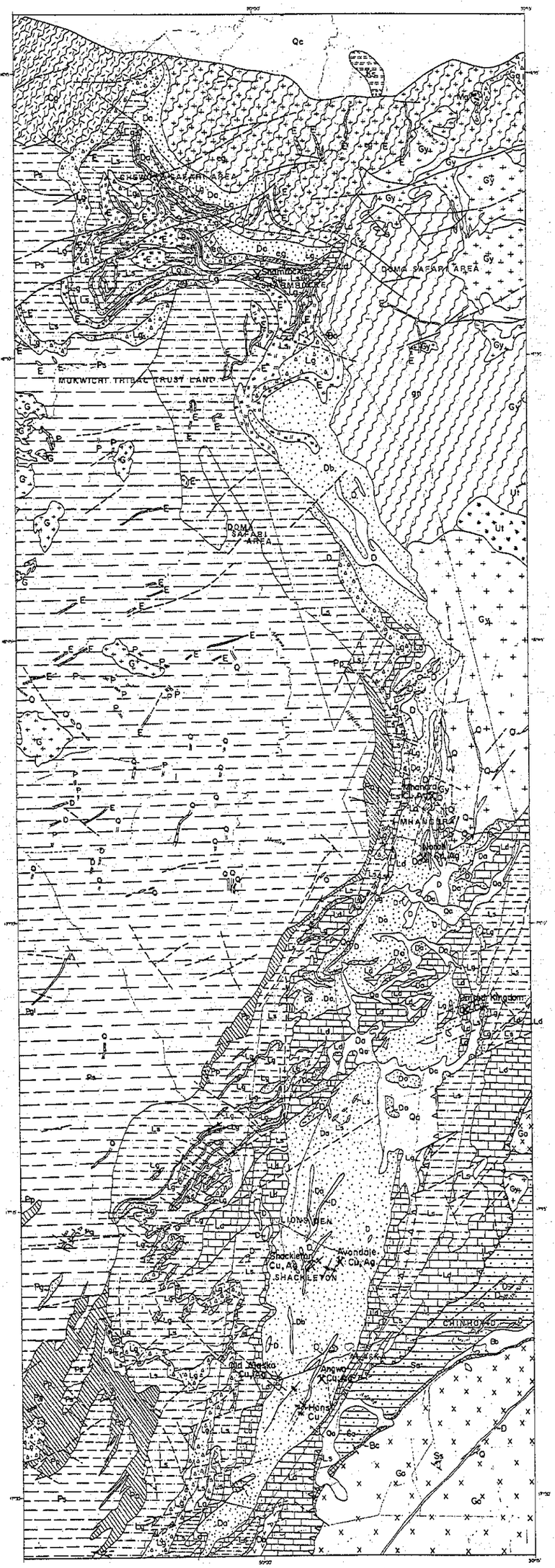
Piriwiri Group mainly consists of phyllite, graywacke, graphitic slate and quartzite, and is partly accompanised with volcanic rocks and pyroclastic rocks. It is widely distributsed in the western part of this area covering Lomagundi Group with conformity.

3-2 Geological structure

The Ssedimentary rocks in Magondi Supergroup was formsed by ssedimentation within the rift valley which was extendsed by the left lateral fault parallel the Great Dyke direction. According to the extension of the rift valley, alluvial fan ssediments and playa ssediments (Deweras Group) which was originatsed from basement rocks were formsed at first, and coversed lagoon ssediments(lower Lomagundi Group) which consists of dolomite, quartzite and slate, later. Finally, pelitic rocks, fissilitic phyllite which was originatsed from pelitic rocks and alteration of fallen volcanic rocks, and deep sea ssediments (Piriwiri Group) depositsed.

Initially, parallel faults and anticline axis cross obliquely to rift valley were formsed by strike-slip fault according to extension of the rift valley. These faults and anticline axis were formsed before compaction of Magondi Supergroup, and formsed the environment of ore solution path and strata boundsed disseminatsed copper deposits.

Second structural movement is so-callsed the Magondi Mobile Belt, which forms fold with N-S and NNE-SSW and thrust structure due to change of this area to compaction. The age of this mobile belt is considersed to be 1,800Ma to 2,000Ma by Pb-Pb and Rb-Sr age determination



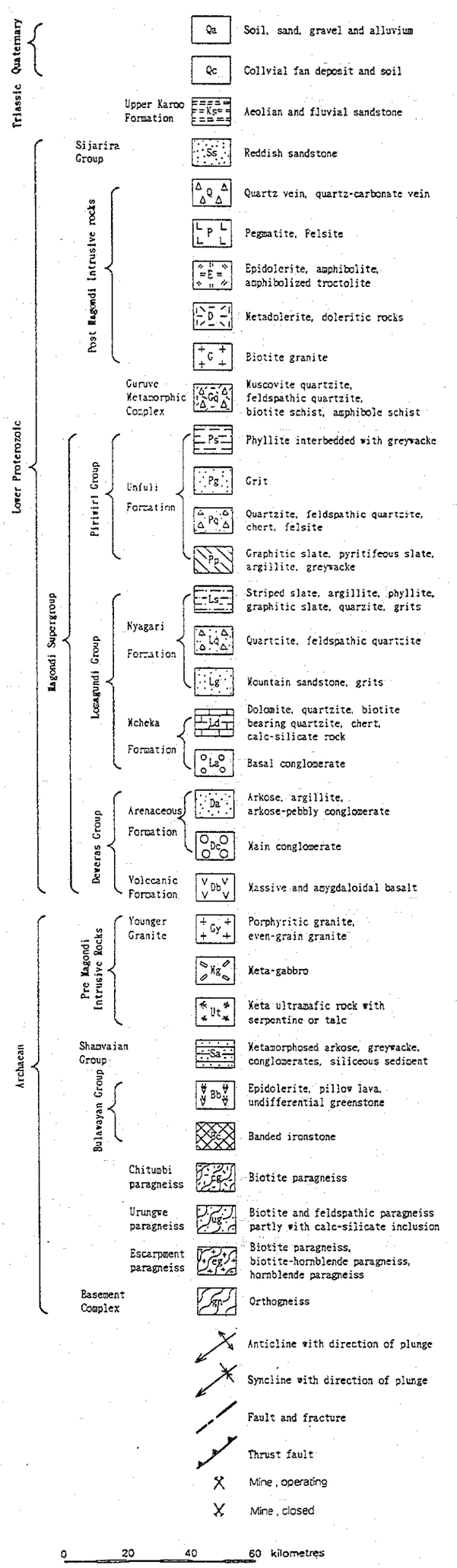


Fig. I-3-1 Geological map

Geological Time	Group		Formation	Geological column	Rock facies
Quaternary				Qa / Qc	Soil, Sand, gravel, alluvium / Collvial fan deposit and soil
Triassic			Upper Karoo Formation	Ks	Aeolian and fluvial sandstone
Lower Proterozoic	Sijarira Group			Ss	Reddish sandstone
	Guruve Metamorphic Complex			Gq	Muscovite quartzite, feldspathic quartzite, biotite schist, amphibole schist
	Magondi Super-group	Piriwiri Group	Unfuli Formation	Ps, Pg, Pp, Pq, Q, P, E, G	Phyllite interbedded with greywacke Grit Quartzite, feldspathic quartzite, chert, felsite Graphitic slate, pyritifeous slate, argillite, greywacke
		Lomagundi Group	Nyagari Formation	D, Ls, Lq, Lg	Striped slate, argillite, phyllite, graphitic slate, quarzite, grits Quartzite, feldspathic qartzite Mountain sandstone, grits
			Mcheka Formation	Ld, La	Dolomite, quartzite, biotite bearing quartzite, chert, calc-silicate rock Basal conglomerate
		Deweras Group	Arenaceous Formation	Da, Dc	arkose, argillite, arkose-pebbly conglomerate Conglomerate
			Volccanic Formation	Db	Massive and amygdaloidal basalt
Archaean	Shamvian Group			Sa	Metamorphosed arkose, greywacke, conglomerates, siliceous sediment
	Bulawayan Group			Bb, Bc	Epidolerite, pillow lava, Undifferential greenstone Banded ironstone
	Chitumbi paragneiss			cg	Biotite paragneiss
	Urungwe paragneiss			ug, D	Biotite and feldspathic paragneiss partly with calc-silicate inclusion
	Escarpment paragneiss			eg, Mg, Gy, E	Biotite, biotite-hornblende and hornblende paragneiss
	Basement Complex			gn, Ut, Go	Orthogneiss

Post Magondi Intrusive rocks
- Q :Quartz vein, quartz-carbonate vein
- P :Pegmatite, Felsite
- E :Epidolerite, amphibolite, amphibolized troctolite
- D :Metadolerite, doleritic rocks
- G :Biotite granite

Pre Magondi Intrusive Rocks
- Gy:Porphyritic granite, even-grain granite (Younger Granite)
- Go:Fine granite, granodiorite, tonalite (Older Granite)
- Mg:Meta-gabbro
- Ut:Meta ultramafic rock with serpentine or talc

Fig. I-3-2 Schematic geological column

method (Master, 1991).

Final Structural movement is callsed the Pan-Africa Zambezi Mobile Belt, which affectsed marksed metamorphism to the northern part of this survey area and controllsed the fold structure in the Shamrocke area.

3-3. Known ore deposits

List of the known mineralisation areas is shown in Table I-3-1.

The copper ore deposits are the only mineral resources which have economic feasibility. Silver and gold associatsed with copper ore deposits are also recoversed. Besides the metal resources, crushsed dolomite for construction and slate for building materials are worksed in several places.

9 mines and ore deposits have operatsed before, but now only the Angwa Mine, the Shakleton Mine including the Avondale ore deposit, and the Mhangura (Miriam) Mine are still mining at present. These ore deposits are shown in Fig.I-3-1.

These ore deposits are roughly classifised into the two deposits occurring in the Deweras Group and in the Lomagundi Group.

The former are strata bound ore deposits occurring within arkose of the Deweras Group. The Hans Mine, the Angwa Mine, the Shackleton Mine including the Avondale ore deposit, the Norah Mine and the Mhangura (Miriam) Mine are developsed. The formation of the ore deposition is considersed to be strongly controllsed by the ssedimentary environment and geological structure of country rock (Simpson, 1990). As the result of the survey of the ore deposits and the mineralisation area, the anticline structure from the direction of the NW-SE is considersed to be important.

The Old Alaska Mine in the south-western part of the area and the Shamrocke Mine in the northern part belong to the latter.

Moreover, there is The United Kingdom Mine as a vein type ore deposit.

TableI-3-1 List of the known ore deposits

Name of Mine and Mineralized Area	Locality Coordinates	Situation	Type of deposits	Mineralized Metal	Ore reserve	Metal grade	Main ore minerals	Accessory minerals	Gangue minerals	Host rock	Present Production
(1)Hans	17°25.47'S 30°01.95'E	closed	Stratabound and disseminated ore	Cu, Ag	0.3million tons Cu1.0%	AgMax93.5g/t CuMax3.71%	Mal, Bo, Cc	Cp	—	Arkose Conglomerate	
(2)Angwa	17°23.96'S 30°03.37'E	Operating	Stratabound and disseminated ore	Cu, Ag	4.5million tons Cu0.95%	AgMax62.6g/t CuMax1.59%	Bo, Cc, Cp	Py, Mt, Hem	—	Arkose Conglomerate	16,000t/m Cu0.6%
(3)Old Alaska	17°23.87'S 30°00.87'E	closed	Stratabound and disseminated ore	Cu, Ag	5million tons? Cu1.5%	AgMax62.6g/t CuMax1.59%	Mal, Bo, Cc	Cp, Py, Cv, Mt, Hem	—	Lomagundi, G Dolomite	
(4)Shackleton	17°18.08'S 30°02.67'E	closed	Stratabound and disseminated ore	Cu, Ag	6million tons Cu1.2%		Bo, Cc	—	—	Arkose Conglomerate	
(5)Avondale	17°17.86'S 30°04.11'E	Operating	Stratabound and disseminated ore	Cu, Ag	1.4million tons Cu0.9%	Ag 11.6g/t Cu 0.45%	Cc	Bo, Cp	—	Arkose Conglomerate	16,000t/m Cu0.8%
(6)United Kingdom	17°04.67'S 30°11.24'E	closed	qz-cal Vein	Cu, Ag		AgMax45.9g/t CuMax2.69%	Mal, Cc	Cv	Qz, Cal, Hem	Arkose	
(7)William	16°53.31'S 30°09.59'E	Operating	Stratabound and disseminated ore	Cu, Ag, Au Pt, Pd, Sc	60million tons Cu1.0%	AgMax33.2g/t CuMax13.0%	Bo, Cc, Cp	Py, Mt, Hem	—	Arkose Conglomerate	4,000t/d Cu0.7%
(8)Norah	16°56.21'S 30°09.16'E	Operating	Stratabound and disseminated ore	Cu, Ag, Ag	3million tons Cu1.2%	AgMax170g/t CuMax13.0%	Cp, Bo, Cc	Py, Cv, Sph, Mt, Hem	—	Arkose Conglomerate	
(9)Shamrocke	16°25.78'S 30°09.52'E	closed	Stratabound and disseminated ore	Cu, Ag, Au	5million tons Cu1.0%	AgMax 8.1g/t CuMax3.47%	Po, Cp	Cub, Sph, Py, Mc, Mt	—	MetaArkose	
(10)Nyamanyoko Hill	16°50.63'S 30°10.57'E		qz-mt Vein	Au, Ag?	Extension2km	Au0.03g/t Ag4.5g/t	—	Hem, Mt	—	Granite	
(11)Rivington	17°00.40'S 30°04.82'E		Banded iron	Fe			Mt, Hem	—	—	slate	
(12)Zawi	17°13.88'S 30°01.58'E		Dolomite	Dolomite			Dolomite	—	—	Lomagundi, G Dolomite	
(13)Hilltop	17°19.01'S 30°07.74'E		Slate	slate			slate	—	—	Lomagundi, G slate	

Abbreviations
Py:pyrite Mc:marcasite Po:pyrrhotite Cub:cubanite Cp:chalcopyrite Bo:bornite Cc:chalcocite Cv:covelline Sph:sphalerite
Mt:magnetite Il:ilmenite Hem:hematite Mal:malachite Qz:quartz Cal:calcite Ot:other gangue minerals

Chapter 4 Consideration of the Survey Result

4-1 Controls on Mineralisation Related to the Geological Structure and Characteristics of Mineralisation

Ore deposits in this area are stratabound copper ore deposit occur in arkose of the Deweras Group. The Hans Mine, the Angwa Mine, the Shackleton Mine, the Norah Mine and the Mhangura (Miriam) Mine are developed. The formation of the ore deposition is considered to be strongly controlled by the sedimentary environment and geological structure of country rock (Simpson, 1990). As a result of the survey of the ore deposits and the mineralisation area, the lowest part of the Deweras Group that form a boundary zone of the basement rocks is considered to be an important geological control at the northern Mhangura Area, the NW–SE anticline structure is considered to be important at the southern Alaska Area.

4-2 Relationship Between Geochemical Anomalies and the Mineralisation

The following areas were selected as high potentialities of expected new ore deposits by the results of the analysis of previous geochemical data and phase I geochemical survey.

1. Greenfields Area
   1) Chimusenga north and central
   2) Greenfields west
   3) Chirombozi east
2. Piringani Area
3. Inyati Area
4. Angwa Area
   1) Cu high content area around the Old Alaska Mine
   2) Cu high content area from the Alaska smelter to Sinoia Drift Estate
   3) Cu high content area from the Angwa Mine to the Hans Mine

In addition, following two areas were adopted as a assignment area by the results of phase I survey.

1) Greenfields Area north and east (Wildene, Brenville)
2) Binge Area (Chipiri, Tchetchenini, Binge, Redwing)

These selected areas conform to the following condition of anomaly area by Cu–Au–Ag mineralisation, and closely related to mineralised area. Therefore, these areas were considered to be important for future survey.

1) Distribution area of arkose of the Deweras Group
2) Cu high content area of soil geochemistry
3) Distribution of high score of 4th principal component for 6 elements (Cu, Pb, Zn, Fe, Co, Ni)

4-3. The relationship between the result of geophysical survey and mineralisation

Summary of geophysical survey is as follows.

Line	Resistivity structure	Resistivity(Ω·m)	IP(mV/V)	IP anomalous body	Depth(m)	Geology
B	2 layers	1'st layer 25~300 2'nd layer 3,000	2.5~10 4.5	-	-	slate, Sandstone, arkose
C	3 layers	1'st layer 150~180 2'nd layer 750 3'rd layer 4,000	1~7 4~7 12~20	-	-	gneiss
L	West portion -low East portion -high	West portion 85~450 East portion 3,000	1~10 2.8	70mV/V (small steep plate)	<50	arkose ~ granite boundary
Za	Centre part -low	Center portion 200~500 End portion 3,000	0.5~4.5 4.5	300mV/V (flat plate)	200~350	arkose ~ granite boundary
O	2 layers	1'st layer 80~500 2'nd layer 4,000	1~2 3	150mV/V (small steep plate)	<150	Quartz Vein
Ys	3 layers	1'st layer 150~300 2'nd layer 750 3'rd layer 2,500	3~9 1~8 2~6	200mV/V (steep plate)	250<	arkose

An IP anomaly caused by mineralisation in this area is considered to be shown in chargeability of 50mV/V to several hundred mV/V. This value
corresponds to the relationship between Cu grade and IP value which was obtained by last year's study. On the other hand, many cases of no IP anomaly with widening shape towards the deep part and high IP but low chargeability (less than 50mV/V) are not caused by mineralisation but by the influences of geology.(e.g. Line B and C).

4-4. Potentiality of expected ore deposits

The results of comprehensive analyses are shown in Fig.II-3-1.

The following sites are considered as potential ore-bearing sites based on the comprehensive study of the Cu anomalous zones obtained by soil geochemical survey and IP anomalous zones by geophysical survey.

1. The Greenfields site
   1-1) The Chirombozi east
   1-2) The Brenville
2. The Inyati site

3. The Angwa site

3-1) The high copper concentration area from the Angwa mine to the Hans mine

The eastern part of the Chirombozi farm to the Brenville farm is located in the lowest horizon of the Deweras group which is nearly the border of the basement rocks. The geological situation is the same as of the Mhangura mine. This site is considered to be in a successive mineralisation zone which continues from the Norah mine to the Mhangura mine.

Mineralisation of the Inyati site has a close relationship to the quartz-calcite vein, and the site is located in the northern extension of mineralisation zone of the United Kingdom mine.

The ore deposits from the Angwa mine to the Hans mine are considered to be originally one ore-bearing zone. A Cu geochemical anomaly and IP anomaly are considered to reflect this continued mineralisation zone.

From of the above mentioned analyses, the selected sites have potential new ore deposits.

Chapter 5 Conclusion and recommendations

5-1. Conclusion

The analyses of previous geochemical data(5 sites, 110 km^2) and IP geophysical survey(6 sites, 74.2 line km) were carried out as this year's survey.

5-1-1. Analyses of previous geochemical data

The soil geochemical data and analysed data which are kept in GSD and ZMDC were supplied for this year's study.

Geochemical data and the coordinates of specimens were input into a computer for univariate analysis.

The following sites were selected by comprehensive analyses of 1992's and 1993's studies as potential ore-bearing sites.

1. The Binge site
   1-1) The Tchetchenini farm
   1-2) The Binge farm
   1-3) The Redwing farm
2. The Greenfields site
   2-1) The Wilden farm
   2-2) The northern part to the central part of the Chimusenga farm
   2-3) The western part of the Greenfields farm
   2-4) The eastern part of the Chironbozi farm
   2-5) The Brenville farm
3. The Piringani site
4. The Inyati site
5. The Angwa site
   5-1) The wide high copper concentration area around the Old Alaska mine
   5-2) The high copper concentration area from the Alaska smelter to the Sinoia Drift Estate farm
   5-3) The high copper concentration area from the Angwa mine to the Hans mine

5-1-2. Geophysical survey

The following sites were determined as potential ore-bearing sites by simulation analyses of provisional section based on the results of reconnaissance survey, semi-detailed survey and the measurement of physical properties (laboratory test of rocks and ores).

1. The Greenfields site
   1-1) The eastern part of the Chirombozi farm
   1-2) The Brenville farm
2. The Inyati site
3. The Angwa site
   3-1) The high copper concentration area from the Angwa mine to the Hans mine

5-1-3. Recommended drilling sites for 1994-Phase III Makonde Mineral Exploration Project

By comprehensive study and analyses of the previous data and geophysical survey, the following sites are recommended as potential sites to find new ore deposits.

1. The Chirombozi site (L line No.18~19 station)
2. The Brenville A site (Za line No.-3 station)
3. The Brenville B site (Za line No.2 station)
4. Inyati site (OS line No.9 ~ Oss line No.9 station)
5. The Blackwood A site (Ys line No.9 station)
6. The Blackwood B site (Y line No.13~14 station)

5-2. Recommendation for the Phase III Makonde Mineral Exploration Project

Based on results of Phase I and Phase II survey, 6 sites of hopeful IP anomalous bodies were identified in the geochemical anomalous areas. These IP anomalous bodies must be confirmed by drilling.

The minimum amount of drilling and priority is as follows;

Priority;

1) Blackwood A	600m
2) Blackwood B	500m
3) Brenville A	300m
4) Brenville B	400m
5) Inyati	200m
6) Chirobozi	200m

In the case of potential ore deposits revealed by above drilling, detailed drilling will be necessary to explore the extend of mineralisation and to calculate the ore-reserves and grade.

Part II Details of the Surveys

Part II Details of the Surveys

Chapter 1 The Analyses of Previous Geochemical Data

1-1 Method of the survey

1-1-1 Purpose of the survey

From the economical point of view, the metal resources which can be profitably worked is copper of the Deweras Group. Exploration of mineral ore deposits in this area were continuously carried out since the late 1940's until the middle of 1970's. In the area, from the northern part of Mhangura Mine to the southern part of Alaska Mine, detailed geochemical soil sampling was carried out over the wide area. From the results of those surveys, the Angwa, Avondale and Shackleton ore deposits were discovered.

This present survey was carried out in order to study the outline and characteristics of the relationship of mineralisation and select the high potential ore areas for the existence of new ore deposits in the Makonde area.

1-1-2 Selection of the survey Areas

The areas of potential copper ore deposits are considered to be the distribution area of the Deweras Group from the central to the southern part, and to be the contact parts of the basement rocks, and the Deweras Group from the central to the northern part.

The selected areas with previous data were selected basing on the results of Phase I survey. A total of 33,681 chemical analyses data from selected and background area were collected for computer analyses. Summary of the selected areas is as follows:

Table II-1-1 List of Areas of the analyses of previous geochemical data

selected area	area	number of analysed data (selected area)	number of analysis data (selected and background area)
1) Greenfirlds area	47 km^2	1,684	1,887
2) Primgani area	5 km^2	591	2,086
3) Inyati area	6 km^2	1,144	3,086
4) Lions Den area	2 km^2	551	2,024
5) Angwa area	50 km^2	19,085	24,598
Total	110 km^2	23,055	33,681

Greenfields area is in the northern extension of Mhangura Mine, and covers the area from the Chirombozi farm to the Sunnyview Estate. The Pre-Magondi intrusive granite of the basement rocks and arkose of the Deweras Group are distributed in a N-S direction continuously. Many geochemical copper anomalies were picked near the boundary of granite and arkose by the results of Phase I survey.

Piringani area is in the south of Norah Mine. The area is overlain by arkose of the Deweras Group. Geochemical copper anomalies were picked at two sampling points by the results of Phase I survey.

Inyati area is the area around the United Kingdom Mine. Arkose of the Deweras Group, Doleritic dykes, and Quartz-Calcite veins are distributed in the central part of this area in a N-S direction. A geochemical copper anomaly was picked at the northern extension of the Mine by the results of Phase I survey.

Lions Den area is north of the Shackleton Mine. Arkose of the Deweras Group, and doleritic dykes are distributed in this area. A geochemical copper anomaly was picked at one sampling point by the results of Phase I survey.

Angwa area include the Angwa Mine, Old Alaska Mine, and Hans Mine. Arkose of the Deweras Group is distributed widely in the central part of this area, dolomite and slate of the Lomagundi Group are distributed in both ends of this area. Many geochemical copper anomalies were identified from the Angwa Mine to the Hans Mine and the Old Alaska Mine by the results of Phase I survey.

1-1-3 Collected Data

Chemical analyses data of previous soil geochemical survey(Phase I) and partly the compiled data which is kept in GSD and ZMDC were used for the existing data analyses.

Location of previous geochemical survey is shown on Fig.II-1-1. List of collected data is shown on Table II-1-2.

Coordinates of sampling points are based on local coordinates systems of Mhangura Mine and Alaska Mine. These coordinates systems are changed and standardised to the Universal Transverse Mercator Coordinates System (UTM coordinates system) at the Suiwerspruit and Chezui triangles, which are original points of the local coordinates system.

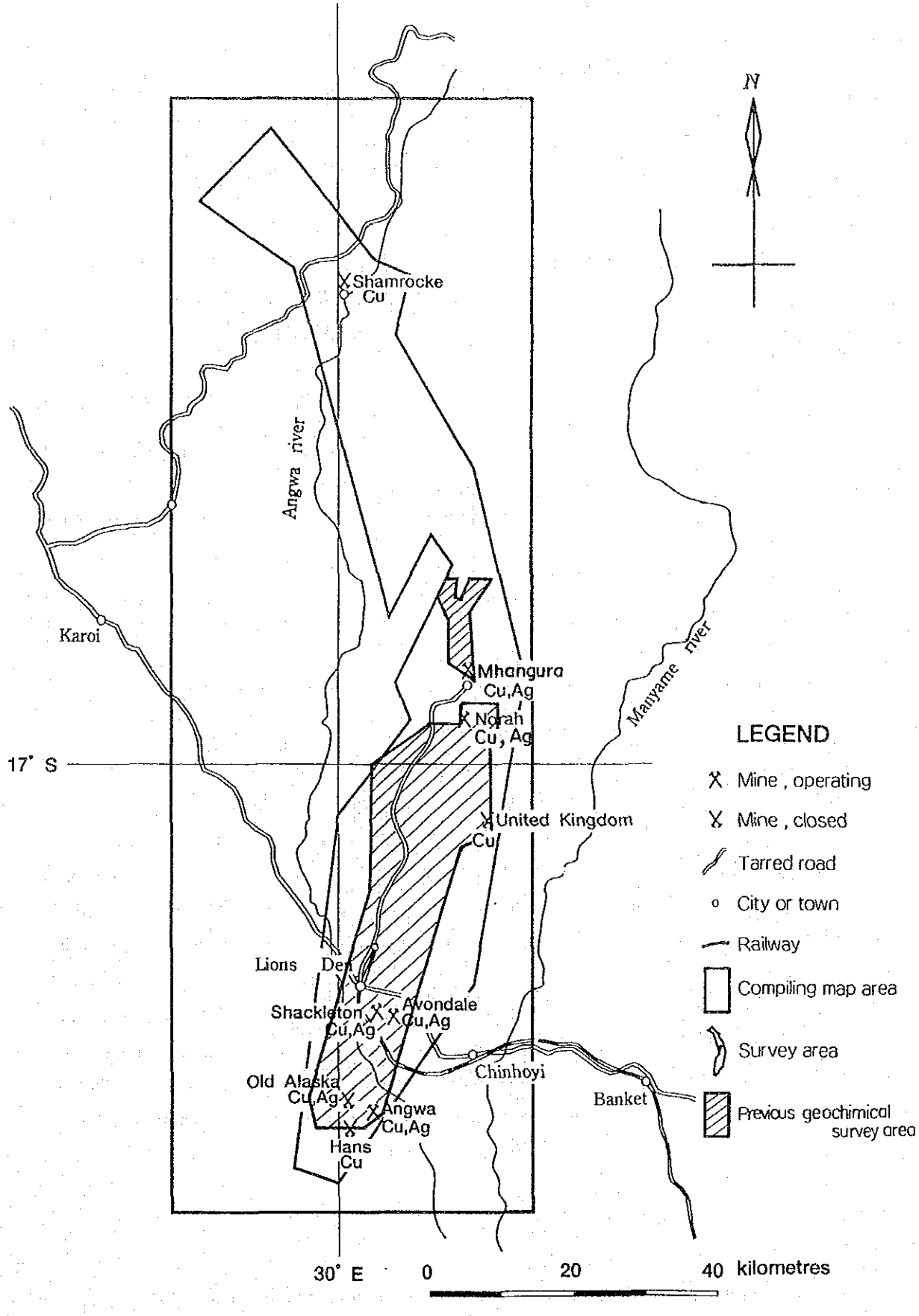


Fig.II-1-1 Locality of previous geochemical survey

TableII-1-2 List of collected data

Collected data	specification
E.P.O.No.351,514 Progress map (scale 1:50,000) Chemical assay maps (scale 1:5,000)	 1 sheet 9 sheets (L1WEST,L1EAST,L12WEST,L12MID, L12EAST,L13WEST,L13MID,L13EAST, L16WEST)
E.P.O.No.414 Progress map (scale 1:50,000) Chemical assay map (scale 1:5,000)	 1 sheet 1 sheet (J2)
Mhangura Mine Geochemical Survey Chemical assay maps (scale 1:2,500)	 7 sheets
ZMDC Copper soil geochem plan maps compiled by Simpson.H.(1990)	2 sheets (Figure No.7,No.8)

1-1-4 Statistical Processing of the Analysed Values

Chemical analyses data of geochemical soil sampling and each coordinate data were input into the computer. The univariate analyses were applied to the results of the chemical analyses.

In case of the geochemical data analyses, the frequencies of the population of trace elements are empirically known to follow logarithmic normal distribution (Lepeltir, 1969). It is general that actual populations of geochemical data consist of several kinds of population whose geochemical characteristics are different. Therefore, anomalous values are generally determined by focusing the deviation (anomalous populations) from the logarithmic normal distribution (the background population) which is formed by most of the indication elements. For the univariate analyses in this study, however, the gap between the standard deviation multiplied by an integer and the geometrical mean value are adopted as a threshold in order to define the density distribution of the content of each component, that is, the concentration contour value I_{ij} for i times of the standard deviation is calculated as ;

$$I_{ij} = m_j \times 10^{\sigma_j \times i}$$

where mj and σ_j are the geometrical mean value and the standard deviation for the j-th component, respectively.

Detectable limit of chemical analyses was 5ppm. Analysed values less than the detectable limit

were taken as 1ppm. Though 5 areas were studied, the statistical processing was carried out in one lump for all the areas.

1-2. Results of the survey

1-2-1. The characteristics of soil geochemical anomalies

The statistical parameters such as geometrical mean and standard deviation of logarithm and the zonal classification of the analyses are shown in Table II-1-3. Frequency distribution and cumulative frequency of the elements are shown in Fig.II-1-2.

TableII-1-3 Statistical parameters and zonal classification of the analyzed values

statistical parameter		zonal classification	
element	copper	I zone	$m\times10^{-\sigma}$ ~ $m\times10^{\sigma}$ 11.0ppm ~ 27.8ppm
Number of samples	33,681		
maximum value	66,000 ppm	II zone	$m\times10^{\sigma}$ ~ $m\times10^{2\sigma}$ 27.8ppm ~ 70.1ppm
minimum value	5 ppm		
mean	52.484 ppm	III zone	$m\times10^{2\sigma}$ ~ $m\times10^{2\sigma}$ 70.1ppm ~ 177.1ppm
geometrical mean	27.765 ppm		
standard deviation	428.478 ppm	IV zone	$m\times10^{2\sigma}$ < 177.1ppm <
standard deviation(log)	2.526		

*m:geometrical mean, σ:standard deviation(log)

Fig.II-1-2 Frequency distribution and cumulative frequency

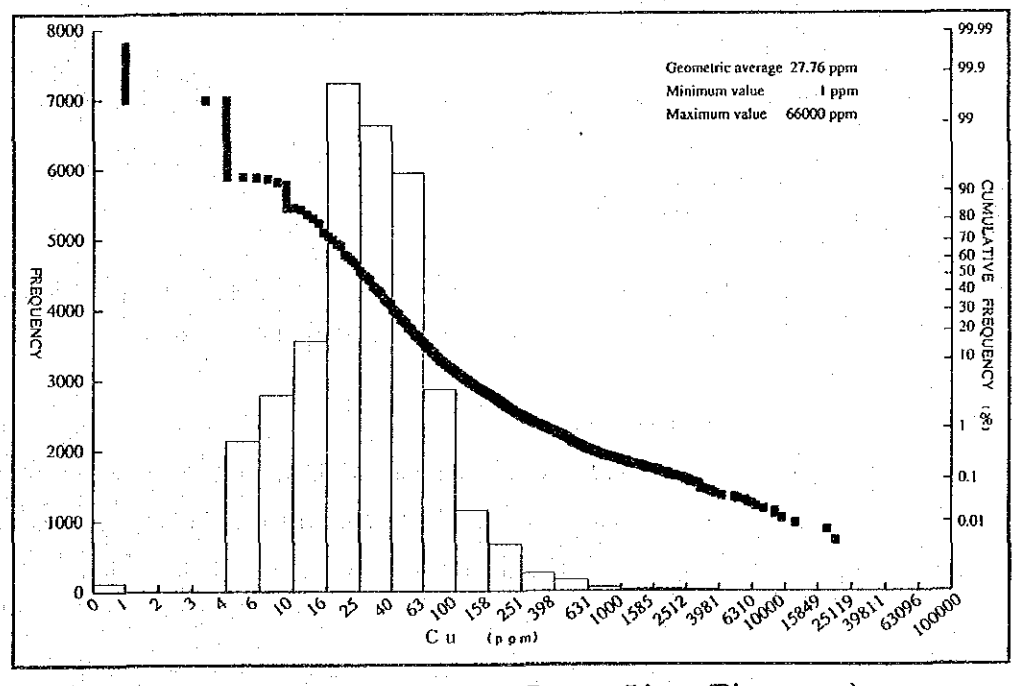


Fig.II-2-1 Locality of Survey Lines (Binge area)

The characteristics of the statistical values and frequency distributions of the copper univariate analyses for all over the area are as follows;

The geometrical mean value and the maximum value are 27.8ppm and 66,000ppm respectively. 0.35% of the population are less than the detectable limit. The relative frequency distribution shows that maximum frequencies occurred at 25ppm.

On the other hand, there is a inflation point near 100ppm in the cumulative frequency distribution curve. The population can be divided into low copper concentration group with steep curve and high copper concentration group with flat curve.

Arkose of Deweras group distribute generally in the high copper concentrate group area suggesting an enrichment of copper mineralisation.

1-2-2. The characteristics of each area

The results of the analyses of previous geochemical data is shown in Fig.II-1-3. The characteristics of each survey area are as follows:

1. Greenfields site

Chemical analyses data and compiled data used for the study in this area, because of many original chemical analyses data were scattered.

High Cu concentration parts of this area are distributed in the south-central part of the Wolwehoek farm, the north-central part of the Chimusenga farm, the western part of the Greenfields farm, the Geduld farm and the eastern part of the Chirombozi farm.

1) The Wolwehoek farm

The high Cu concentration part widely distributes in this area. It corresponds to the distribution of the dolomites of the Lomagundi group and the basic intrusives.

2) The Chimusenga farm

Small scale high Cu concentration areas are scattered in this area. They correspond to the distribution of the arkose of the Deweras group and the small scale basic intrusives.

3) The western part of the Greenfields farm

The distribution is narrow. It corresponds to the distribution of the boundary part of the arkose of the Deweras group and the basement granite. This boundary is the ore-bearing horizon of the Mhangura mine.

4) The Geduld farm

The high Cu concentration parts are widely distributed in this site. They correspond to the distribution of the basic intrusives within the Deweras group.

5) The eastern part of the Chirombozi farm.

The small scale high Cu concentration areas are scattered on this site. The high Cu concentration part of the western side of the main road corresponds to the basic intrusives. The high Cu concentration area along to the main road corresponds to near the boundary of the arkose and basement granite, and it tends to continue from the north to the south.

2. The Piringani area

Chemical analyses data and the compiled data were also used for the study in this site.

The zone of more than 50ppm of Cu concentration is widely distributed in this area. On the other hand, the distribution of the zone more than 100ppm concentration is limited to a narrow area.

3. The Inyati area

The high Cu concentration zones are widely distributed in the northern, the eastern and the western marginal part of the area. The small scale high Cu concentration zones lie scattered in the central part of this area. The high Cu concentration zones of the marginal parts correspond to the distribution of dolomite of the Lomagundi group. The high Cu concentration zone of the central part corresponds to the distribution of basic rocks and quartz vein. The old United Kingdom mine is situated at the contact part of the basic dyke and quartz vein.

4. The Lions Den area

The high Cu concentration zone(Cu>70.1ppm) of this area is characteristic of a narrow NNW - SSE trend in the central part of this site. The Cu concentration zone of more than 27.8ppm is distributed in the NS direction with a tree like shape. This high Cu concentration zone corresponds to the extension part of a basic dyke.

5. The Angwa area

The distribution of high Cu concentration zone(Cu>70.1ppm) of this area is classified into the following four sites.

1) The wide high Cu concentration zone around the Old Alaska mine

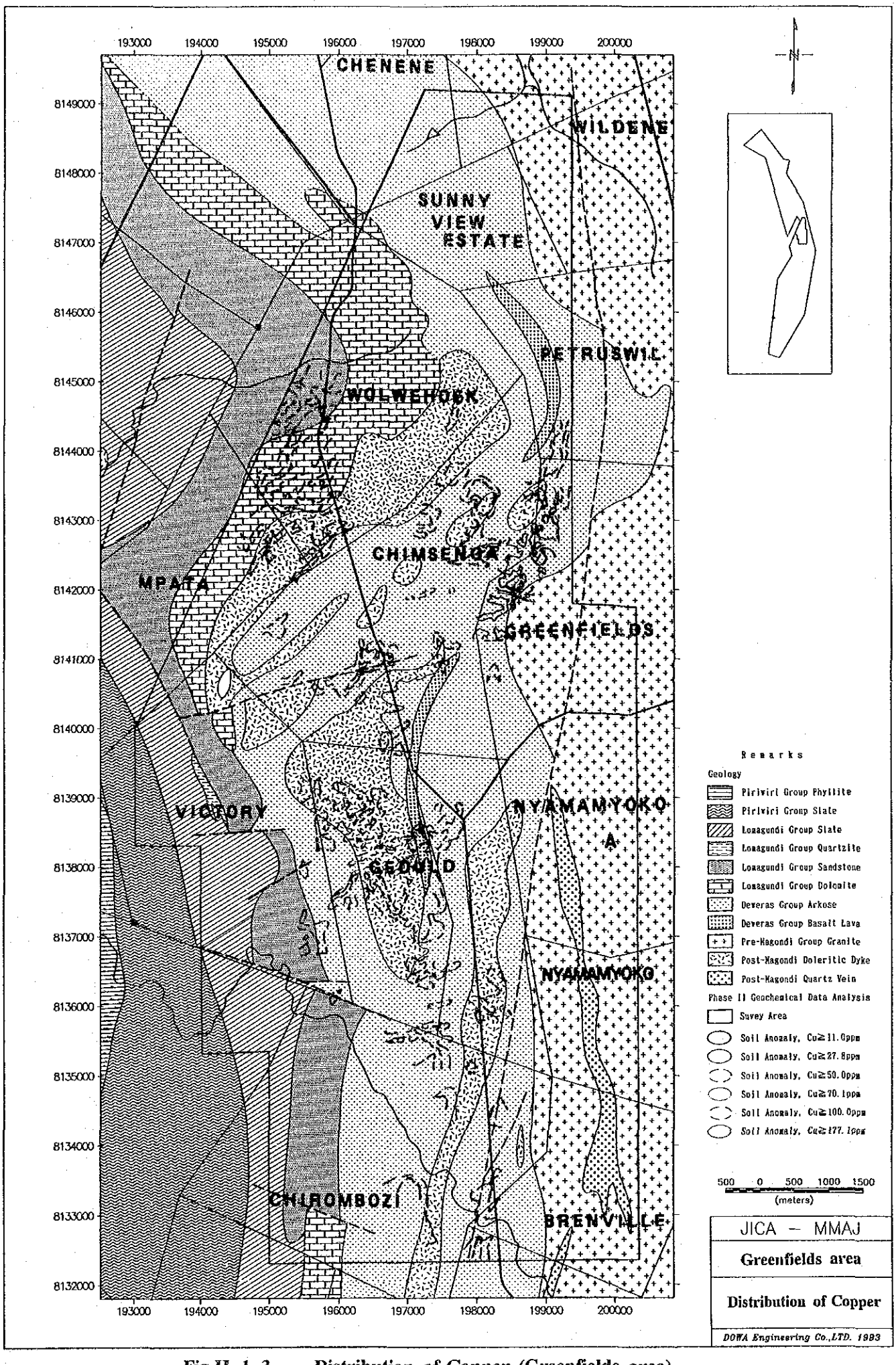


Fig.II-1-3 Distribution of Copper (Greenfields area)

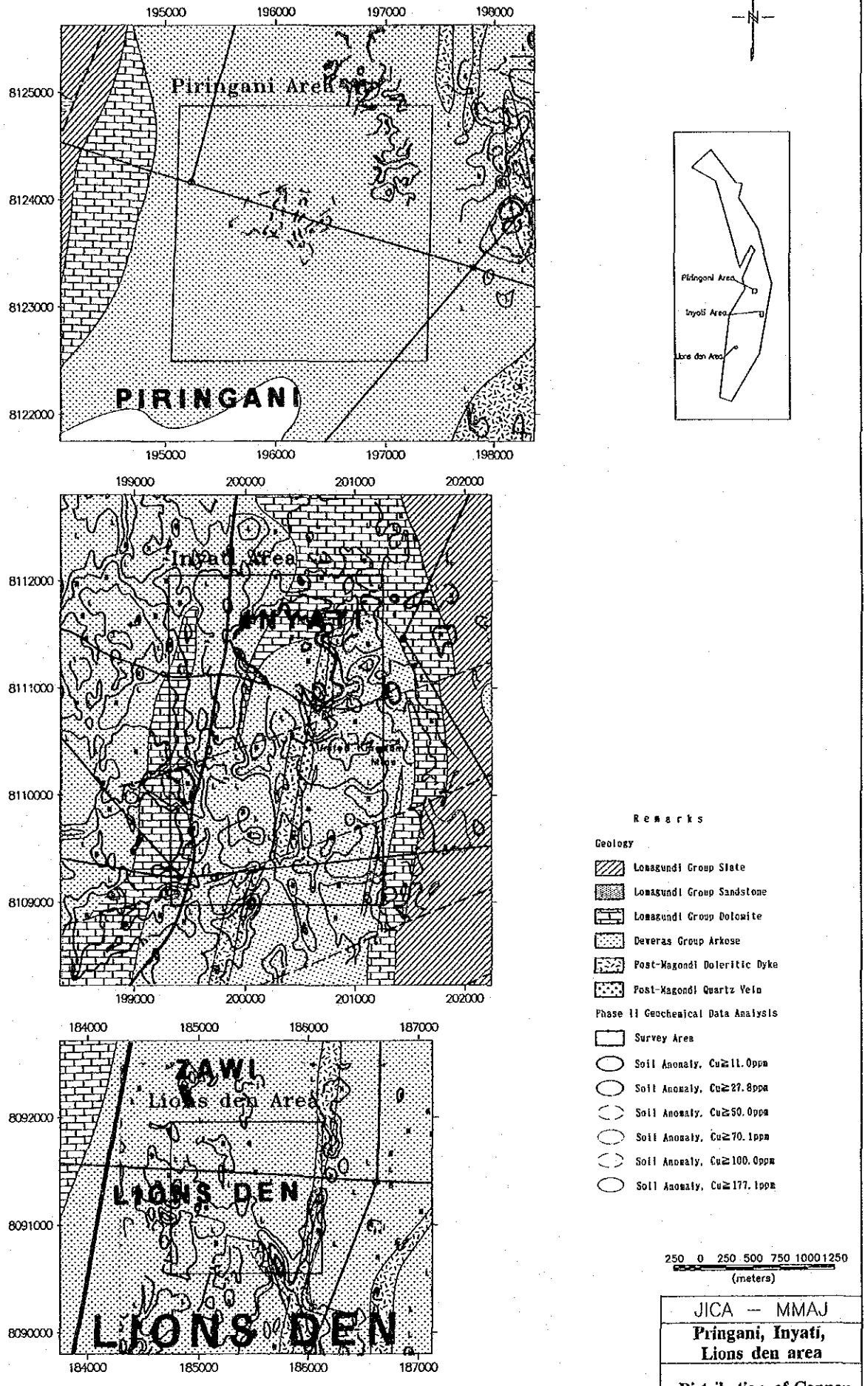


Fig.II-1-3 Distribution of Copper (Pringani, Inyati, Lions den area)

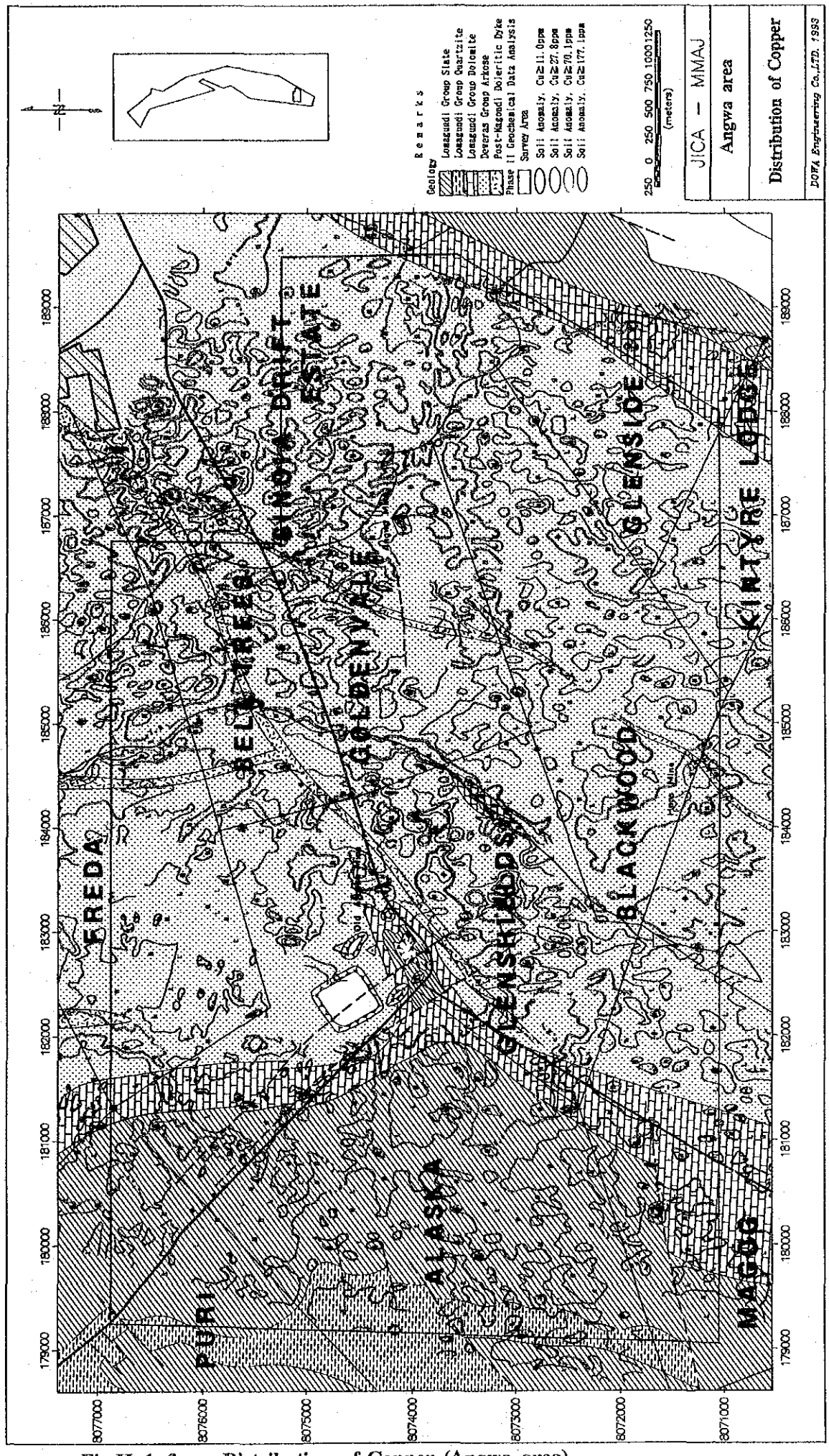


Fig.II–1–3 Distribution of Copper (Angwa area)