REPORT

ON

THE MINERAL EXPLORATION

IN

THE MALAWI AREA,

THE REPUBLIC OF MALAWI

(PHASE I)

MARCH 1983

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

REPORT
ON
THE MINERAL EXPLORATION
IN
THE MAKONDE AREA,
THE REPUBLIC OF ZIMBABWE

PHASE I

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Preface

In response to the request the Government of Zimbabwe, the Japanese Government decided to conduct a Mineral Exploration 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 21 June to 18 September, 1992.

The team exchanged views with the officials concerned of the Government of Zimbabwe and conducted a field survey in the Makonde area. After the 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.

MARCH 1993

Kensuke YANAGIYA
President
Japan International Cooperation Agency

Takashi ISHIKAWA
President
Metal Mining Agency of Japan

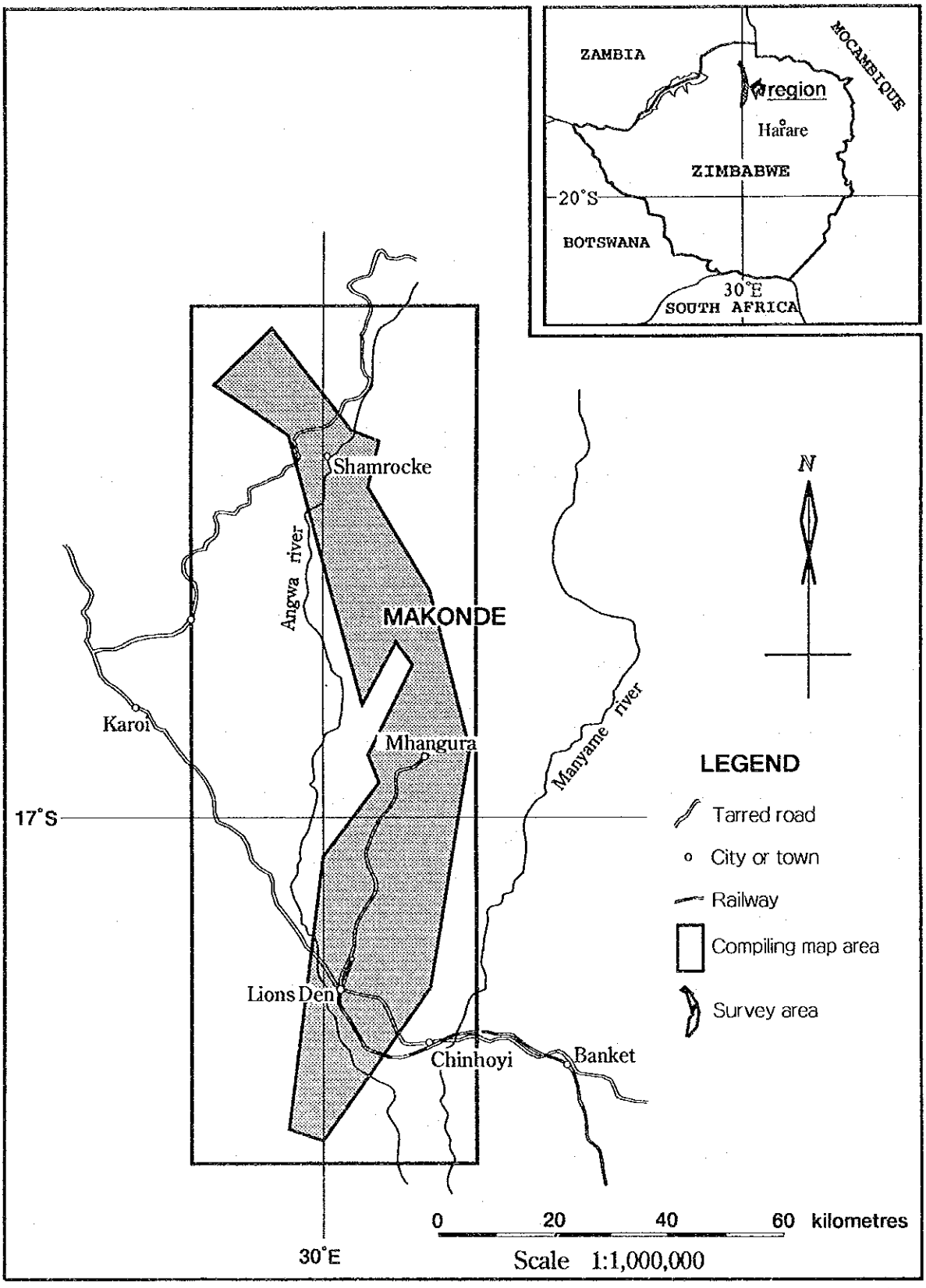

Fig.I-1-1 Locality of the survey area.

Abstract

This survey was carried out in order to study the situation of geology and explore new ore deposits in the Makonde area, the Republic of Zimbabwe.

The literature search covering the area of 7,500 square kilometres, geological survey covering the area of 2,250 square kilometres, and geochemical soil sampling covering the area of 919 square kilometres were carried out in this fiscal year as the Phase I of this project. The results are summarized below.

The literature search was carried out in order to understand the characteristics of geology and mineralization 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 mineralization 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 recognized. All the big economical ore mineral deposits such as tha Mangula 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 mineralization from the other is more expectative in case of application of geophysical prospecting in this area.

On the soil geochemical survey, the following places are extracted as the high potential areas for the existance 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

Based on the survey results above mentioned, the method of the survey of the phase II are proposed as follows :

1. The detailed data analyses

The detailed analysis of soil geochemical analyses data of the target area which are kept in the ZMDC must be carried out in addition to the data which were examined in this survey

2. The detailed geological survey

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

3. The geophysical survey

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

4. Drillings

Drillings in the most expectative areas based on the detailed data analyses, the detailed geological survey and the geophysical survey must be carried out in order to recognize the existance of the sulfide mineralization.

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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,1992, is the phase I 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 Mangula 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 corresponded the request and conducted the literature search, the geological survey, and geochemical surveys by soil geochemistry and CO_2 gas chromatography. Through these surveys, the survey team was dispatched and carried out the fundamental survey in order to explore new deposits.

1-2 The Survey Area and the Outline on the Works of the Phase I

The survey area is shown in the following coordinates.

(1) Data Compiling : area of 7,500 square kilometres

1)	16°11.86'S	29°47.00'E
2)	16°11.85'S	30°15.00'E
3)	17°38.97'S	30°15.00'E
4)	17°38.96'S	29°47.00'E

(2) Geological Survey: area of 2,250 square kilometres

A	17°30.86'S	30°00.00'E	B	17°30.04'S	29°56.78'E
C	17°04.42'S	30°00.19'E	D	16°56.38'S	30°05.94'E
E	16°53.41'S	30°04.72'E	F	16°44.32'S	30°08.97'E
G	16°42.78'S	30°07.84'E	H	16°49.69'S	30°04.25'E
J	16°22.84'S	29°56.36'E	K	16°18.52'S	29°48.86'E
L	16°12.90'S	29°55.26'E	M	16°23.15'S	30°02.96'E
N	16°23.57'S	30°05.32'E	O	16°28.18'S	30°04.12'E
P	16°38.24'S	30°10.15'E	Q	16°55.01'S	30°14.41'E
R	17°16.46'S	30°10.02'E			

The outline of the survey of the Phase I is as follows :

1. Literature Search

The analyses of the previous works by E.P.O.s (Exclusive Prospecting Orders) and Geological

papers kept in the Geological Survey Department, Ministry of Mines (hereinafter called GSD) were done. The results of the study about the characteristics of geology and mineralization based on the existing data were summarized and compiled in geological map on a scale of 1:100,000.

2 Geological Survey

The compiled geological map was confirmed and amended by field investigation. In the mineralized zone, assessment of mineralization characteristics and occurrence was carried out and collected the samples for the laboratory analyses.

3 Geochemical Surveys

Soil samples were collected in the interval of every 500 metres in selected areas. The GPS (Global Positioning System) was used to confirm the position of the sampling. Descriptions of soil colour and rock fragments containing in the soil were carried out in order to recognize the characteristics of geology and mineralization at same time.

Three area were selected for CO_2 gas chromatography, where are expected to search the existence of mineralization, fault zone and dyke systems. In each target area, test holes were drilled every 20 metres by 40 metres in order to measure CO_2 concentration within the soil. the ground measurement was carried out in order to determine the positions of the sites and survey lines in higher accuracy. Description of rock fragments collected from the holes was carried out in order to clarify the geology and the mineralization in the area.

Specification of each survey are shown in Table I-1-1.

Table I-1-1 The outline of the survey.

Specification of the survey	Numbers of survey	
Literature search		
Geologic map (1:100,000)	7	sheets
Reports of the past survey	1	set
Geological Documents	1	set
Airborne magnetic survey data	14	sheets
Geological survey		
Survey area Reconnaissance	2,25 0	sq.km.
Mineralization zone (9 areas)	90	sq.km.
Extension of survey line Rconnaissance	100	km.
Mineralization zone	135	km.

Table I-1-1 (Continued).

Geochemical surveys		
Survey area		916 sq.km.
Number of sample	Soil	3,676
Number of measurment	CO_2 gas	781

Specifications of laboratory test	Amounts of samples
1. Microscopic observation of rock thin section	50
2. Microscopic observation of polished ore samples	31
3. Chemical analyses	
1) Ore mineral: Au,Ag,Cu,Ni,Co,Pb,Zn,Pt	52
2) Soil : Cu,Au,Ag,Pb,Zn,Fe,Co,Ni,As,Hg	3,767
4. Measurement of resistivity and chargeability	41

1-3. Members of the survey team

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

Planning and Negotiation:

(Japanese Members)

Mr.Satoshi OKUMURA :Leader,Director of Overseas Activity Department,MMAJ
Mr. Shinji IKEDA :Ministry of International Trade and Industry
Mr.Jiro KOMATU :Ministry of Foreign Affairs
Mr.Hitoshi SATOH :JICA
Mr.Haruhisa MOROZUMI :MMAJ
Mr.Takahisa YAMAMOTO :Nairobi Office, MMAJ

(Zimbabwean Members)

Dr.John Lisle ORPEN :Director of GSD
Mr.Surrender Mdunyiswa Nyahwa NCUBE :Deputy Director of GSD

Field Survey

(Japanese)

Yoshioki NISHITANI :DOWA Engineering.,Ltd.
Naoya YUNOHARA :DOWA Engineering.,Ltd.
Makoto SUGA :DOWA Engineering.,Ltd.
Shin-ichi IWAYA :DOWA Engineering.,Ltd.
Hirohide KONNO :DOWA Engineering.,Ltd.

(Zimbabwean)

Fadzanai Bornewell MUPAYA :GSD

Field Supervisor:

Haruhisa MOROZUMI : MMAJ

1-4. Term of the Survey

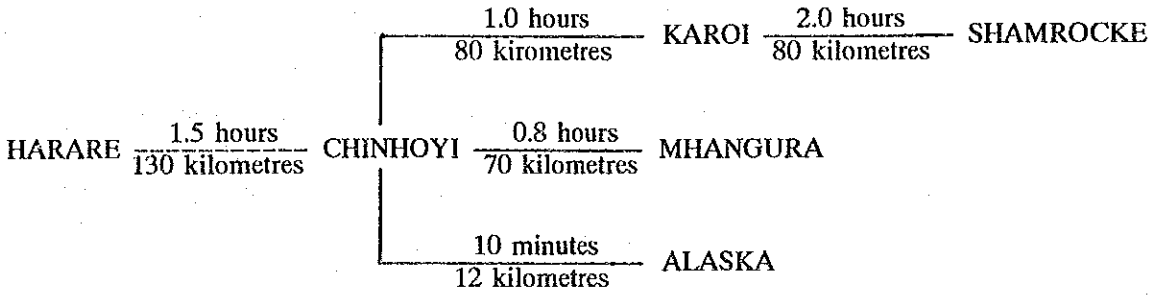
Field survey was carried out as follows:

Field survey	; from24 June	to 14	September	, 1992
Literature search	; from24 June	to 1	July	, 1992
Geological survey	; from 3 July	to 1	August	, 1992
Geochemmical surveys	; from10 August	to 10	September	, 1992

Chapter 2 Physical features

2-1 Location and Traffics

The Makonde area is located in the northern part of Zimbabwe. The distance and travel time by car from Harare are as follows:



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. However, roads between Karoi and Shamrocke are not paved, and only the 4WD cars can drive in the Safari area. So it is difficult to survey in the rainy season.

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

2-2 Topography and River System

The topography of the survey area reflects the characteristics of rocks. Topography of the southern area where generally affected by low grade metamorphism shows peneplain like a moderate swell of the elevation of 1,000 metres to 1,250 metres. On the other hand, The northern area where affected by high grade metamorphism shows steep topography with valleys.

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.

2-3 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 December). Climatic elements of each month are as follows:

Table I-2-1 The temperatures and rain falls in the area.

	Chinhoyi (1962-90 Average)			Karoi (1951-91 Average)		
	Temperature (c°)		Rainfalls (mm)	Temperature (c°)		Rainfall (mm)
	Maximum	Minimum		Maximum	Minimum	
April	27.8	13.5	36.0	24.2	13.9	39.9
May	26.0	9.3	6.9	22.2	11.2	8.0
June	24.1	6.1	1.9	25.6	8.7	3.0
July	24.1	5.6	1.2	22.2	8.2	1.5
August	26.5	7.7	2.4	24.6	9.8	1.1
September	29.9	11.8	5.7	27.7	13.0	4.8
October	31.2	15.4	28.7	29.4	15.9	18.3
November	30.1	17.0	82.6	28.1	16.8	80.8
December	28.0	17.4	161.1	26.1	16.9	178.7
January	27.8	17.5	179.8	25.8	16.9	189.1
February	27.4	17.2	170.9	25.6	16.8	193.8
March	28.1	16.1	111.7	25.7	15.9	108.2

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 Mangula Mine is owned by large-scale farmers to grow wheat, corn and grass, and pastures.

2-4 Others

The northern part of survey area near the Shamrocke Mine is called the State Land and the Safari Area. It is prohibited to enter without the licence of the competent authority.

Chapter 3. Previous Works

3-1. Outline of Previous Works

As regards the geology of this area and the surrounding area, geological maps of Zimbabwe on a scale of 1:1,000,000 and 1:100,000 are published by GSD.

As regards the exploration data of this survey area, 30 explorations was carried out between 1948 and 1978 by Messia Transvaal Development Co.Ltd.(hereinafter called MTD Co.Ltd.), Rhodesia Copper Ventures Limited (hereinafter called RCV Ltd.), Rhodesia Section Trust Exploration Limited (hereinafter called RSTE Ltd.) and other organizations with Exclusive Prospecting Order (hereinafter called E.P.O.).

As regards the nation wide surveys, the airborne magnetic survey was carried out by the financial and technical cooperation of CIDA (Canadian International Development Agency) and GSC (Geological Survey of Canada) in 1983 and 1990. By this survey, the structure of Magondi Supergroup and low magnetic anomalies at the shallow deposit zones of the Mhangura Mine, the Angwa Mine and the Hans Mine are revealed.

As the theses, there are many papers about geology such as Mundon,1987; Shoko,1985; Vinyu,1985 and Jacobsen,1962, and about ore deposits such as Kyle,1972; Muchenje,1974 and Tsomondo,1980, As regards the other authors, Thole,1974 and Master,1991, studied about this area.

Zimbabwe Mining Development Cooperation (hereinafter called ZMDC) re-examined the Previous E.P.O.s and the various records kept in the Mangula Mine since 1987, and recommended the following guiding principles of survey (Simpson:1990).

1) As regards geology and geological structure of ore deposit.

a) Cyclic sedimentation associated with the building of alluvial fans, stream delta, etc.

b) Early anticlinal fold axis which are formed before lithofication of the sediments.

c) Airborne magnetic and soil geochemical trends which transgress the N-S basin in a NE-SW direction.

d) Early strike slip faults parallel to the basin edge which could act as feeder for mineralized fluids.

2) Guidance of the future survey and the survey area based on the examination above mentioned.

a) Geological mapping of known structural trends crossing the basin;

i) Wari-Shackleton-Avonshack-Nijri

ii) Kenilworth-Hans-Angwa

iii) Muni West-Muni-Munwa

iv) Veldesia

v) North and South of Greenfields

b) Reconnaissance mapping from airphotos of areas not covered above.

c) Test surveys with several geophysical methods to see it known ore bodies can be found.

d) Drilling of Wari, Muni West and Kenilworth zones down plunge from present intersection.

e) Drilling of the Muni under Muni West will require good surface mapping before hole placement.

f) Drilling of Valdesia and Nijiri based on the surface mapping of the known mineralized areas.

g) Study of known ore bodies by geochemical and mineralogical methods to see if there is a marker alteration to the ore zone. This could be done by the University of Zimbabwe as several undergraduate projects or a graduate degree. Possibly a company geologist could do a master Degree on it part time.

3-2. General geology of the survey area

This survey area is located in Magondi Mobile Belt in the northern part of the Republic of Zimbabwe as shown in Fig.I-3-1. This Magondi Mobile Belt is bordered by the Zambezi Escrapment in the northern and the western part, and is also bordered by the Zimbabwe Craton in the eastern part.

Geology of this area consists of gneiss, green rocks and granites of Archaean era which forms the basement, and sedimentary rocks and volcanic rocks of Proterozoic era called Magondi Supergroup.

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

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

Deweras Group mainly consists of alluvial fan sediments such as conglomerate, arkose with cross-bedding and grading, and pelitic schist partly associated with chemical sedimentary rocks. It shows the structure of repeated sedimentation of the unit of Playa. This Group is distributed in the central part of the area successively from the north to the south, and includes strata-bound copper deposits.

Lomagundi Group can be divided into the lower formation which mainly consists of dolomite and poke-marked quartzite and the upper formation which mainly consists of stripped slate.

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

3-3. Geological setting

The Archaean basement rock is distributed in the eastern part of this survey area. Sedimentary rocks and volcanic rocks called Magondi Supergroup are markedly distributed in the western part of this area covering the basement rock with unconformity.

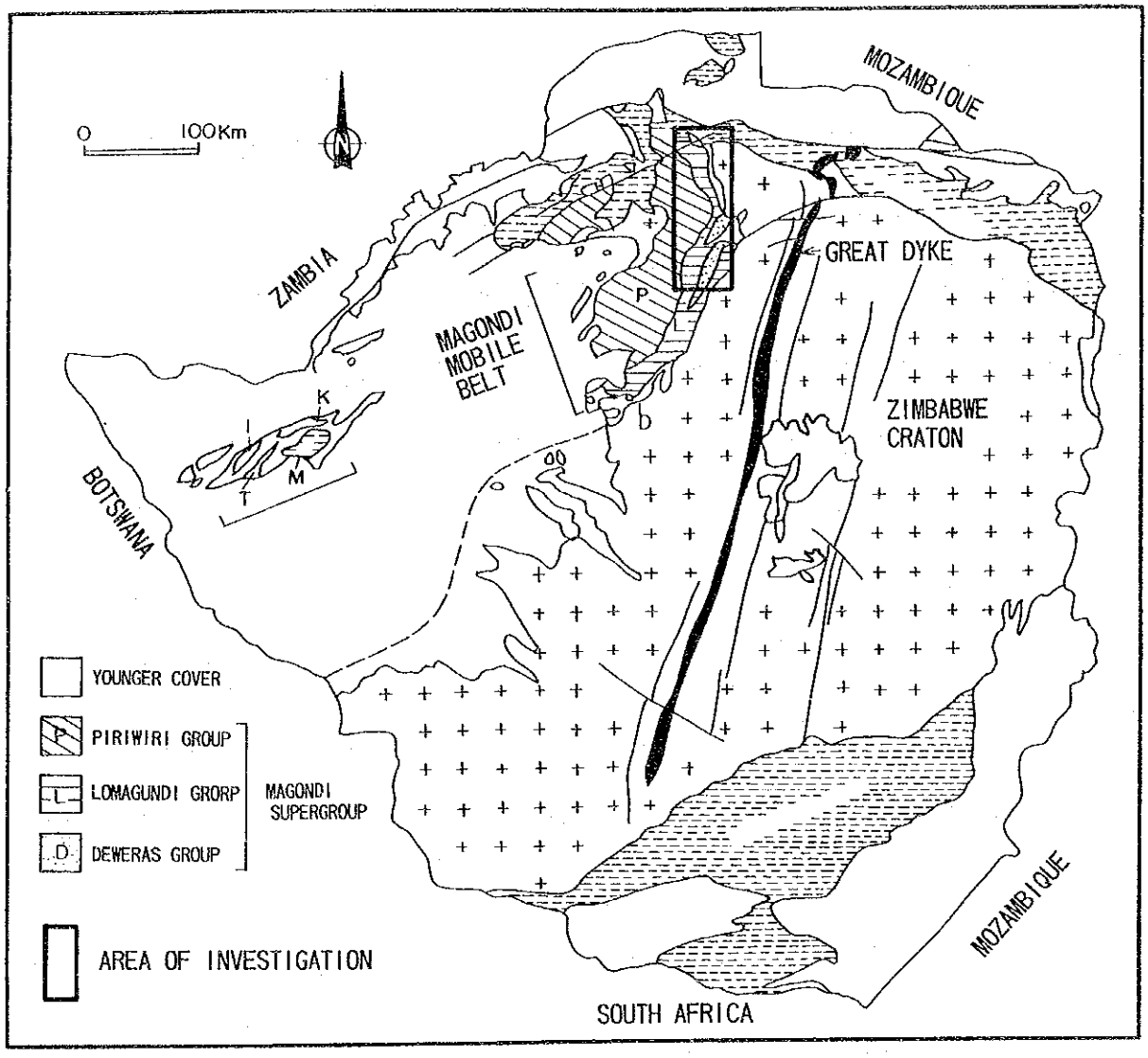


Fig.I-3-1 Geological setting of the survey area.

The age of Younger Granite within the basement rock is reported from 2,300 Ma to 2,600 Ma (Simpson, 1990).

The Sedimentary rocks in Magondi Supergroup was formed by sedimentation within the rift valley which was extended by the left lateral fault parallel the Great Dyke direction. According to the extension of the rift valley, alluvial fan sediments and playa sediments (Deweras Group) which was originated from basement rocks were formed at first, and covered lagoon sediments(lower Lomagundi Group) which consists of dolomite, quartzite and slate, later. Finally, pelitic rocks, fissilitic phyllite which was originated from pelitic rocks and alteration of fallen volcanic rocks, and deep sea sediments (Piriwiri Group) deposited.

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

Second structrual movement is so-called 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 considered to be 1,800Ma to 2,000Ma by Pb-Pb and Rb-Sr age determination method (Master, 1991).

Final Structural movement is called the Pan-Africa Zambezi Mobile Belt, which affected marked metamorphism to the northern part of this survey area and controlled the fold structure in the Shamrocke area.

3-4. Mining History

There had been many copper mines before Europian hunters and miners came into this area. The mining companies were established by Europian people in late 19th century and the mining right was established (Stegman 1978). The Old Alaska Mine area was also worked from late 19th century (Anon 1962b).

There are two epochs in the Zimbabwe mining industry. They are before 1930's and after 1940's, respectively. The first epoch of active mining was in early 1910's to middle of 1920's, when it corresponds to the First World War. Zimbabwe produced copper of 3,000t per year during this time. It was the most prosperous time of the Old-Alaska Mine, the Cedric Mine and the Silverside Mine in and the surrounding of area. The second epoch was opened from late 1940's by organized and continuous exploration of ore deposits. During this time, MDC, RCV Ltd., RSTE Ltd. and other organizations conducted the explorations of ore deposits under E.P.O. between 1948 and 1978. The total exploration expenses during this time was supposed to be R$ 4,000,000.

The Miriam ore deposit (ore resereves 60,000,000 tons; Cu, 1.0 %), the Norah Mine (ore reserves 8,000,000 tons; Cu, 1.2 %) and the Shamrocke Mine (ore reserves 5,000,000 tons; Cu, 1.2 %; Ag,

0.8 g/tons; Au, 0.018 g/tons) were discovered and developed. Geochemical surveys for copper was carried out between late 1950's and middle of 1970's. The Anguwa ore deposit (ore reserves 4,500,000 tons), Shackleton ore deposit (ore reserves 6,000,000 tons; Cu, 1.2 %) and Avondale ore deposit (ore reserves 4,400,000 tons; Cu, 0.9 %) were discovered.

Copper production in Zimbabwe is shown in Fig.I-3-2. As the result, copper production of Zimbabwe was remarkably progressed, and the maximum amount of copper production was recorded 55,000 tons in 1974. After the time, because of finishing of production in the Old Alaska Mine (1977), the Shamrocke Mine (1978) and the Shackleton Mine (1984) by decreasing the grade of crude ore and reduction of mining, the copper production decreased 20,000 tons in 1990.

The discovery and development of new ore deposits are urgent requirement for Zimbabwe at present based on these facts.

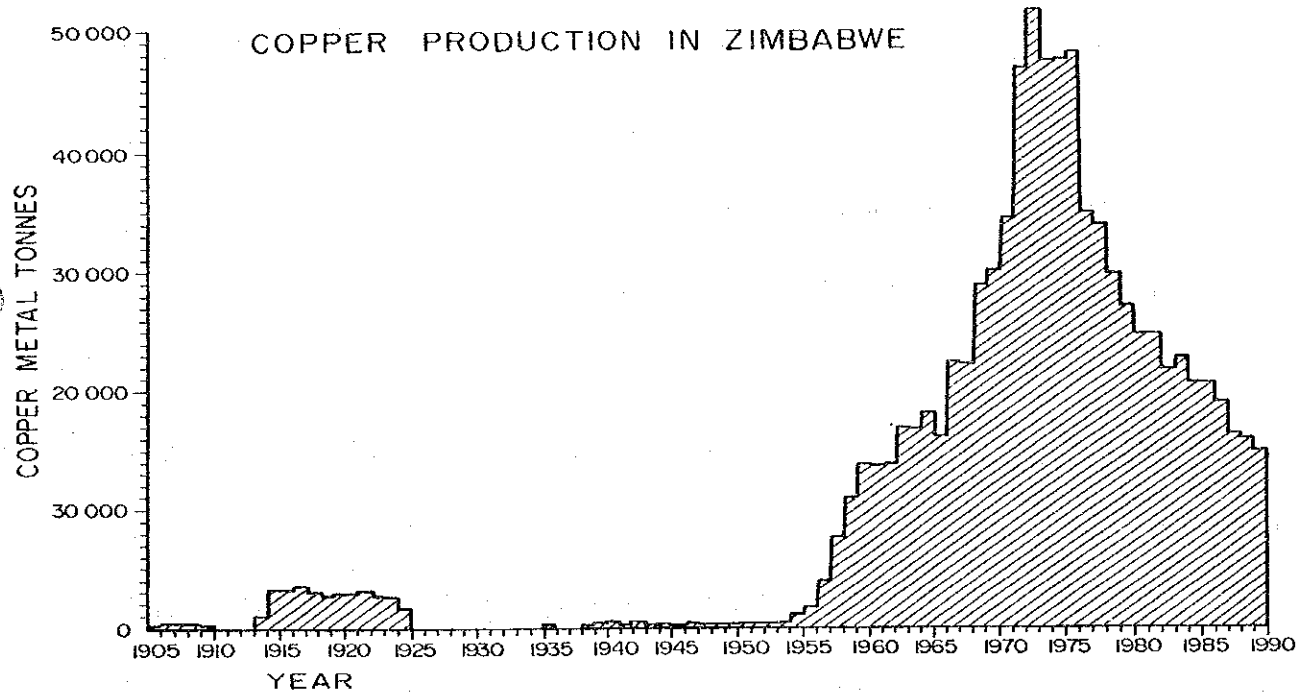


Fig.I-3-2 Copper production in Zimbabwe in 1905 - 1990.

Chapter 4 Considerations of the Survey Results

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

Sedimentary rocks of the Deweras Group of the Magondi Supergroup of proterozoic period are distributed stretching from the north to the south this area.

The Deweras group was affected at least three times of metamorphism.

The fold structure in early stage from the NE–SW direction is remarkable, and the N–S direction of the fold structure, thrust and NE–SW direction of the right lateral strike slip faults in the Magondi mobile period was overlaped in the southern part of this area (the south of the Norah Mine). The fold structure from the N–S to the NNE–SSW direction and thrust in the Magondi mobile period are prominent in the central part of this area (the Mangula Mine area and the northern extending part).

The fold structure from the NE–SW direction and the lateral faults from the NE–SW direction due to the effects of the Zambezi mobile period are prominent in the northern part (the area of the Shamrocke Mine).

The main mineralization in this area is strata bound disseminated copper ore deposits, such as the Old Alaska Mine, the Angwa Mine, the Hans Mine, the Shackleton Mine including the Avondale ore deposits in the southern part, the Mangula Mine and the Norah Mine ore deposits in the central part, and the Shamrocke Mine in the northern part of the area belong to this type of mineralization.

These ore deposits have the following some characteristics with some exceptions;

1) The ore deposits mainly occur within the Deweras Group, however, the Old Alaska Mine and the Shamrocke Mine occur within the Lomagundi Group.
2) The country rock of the ore deposits consists arkose or conglomerate to arkose just under the pelitic rock which forms the sedimentary cycle with conglomerate, arkose with gradings, cross-beddings and pelitic rock with evapolites layer.
3) Main ore minerals are irregular shaped bornite, chalcocite and chalcopyrite with minor covelline, magnetite and hematite as accessory minerals.
4) Major occurrences of the ore minerals are dissemination minerals which fill among the particles of the country rock. Quartz–sulphide veins are partly observed, particularly, high grade ore deposit accompanies both the occurrences.
5) Near the surface, the ore deposit forms oxidized zone which mainly consists of malachite and covelline.
6) On the grade of ore specimens analyzed by this survey, Au is 0.01 to 0.5 % except more than 1 % in the part of the thin vein. Ag is 1 to 30 g/ton except more than 60 g/ton in the part of the thin vein. Cu is within the range of 0.01 to 3.5 %.

As regards mineralization control, the ore deposit formation is controlled by the geological structure in the Shackleton and Avondale Mines. These ore deposits occur in the anticline axis from the NE–SW direction of the early stage or along the crest part of the small dome structure (the Avondale ore deposit) and in both the sides of the fault from the prominent N–S direction (the Shamrocke Mine). The Old Alaska Mine, the Angwa Mine and the Hans Mine occur under the same structural conditions.

As the Miriam ore deposit, the Norah Mine and the Shamrocke Mine are affected by the deformation after the formation of the ore deposits, the shape during the mineralization is indistinct. However, the ore deposits are presumed to be formed under nearly the same conditions.

From the view point of related igneous rocks, there are doleritic dykes near all of the ore deposits. The many dykes exist in the area without ore deposits. It seems difficult that the dykes have some relationship to ore deposits.

The above facts are summarized as follows:

1) Rocks such as conglomerate to arkose were regionally formed according to expansion of the rift valley.
2) Fine–grained pelitic rocks partly with evapolites were sedimented according to marine transgression.
3) The above 1 and 2 occur repeatedly to form the Deweras Group.
4) Fold structures, fault zones and fracture zones were formed by orogenic movement.
5) Ore fulid ascent through the fault zones and fracture zones, and selectively passed within the porous rocks along the anticline axis. The fine grained–pelitic rocks became the cap rock at that time.
6) In the above process, copper sulphide minerals precipitated to form the ore minerals of dissemination and fine veins.
7) Present shapes of ore deposits were formed by the effect of the folds and faults during the Magondi orogany and the Zambezi orogany after the deposition.

4–2 Potentialities of Expected Ore Deposits

The mineralization of the survey area formed the strata bound disseminated copper ore deposits, vein type ore deposits and banded iron ore deposits.

All the ore deposits, some are worked and some are suspended to mine, are the strata bound disseminated copper ore deposits, these deposits occur within conglomerate to arkose in each sedimentary cycle of the Deweras Group. They have the close relationship to the fold structure from the NE–SW direction which was formed in the early stage and the fault zones and the fracture zones which obliquely cross the fold structure. This ore horizon is distributed stretching from the north to the south in the central part of this area. The fold structure from the NE–SW direction and the fault zones and the fracture zones which obliquely cross the fold are expected besides the known ore deposit area.

Based on the above facts, this area is considered to have high potentiality of occurrence of new ore deposits.

As regards the vein type ore deposits, quartz veins within the basement granite are poor in grade of ore, and copper and silver bearing parts are observed in quartz-calcite veins within the Deweras Group, however, the scales are small. Banded iron ore deposits occur only in the boulder zone and all the details are unknown. Based on the facts, both the possibility of development and the economical value of vein type ore deposits and banded iron ore deposits are not recognized.

4-3 Relationship Between Geochemical Anomalies and the Mineralization

As the results of the soil geochemical survey based on Cu anomaly and the 4th principal component of 6 elements (Cu, Pb, Zn, Fe, Co and Ni)) multi-component analyses, the follows are extracted as the high potential areas of ore deposit occurrence.

1) The Angwa to Hans area
2) The south-west of the Old Alaska area
3) The Inyati area
4) The Pringani area
5) The Greenfields area
6) The Widene area
7) The Chipiri area
8) The Binge area

The geochemical anomalies of the Angwa to Hans and the south- western Old Alaska include the known ore deposits (the Old Alaska Mine, the Angwa Mine and the Hans Mine) and have the trend of the NE-SW direction. This facts harmonize the geological structure and the successive direction of the mines and mineralization zones in the survey area.

The Inyati area have the trend of the N-S direction include the United Kingdom Mine.

The Pringani area, the Greenfields area and the Wildene area are located in the south and northern end of extension of the known ore deposits (the Norah Mine, and the Mangula Mine) which stretch from the north to the south. The same geological condition with the known ore deposits was expected in these areas.

These facts mean that the soil geochemical anomalies show the significant signs for the next of the survey.

4-4 Physical Properties of Rocks and Ore Samples

The measurements of the apparent resistivity for 0.3Hz and 3Hz of frequency, the chargiability, and spectral IP of rocks and ore samples which were sampled at the outcrops and in the underground

of the mines was carried out.

Results of measurement are as follows :

1. Apparent resistivity

1) Aparrent resistivity varies from 128 to 13,216 Ω·m. The resistivity of slate is the minimum, and it has the tendency of increasing from arkose-conglomerate, through mafic rocks, quartzite, quartz vein, sandstone, granite to dolomite.
2) Apparent resistivity of the arkose of the Deweras Group which is the main horizon occurring ore deposits is high whose value is 3,000 to 7,000 Ω·m in the specimens which were mineralized by sulphides. The apparent resistivity varies 500 to 7,000 Ω·m in the specimens which are not mineralized. Therefore, mineralization does not make any effect to the resistivity. On the other hand, the apparent resistivity in the specimens which are oxidized ore samples shows the tendency of slightly lower of 500 to 1,000 Ω·m.
3) The apparent resistivity in dolerites and amphibolites which were mineralized by sulphides markedly varies from 700 to 6,000 Ω·m.

2. The chargeability

1) The chargeability of arkose specimens which is mineralized by sulphides shows high IP from 5 to 18 % according to the grade of copper. However, the chargeability in arkose which are mineralized by oxides only shows less than 1 % of IP.
2) The chargeability of dolerite and amphibolite specimens which was mineralized by sulphides shows high IP from 4 to 10 % according to the grade of Cu content.
3) Graphitic slate shows high IP of approximate 10 %.
4) The other rocks show low IP of 1 to 3 %.

3. Spectral IP

1) In sulphide ore samples, the phase difference is wide but a constant regardless of the frequency.
2) In oxide ore samples, the phase difference is nallow but a constant regardless of the frequency.
3) In dolerite and arkose with little copper mineralization, the phase difference is nallow for the low frequency, and the phase difference for the high frequency constant is 2 or 3 times of that for low frequency.
4) As regards magnitude, some rock specimens show the tendencies of increasing or decreasing for high frequency, and some rock specimens show constant. There is no obvious difference in relationship between the magnitude and the mineralization.

From the above facts, the following points must be noticed.

1) Possibility of effect to the resistivity by sulphide mineralization is little.

2) The arkose of the Deweras Group which is the main horizon of ore deposit occurrence in this area shows high IP according to the progress of the sulphide mineralization.
3) The specimens of dolerites and amphibolites which were mineralized by sulphides shows high IP according to progress of the sulphide mineralization.
4) Non-mineralized rocks and oxydized ore specimens show a low IP of 1 to 3 %.
5) Although graphitic slate shows high IP of approximate 10 %, the distribution is not recognized within the Deweras Group. Therefore, the graphitic slate can not be the interruption factor of IP survey.
6) Judging from the spectral characteristics, variety of the phase differences in sulphide ore samples and the other rock specimens are observed.

As the result, the chargeability method (e.g. IP survey) which detect the difference of the sulphide mineralization from the others is more expectative in case of application of the geophysical survey in this area.

Chapter 5 Conclusion and recommendation

5-1 Conclusion

The literature search, the geological survey and the geochemical survey were carried out in this fiscal year as the Phase I of this project.

The literature search: There are publications of the GSD such as the Geologic Maps and the Geomagnetic Chart, theses of the University of Zimbabwe and E.P.O.s' reports. The compiled geological map was made based on these data.

Geology of this area consists of the basement which consists of gneiss, granites, green rocks and siliceous rocks of Archaean, sedimentary rocks, volcanic rocks and intrusive rocks of proterozoic period, Triassic sedimentary rocks and Quaternary sediments in ascending order.

The existing main ore deposits are copper ore deposits. 9 copper mines were developed in the survey area and 4 mines such as the Angwa Mine, the Shackleton Mine (Avondale ore deposit), the Mangula Mine and the Norah Mines Mine are worked at present.

On the works for mineral resources, 30 surveys under E.P.O.s were conducted. The soil geochemical surveys for copper element were mainly carried out. As the results of these surveys, 54 places with Cu anomalies in the distribution areas of sedimentary rocks were extracted. Particularly, wide Cu anomaly is recognized in the area from the southern part of the Alaska Smelter through the southern part of the Hans Mine to Kennilworth. These geochemical surveys were carried out for Cu analysis. Analyses of other chemical elements were partly carried out, however, regional multi component analyses have not been carried out.

Geological survey : Field reconaissance was carried out based on the compiled geological map, and the geological map was revised.

The sedimentary rocks of proterozoic period in the survey area have the characteristic of extension of the rift valley. They are composed of the Deweras Group which consists of conglomerate, arkose and basalt lava, the Lomagundi Group which consists of dolomite, quartzite and pelitic rocks, and the Piriwiri Group which consists of phillyte, graywacke, graphitic slate and quartzite.

The known ore deposits in this area are strata bound copper ore deposits and vein type ore deposits occurring within the Deweras Group and the Lomagundi Group which are continuously distributed from the north to the south in the central part of this area.

The surveys of mines and mineralization zones were carried out for the mineralization zones such as the Hans, Angwa, Old Alaska, Shackleton, Avondale, Norah, Miriam and Shamrocke ore deposits (they are the strata-bound copper ore deposits), the United Kingdom ore deposit (vein type ore deposit) and other mineralization zones which were detected by the field reconnaissance.

The characteristics of the strata bound disseminated copper ore deposits in the survey area are as

follows :

1) The ore deposits mainly occur within the Deweras Group, however, the Old Alaska Mine and the Shamrocke Mine occur within the Lomagundi Group.
2) the country rocks of the ore deposits consist of arkose to conglomerate just under the pelitic rock which form the sedimentary cycle of arkose with grading, cross-bedding and pelitic rock with evapolite layer.
3) The main ore minerals are irregular shaped bornite, chalcocite and chalcopyrite with minor covelline, magnetite and hematite as accessory minerals.
4) Occurrence of the ore minerals is disseminated minerals which fill among particles of country rock, and partly accompanies with small vein minerals.
5) Near the surface, the ore deposit forms oxidized zone which mainly consists of malachite and covelline.
6) On the grade of ore specimens analyzed by this survey, Au is 0.01 to 0.5 % except more than 1 % in the part of the thin vein. Ag is 1 to 30 g/ton except more than 60 g/ton in the part of the thin vein. Cu is within the range of 0.01 to 3.5 %.

The process of the mineralization of the ore deposits are considered as follows :

1) The Deweras Group was formed by the repeated sedimentation of porous rocks such as conglomerate to arkose and fine grained pelitic rocks partly with evapolites according to extension of the rift valley.
2) Folds, fault zones and fracture zones were formed by a orogenic movement.
3) Ore solution ascent through the fault zones or the fracture zones, and selectively passed within the porous rocks along the anticline axis. Fine-grained pelitic rocks became the cap rock at that time.
4) In this process, copper sulphide minerals precipitated to form dissemination type and thin vein type.
5) Present shape of ore deposit was formed by the effect of fold and fault after ore depositions.

The measurement of physical properties of rocks and ore samples which were sampled by the outcrops and in the underground of the mines were carried out in order to obtain the data for the geophysical survey. The measurement items are resistivity for 0.3 Hz and 3 Hz of frequency, chargeability and spectral IP (SIP).

Results of measurement are as follows :

1) Possibility of effect to the resistivity by sulphide mineralization is little.
2) The chargeability of Arkoses of the Deweras Group show high IP from 5 to 18% according to the grade of copper.
3) The chargeability of Mineralized dolerite and amphibolite shows high IP from 4 to 10% according

to progress of mineralization.

4) The chargeability of non-mineralized rocks and oxidized ore specimens shows low IP from 1 to 3%.
5) Although graphitic slate shows high IP of approximate 10 %, the distribution is not recognized within the Deweras Group. Therefore, the graphitic slate can not be interruption factor of IP survey.
6) Judging from the spectral characteristics, variety of the phase differences in sulphide ore samples and other rock specimens are observed.

From the above facts, the chargeability method (e.g. IP survey) which detect the difference of the sulphide mineralization from the others are more expectative in case of application of the geophysical survey in this area.

Geochemical surveys : 3,676 samples were collected mainly in the Deweras Group in the area of 919 square kilometres, including the Alaska area, the Umboe area, the Mangula North area and the Shamrocke area based on the occurrence of main ore deposits within the Deweras Group.

The analyses of Cu, Ag, Au, Pb, Zn, Fe, Co, Ni, As and Hg were carried out, and univariate analysis and multivariate analyses were also carried out.

In comparison of univariate analysis and geology, the distribution of Cu anomaly places are classified into corresponding to mafic rocks, and originating in the initial copper mineralization.

The anomalies of Au, Ag, As and Hg does not show characteristic distribution. The reason is considered that many of the samples contain the above elements less than detection limits.

Fe anomalies correspond to the distribution of original rocks, and it has tendency of increasing from slate of the Lomagundi Group, arkose of the Deweras Group, dolomite of the Lomagundi Group and mafic rocks.

The high anomalies of Pb, Zn, Co and Ni correspond to distribution of mafic rocks.

The principal component analyses were carried out for ten elements of Cu, Pb, Zn, Fe,Co, Ni, Au, Ag, As and Hg, and for the 6 elements except Au, Ag, As and Hg from the above 10 elements.

The factor loadings of the 1st principal component for ten elements has positive relationship to all the elements. This component shows general concentration of metals. The 2nd to 5th principal components express that many samples contain Au, Ag, As and Hg less than the detection limits. The 6th principal component has positive relationship to Au and Pb contents.

The 1st principal component for 6 elements shows the same tendency of the 1st principal component for ten elements. The 2nd and 3rd principal components have high positive correlations with Ni and Pb. The factor loadings of the 4th principal component have positive correlations with Cu, Pb and Ni and the negative correlations with Zn, Fe and Co. It is possible to extract the Cu mineralization from Cu anomalies using of the 4th principal component for 6 elements.

The standard of judgement to extract the soil geochemical anomalous places accompanied with mineralization are as follows :

1) The high anomalous places for the only one component of Cu.
2) The high scored area of the 4th principal component for 6 elements.

The following places are extracted as the soil geochemical anomalous areas ;

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

Within the above areas, as 1) The Angwa to Hans area, 2) The south-west Old Alaska area, 4) The Pringani area, 5) Greenfields area, 6) The Wildene area and 7) The Chipiri area are located in the distribution area of the Deweras Group, the capability of the anomalies due to strata bound copper ore deposit is high. The anomalies of 3) The Inyachi area due to strata bound copper ore deposit and vein type ore deposit are considered, because of the existence of the United Kingdom Mine. Although 8) The Binge area is located in the distribution area of the basement rocks, the marked anomaly is recognized in the Binge area.

It is necessary to verify about the geology and mineralization around the above these anomalous areas.

As regards CO_2 gas geochemical survey, the following studies were carried out :

1) Comparison of the results of the gas chromatography to the sub-outcrops of the Avondale ore deposit (in the Avondale area).
2) Verification of the result of the gas chromatography to mafic dyke (the Shackleton area).
3) Comparison of the result of the gas chromatography to presumed southern extension of the Norah Mine (the Norah area).

As the result of the survey, most of the CO_2 values of the gas chromatography finally reflect the animals and plants of the surface. As the reason is considered that the sulphide contents of ore deposits

in this area are originally low, the results of CO_2 gas chromatography was strongly affected by the effects of the animals and plants.

5-2 Recommendation for the Phase II

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

The survey areas are the following expectative geochemical anomalous areas where were selected by this survey.

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

The method to be applied are as follows :

1. The detailed data analyses

The detailed analyses of soil the previous 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 mineralization 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 mineralizations.

Part II Details of the Surveys

Part II Details of the Surveys

Chapter 1 Literature Search

The localities of the known mineralization areas and the localities of previous works are shown in Fig.II-1-1 and Fig.II-1-2. List of the literature is shown in Table II-1-1.

4 copper mines are still worked at the present of 1992. Many surveys of orc deposit under E.P.O.s were carried out in the survey area.

1-1 Geology and Economic Geology

As regards geology of this area, there are "the Geological Map of Zimbabwe" on a scale of 1:1,000,000 (Stagman, 1978) and "the Geological Map" on a scale of 1:100,000 and "The Attached Explanation" (Fey and Broderic, 1990 ; Hahn and Steiner, 1990 ; Kirkpatrick, 1976; Stegman, 1959, 1961 ; Tennick, 1976 ; Wiles, 1961) published by the GSD of Zimbabwe.

1. Outline of Geology

The compiled geological map is shown in Fig.II-1-3. A comparison of stratigraphy of each map is shown in Table II-1-2. There are some contradictions among these comparison of stratigraphy. Therefore, the stratigraphy of the compiled geologcal map was made to add or to delete based on Simpson's stratigraphic classification (Simpson, 1990) after the comparisons of each stratigraphic classification of the geologcal map.

Geology in the area consists of the archaean era as the Basement Rocks, the Bulawayan Group, the Shanvaian Group and the Pre Magondi Intrusive Rocks, early proterozoic era as the Magondi Supergroup, the Guruve Metamorphic Complex, the Post Magondi Intrusive Rocks and the Sijarira

Table II-1-1 List of literature.

the leterature[1)]	amounts
Geological maps a scale of 1:1,000,000 a scale of 1:100,000	 1 sheet 7 sheets
The prvious E.P.O.s.	30 (Nos. 4, 5, 6, 20, 21, 35, 42, 43, 61, 62, 71, 74, 75, 80, 82, 83, 101, 106, 122, 137, 152, 249, 297, 351, 377, 396, 414, 422, 507, 514)
Geophysical Survey aeromagnetic maps, a scale of 1: 50,000	14 sheets
Others	9 papers

1) See the refference.

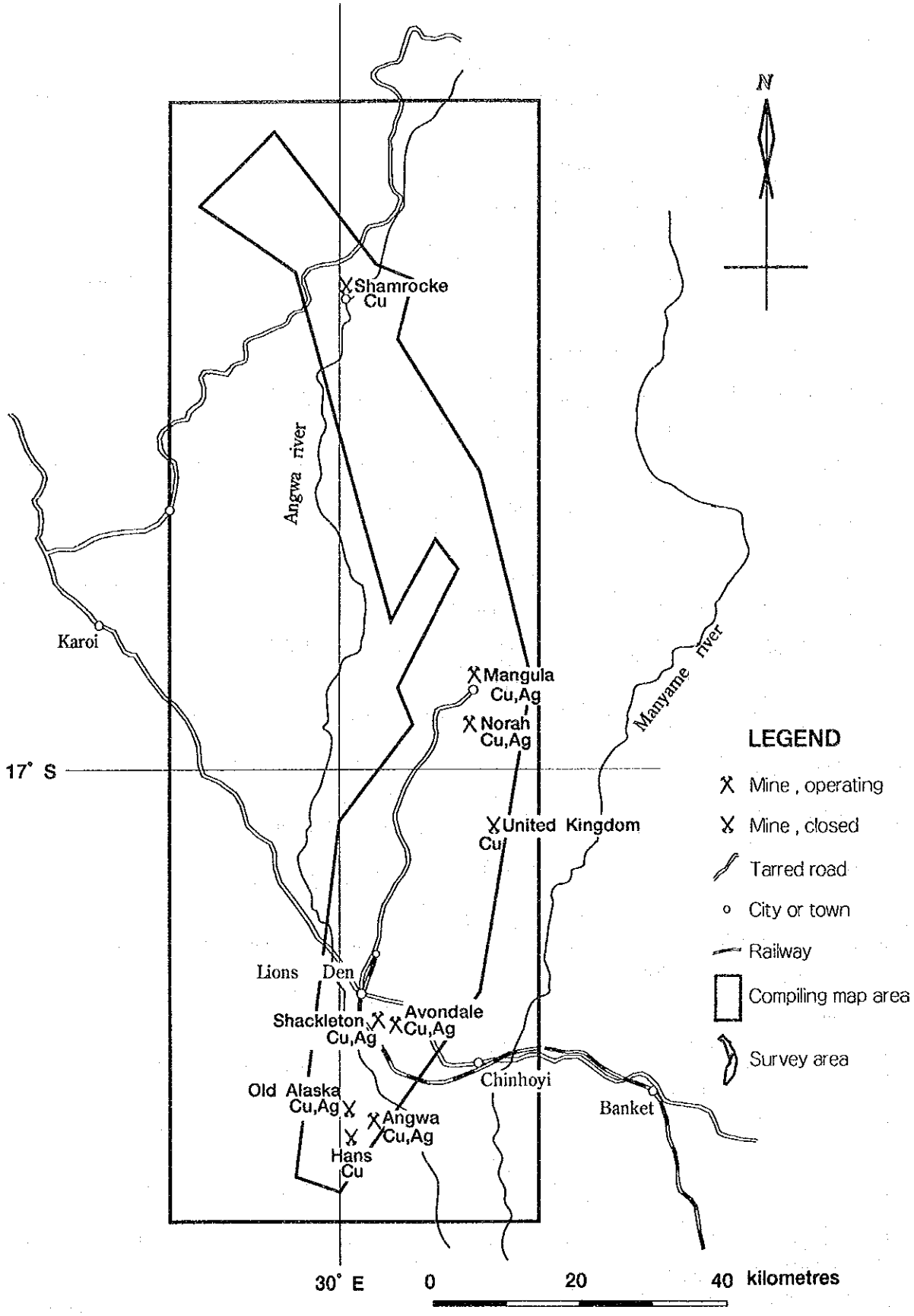


Fig.II-1-1 Locality of known mineralization area.

Group, the Upper Karoo Formation of triassic, and Quarternary sediments from lower to upper.

The Basement Rocks is distributed in the northern part of the compiled area, and consists of tonalite or orthogneiss of the composition of granodiorite, the Zambezi Escarpment Paragneiss, Urungwe Paragneiss and Chitumbi Paragneiss which have originated from graywacke and arkose.

The Bulawayan Group is distributed in the south-eastern part. The Group consists of banded the iron formation which often develops in the basement, meta-dolerite, pillow lava and basaltic green rocks.

The Shanvaian Group consists of meta-arkose, graywacke, conglomerate and fine-grained siliceous rock.

The Pre-Magondi Intrusive Rocks are distributed in the south-eastern part, the east and the north-eastern part of this area. They also consist of serpentinized ultra-basic rock, meta-gabbro and porphyritic or even-grained granite called Younger Granite.

Magondi Supergroup is widely distributed from the central part to the western part of the area. It is roughly classified into the Deweras Group, the Lomagundi Group and the Piriwiri Group. The Deweras Group is divided into the Sandy Formation with mainly arkose with conglomerate and the Volcanic Formation of basaltic lava and pyroclastics. The grain size of arkose varies from granule to clayish. It is arranged such that the sediments consist of alluvial fan sediments, stream sediments and playa sediments in the so-called Magondi sedimentary basin which was formed by extension of rift valley. This Group is main country rock of copper ore deposits in this area. The Lomagundi Group consists of the Mcheka Formation and the Nyagari Formation, and is distributed surrounding the Deweras Group. Mcheka Formation consists of dolomite, quartzite and siliceous rock partly with basal conglomerate. The Nyagari Formation is composed of mountain sandstone, quartzite, felsic quartzite and slate. Only The Unfuli Formation is distributed in the compiled area as the Piriwiri Group. Graphitic slate is distributed in the boundary part of the Lomagundi Group in the lower part, and phyllite with graywacke is widely distributed. Quartzite and sandstone is partly recognized.

The Guruve Metamorphic Complex consists of mainly quartzite, biotite schist and hornblende schist and is distributed along the Zambezi fault scarp in the north-eastern part of the survey area.

The Post-Magondi Intrusives Rocks consist of biotite granite, mete-dolerite or doleritic rock, amphibolite, pegmatite and quartz (-carbonate) vein. Biotite granite which has intruded into the Piriwiri Group which is distributed in the north-western part of the area. Dolerite, amphibolite and quartz vein are also widely intruded in this area. Pegmatite is recognized in Younger Granite in the eastern part and is distributed within the Piriwiri Group showing a dyke form in the area of the western to the north-western part.

The Sijarira Group is exposed in the Younger granite area in the south-western part of the compiled area on a small scale.

The Upper Karoo Formation of the Triassic period is distributed along the Angwa river on a small scale in the northern part of the compiled area. It consists of aerolian or fluvial eroded sandstone with

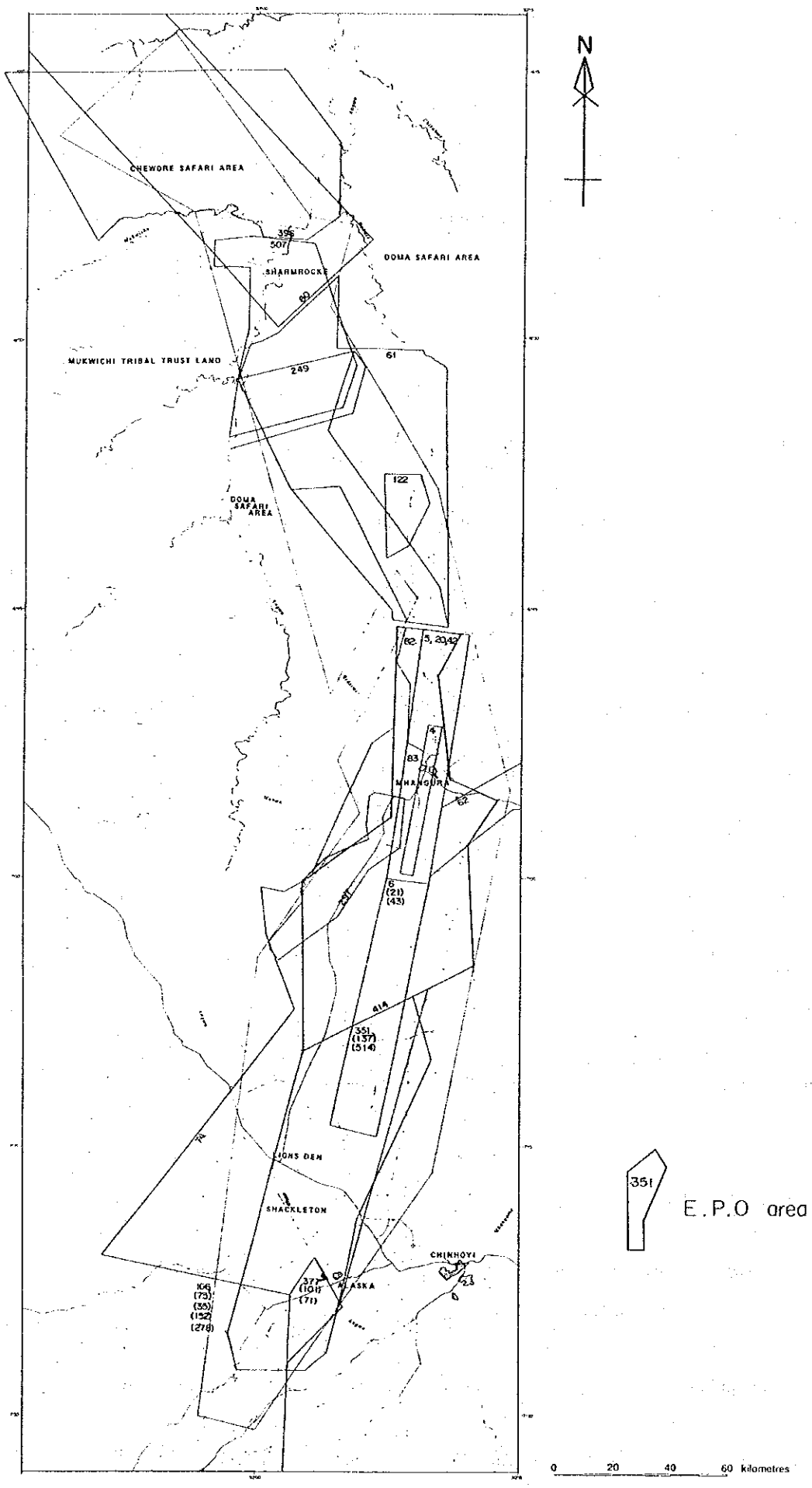
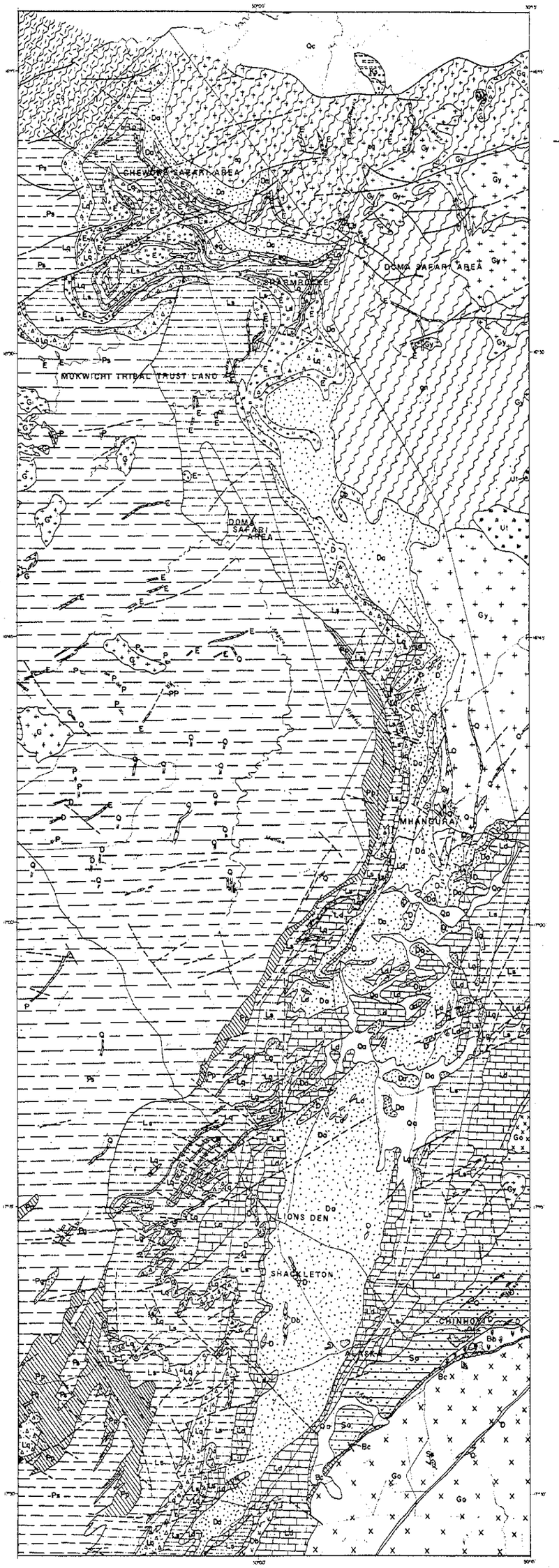


Fig.II-1-2 Locality of previous works.



Quaternary
- Qa — Soil, sand, gravel and alluvium
- Qc — Colluvial fan deposit and soil

Lower Proterozoic

Upper Karoo Formation
- Ks — Aeolian and fluvial sandstone

Magondi Supergroup

Sijarira Group
- Ss — Reddish sandstone

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

Guruve Metamorphic Complex
- Gg — Muscovite quartzite, feldspathic quartzite, biotite schist, amphibole schist

Piriwiri Group

Unfuli Formation
- Ps — Phyllite interbedded with greywacke
- Pg — Grit
- Pq — Quartzite, feldspathic quartzite, chert, felsite
- Pp — Graphitic slate, pyritifeous slate, argillite, greywacke

Lomagundi Group

Nyagari Formation
- Ls — Striped slate, argillite, phyllite, graphitic slate, quarzite, grits
- Lq — Quartzite, feldspathic quartzite
- Lg — Mountain sandstone, grits

Mcheka Formation
- Ld — Dolomite, quartzite, biotite bearing quartzite, chert, calc-silicate rock
- Lc — Basal conglomerate

Deweras Group

Arenaceous Formation
- Da — Arkose, argillite, arkose-pebbly conglomerate
- Dc — Main conglomerate

Volccanic Formation
- Db — Massive and amygdaloidal basalt

Archaean

Pre Magondi Intrusive Rocks

Younger Granite
- Gy — Porphyritic granite, even-grain granite
- Mg — Meta-gabbro
- Ut — Meta ultramafic rock with serpentine or talc

Shamvaian Group
- Sa — Metamorphosed arkose, greywacke, conglomerates, siliceous sediment

Bulawayan Group
- Bb — Epidolerite, pillow lava, undifferential greenstone
- Bc — Banded ironstone

Basement Complex

Chitumbi paragneiss
- Cg — Biotite paragneiss

Urungwe paragneiss
- Ug — Biotite and feldspathic paragneiss partly with calc-silicate inclusion

Escarpment paragneiss
- eg — Biotite paragneiss, biotite-hornblende paragneiss, hornblende paragneiss

- Gn — Orthogneiss

- Anticline with direction of plunge
- Syncline with direction of plunge
- Fault and fracture
- Thrust fault

0 20 40 60 kilometres

Fig.II-1-3 Compiling geological map.

Table II-1-2 Correlation of stratigraphies.

Ages	North West Fey & Broderick(1990)	North East Hahn & Steiner(1990)	Central West Wiles(1961)	Central East Stagman(1956)	Southern West Kirkpatrick(1976)	Southern East Stagman(1961)	Southen margin Tenick(1976)	Mhangura to Alaska Simpson(1990)
Quarternary	Recent	Recent	Recent	Recent	Recent	Recent	Recent	Recent
Cretaceous/ Jurassic		Kadzi Beds						
Triassic		Upper Karoo						
Lower Proterozoic	Piriwiri Group Lomagundi Group Argillaceous Formation Arenaceous Formation Deweras Group	Guruve metamorphic Complex Lomagundi Group Nyagari Formation Mcheka Formation Deweras Group	Intrusive Igneous Rocks (Divided by Meta- morphic grades)	Intrusive Igneous Rocks Lomagundi System Argillaceous Series Arenaceous Series Deweras Series ? System Piriwiri Series	Sijarira Group Igneous Rocks Lomagundi Group Zhonzhi Formation Sinoia Caves Formation Deweras Group Piriwiri Group Chitena Formation Kanyaga Formation Allochthonous Rocks of the Urungwe Klippe	Intrusive Igneous Rocks ? System Sijarira Series Intrusive Igneous Rocks Lomagundi System Upper Series Deweras Series ? System Piriwiri Series	Various Ages Piriwiri Group Umfuli Formation Lomagundi Group Nyagari Formation Mcheka Formation Deweras Group Arenaceous Formation Volcanic Formation	Post Magondi Intrusives MAGONDI SUPPER GROUP Piriwiri Group Umfuli Formation Lomagundi Group Nyagari Formation Mcheka Formation Deweras Group Multi-colour schist F. Mirian Grit Formation Gombera Hill Volcanic F.
Archaean	Chitumbi Paragneiss Urungwe Paragneiss Escarpment Paragneiss Basement Complex	Younger Granitoids Older Granitoids Mafic/Ultramafic Intrusive Rocks Escarpment Complex Shamvaian Group Coeval Units Bulawayan Group		Intrusive Igneous Rocks Younger Granite Older Granite Shamvaian System Bulawayan System	Urungwe Group Gneissose Granite	Intrusive Igneous Rocks Shamvaian System Sedimentary Series Bulawayan System Volcanic Series	Intrusive Igneous Rocks Bulawayan Group Felsic Formation	Pre Magondi Intrusives Lamprophyre & Granodiorite Mangula (Young) Granite Archean (Old) Granite Diabase dyke Shamvaian Greenstone Belt

Table II-1-3 Geochronology of the Magondi Mobile Belt.

Stratigraphy			Age (Ma)	Data	Events
			650~400	K-Ar mica age(Clifford et al. 1967))	Pan-African Zambesi thermal event
			1659± 50	K-Ar Piriwiri phyllite(Vail et al. 1968)	Magondi metamorphic age
			1753± 65	〃	
			1905± 70	K-Ar Lomagundi striped slate(Vail et al. 1968)	
			1974± 70	〃	
			1780±280	Rb-Sr Piriwiri granulite(Treloar & Kramers, 1989)	
			1890±260	Rb-Sr Piriwiri enderbite(Treloar & Kramers, 1989)	
			2000~1800	(Treloar & Kramers, 1989)	
			2000~1700	(Hahn & Steiner, 1990)	
	Post Magondi Intrusive rocks		1980± 80	Rb-Sr WR granitoid(Loeny, 1969))	Syn- to post-tectonic granites
			2153±125	Rb-Sr WR Urungwe granite(Clifford et al. 1967))	
			2150±100	Rb-Sr Pegmatite and late Granite	Post tectonic granites
Lower Proterozoic	Lagondi Super-Group	Piriwiri Series	2100±200	Pb-Pb Copper Queen massive sulphide(Leyshon, 1969)	Sedimatation ages
		Lomagundi Series	–	———	
		Deweras Series	2170±100	Rb-Sr lava(Hoehndorf, unpub. data, 1985)	
			2050	(Hoehndorf et al. 1990)	
	Pre Magondi Intrusive Rocks	Younger Granite	2600± 70	(Hahn & Steiner, 1990)	
		Older Granite	2700	(Wilson et al. 1978)	
		Great Dyke	2460± 16	(Cahen & Snelling, 1984)	
			2514± 16	(Hamilton, 1977)	
		other Dykes	2490±120	(Hahn & Steiner, 1990)	
Archaean	Shamvaian Series		–	———	
	Bulawayan Series		–	———	
	Chitimbi paragneisses		2360± 90	Rb-Sr Chipisa paragneiss	Early Proterozoic crust forming event
	Urungwe paragneisses		2465± 53	Rb-Sr Kariba paragneiss	
	Escarpment paragneisses		–	———	
	Basement Complex		–	———	

poor sorting.

There are two kinds of Quarternary sediments. One is composed of talus alluvial fan sediments which is distributed along the northern big river of Zambezi fault scarp in the northern part of the area. The other is composed of pebble, sand, soil and alluvial sediments which is markedly distributed along the rivers in the area of the southern to the central part.

2. Geological structure

Geochronoloy of the Magondi Mobile Belt is shown in Table II-1-3.

The survey area is located in the Magondi mobile belt. The Magondi Supergroup which consists of Proterozoic sediments and volcanics is widely distributed from the direction of the south to the north. The Magondi Supergroup is roughly divided into the Deweras Group, the Lomagundi Group and the Piriwiri Group in ascending order horizon. Deweras Group is considered to be sediments within the sedimentary basin of the rift valley (Cooper, 1978) or the craton (Maiden et al, 1984). The eastern margin of the Group is controled by fault from the direction of NNE-SSW. The thickness of the Piriwiri Group of the upper horizon becomes thicker to the western side, which indicates expansion of the sedimentary basin.

Structural analyses of the southern part of the Magondi Mobile Melt are carried out for the Copper Queen district which is located 60 kilometres west of Chinhoyi (Leyshon, 1969), Shackleton district (Treloar, 1988) and Chinhoyi district (Stowe, 1978). Three periods of deformation are distinguished

in these district. The fold structure with the direction of the NE or NNE is considered to be the main facies (F1) which originated from the initial cleavage. The F2 fold in the Copper Qeen district has the same direction of fold axis of F1, however, the axial-plane inclined to the west. F3 with the direction of the NW forms an oblique fold against F1 and F2 folds (Leyshon and Tennick, 1988). The fold axis of the NW is considered to be F2 in Chinhoyi district and the axis of the direction of the NE is F3 (Stowe, 1978). F1, F2 and F3 have the directions of 10°E, 55°E, and 30°E, respectively. The NW trend is not recognized in the Shackleton district (Treloar, 1988).

On the other hand, there are three of the deformation structures which shows the NNE-SSW to the N-S and fold structure of the direction of the NE-SW, and lateral fault of the direction of the NE-SW in the northern part. However, the structure with the direction of the NW-SE is not recognized (Thole, 1974).

3. The known ore deposits

List of the known mineralization areas is shown in Table II-1-4.

The copper ore deposits are the only mineral resources which have economic feasibility. Silver and gold associated with copper ore deposits are also recovered. Besides the metal resources, crushed dolomite for construction and slate for building materials are worked in several places.

9 mines and ore deposits have operated before, but now only the Angwa Mine, the Shakleton Mine including the Avondale ore deposit, the Norah Mine and the Mangula (Miriam) Mine are still mining at present.

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

The former are strata bound ore deposits occuring 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 Mangula (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 the result of the survey of the ore deposits and the mineralization area, the anticline structure from the direction of the NW-SE is considered 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.

1-2 E.P.O.'s Reports

Mining activities in the survey area have a long history. The Old Alaska Mine had been in existence before the visit of the Europian peoples. The surveys of copper were carried out successively from the 1940's to the middle of 1970. The surveys of ore deposits are carried out under the Exclusive Prospecting Order (hereinafter called E.P.O.). All of the E.P.O. which were established in the survey

Table II-1-4 List of the known mineralization areas.

No.	Name	Minerals	Ore type	Products	Activity	Hosted rocks	Main ore minerals
1	Hans	Cu, Ag	Massive sulphide	300,000t 1.0%Cu (1974 - 1976)	closed	Deweras Group, arkose, conglomerate	malachite
2	Angwa	Cu, Ag	Massive sulphide	16,000t/m 0.6%Cu, 18g/tAg	operating	Deweras Group, arkose, conglomerate	chalcocite, bornite, pyrite, chalcopyrite
3	Old Alaska	Cu, Ag	Massive sulphide	32,736t Cu (1929 - 1977)	closed	Lomgundi Group dolomite, slate	malachite, chalcocite
4	Shakleton	Cu, Ag	Massive sulphide	6,000,000t 1.2%Cu (1968 - 1984))	closed	Deweras Group, arkose, conglomerate	chalcocite, bornite, chalcopyrite
5	Avondale	Cu, Ag	Massive sulphide	16,000t/m 0.8%Cu, 18g/tAg	operating	Deweras Group, arkose, conglomerate	chalcocite, bornite
6	United Kingdom	Cu, Ag	Vein type	2.72t Cu, 1.59kg Ag (1939 - 1940)	closed	Deweras Group, Dolerite arkose, dolerite dyke	malachite, crysocolla
7	Norah	Cu, Ag	Massive sulphide	50,000t/m 0.64%Cu, 0.78g/tAg 0.05g/tAu	operating	Deweras Group, arkose, conglomerate	bornite, chalcocite, chalcopyrite
8	Mangula(Miriam)	Cu, Ag, Au	Massive sulphide	120,000t/m 0.70%Cu, 8.2g/tAg 0.068g/tAu	operating	Deweras Group, arkose, conglomerate	chalcocite, bornite, chalcopyrite, pyrite
9	Shamrocke	Cu, Au, Ag	Massive sulphide	25.36t Cu 117.13kg Au 754kg Ag (1971 - 1978)	closed	Lomagundi Group Graphitic slate, sandstone	chalcopyrite, pyrrhotite, arsenopyrite, sphalerite

area include Nos. 4, 5, 6, 20, 21, 35, 42, 43, 61, 62, 71, 74, 75, 80, 82, 83, 101, 106, 122, 137, 152, 249, 297, 351, 377, 396, 414, 422, 507 and 514. Almost all final reports of surveys are filed in GSD, and are available to examine. Summaries of the surveys of the E.P.O. No.1 to No.500 were published in the GSD (Morrison, 1972, 1974, 1978). A part of the original data is kept in the offices of the Mangula Mine and the Shackleton Mine.

List of previous survey is shown in Table II-1-5. The survey of the E.P.O. is ordinarily established within 3 years plan, however, the termination or extension is conducted depending on the situation in the middle of the plan. In case of continuation of the survey in the same area or in selected area, E.P.O. is re-established. The outline of E.P.O. is described later. E.P.O.s which are obviously considered to be the continuation, are described in the same paragraph.

1. E.P.O.Nos. 4, 5, 6, 20, 21, 42, 43, 82 and 83

These E.P.O.s were located along the eastern margin of the Magondi sedimentary basin which is located around the present Mangula Mine to the south of the Norah Mine. A series of these E.P.O.s for the survey of copper deposits was carried out during 14 years from 1948 to 1961. Although Rhodesia Copper Venture Limited (hereinafter called RCV Ltd.) initially conducted the survey, as RCV Ltd. was purchased by the Messina Transvaal Development Company Limited (hereinafter called MTD Co.Ltd.), from 1956 onward the survey was continued by MTD Co.Ltd.

In the survey area of these E.P.O.s, arkose of the Deweras Group is distributed and mafic rocks are intruded.The Younger Granite and the Shanvaian Group is distributed in the north-eastern marginal part of the area.

Pit and trenching were carried out for known mineralized area before 1950, and diamond drilling were conducted during 1950 to the end of 1951.

Three vertical shafts were constructed in the West Molley ore deposit in January, 1952, and cross cut was excavated systematically on the 30 metres and 120 metres level. Deep diamond drillings were carried out at the end of 1952. The survey was suspended because of final negotiation, only the maintenance of facilities was carried out from 1953 to 1954. The commencement of mining was determined in December,1954. In response to the determination, diamond drilling were reopened and the Molley vertical shaft was sunk down to 300 metres.

The continuation of mining of the Molley and the Norah Mines was emphasized during 1956 to 1959. Besides the operation, geologcal mapping, soil sampling, SP survey and magnetic survey were carried out in the area of E.P.O. No.21 and No. 42.

Geological mapping, soil sampling, trenching and drilling were carried out concentratedly in the contact part of the Younger Granite and arkose of the Geweras Group during 1956 to 1961.

Almost all the data obtained by these surveys such as analyses of geochemistry and the original data of the geophysical survey were lost.

Table II-1-5 List of the previous survey.

EPO. No.	Holder	Duration	Previous EPOs	Metal sought	Remarks
263	Rio Tint Ltd	21. 2. 69-21. 2. 72		Cu, Ni, platinoids	A continuation of the anomaly in EPO 217 was found.
217	Rio Tint Ltd	15. 3. 68-15. 3. 71	70	Cu, Ni	Low Cu content in the anomalies.
297	S. A. Manganese Ltd	11. 10. 69-10. 10. 71		Cu, Ni	Anomalous vanadium mineralisation noted.
377	MDC Ltd	27. 2. 71-10. 7. 75	6, 21, 35, 43, 74, 75, 76, 101, 137, 152, 278	Cu	The EPOs covered the area around Alaska, Shackleton and Avondale copper mines.
383	Blanket Mine (Pvt) Ltd	27. 3. 71-26. 3. 73	70, 217	Ni, Au, Cu	Disappoiting results.
396	Prospect of Rhodesia(Pvt) Ltd	10. 7. 71-9. 7. 72		Ni, Cu and precious metals	
411	Blanket Mine (Pvt) Ltd	7. 1. 72-7. 1. 74	8, 35, 39, 76, 84, 85, 152, 161, 278, 322, 324	Cu, Zn, Pb, Ni and Co	Cu mineralisation too low a grade
414	MDC Ltd	19. 2. 72-9. 9. 77	3, 4, 5, 6, 16, 20, 21, 35, 42, 43, 71, 74, 75, 76, 82, 83, 101, 106, 137, 152, 351	Cu	Sub-economic copper prospect.
514	LSM	18. 10. 75-9. 9. 77		Cu	
518	Blanket Mine (Pvt) Ltd	29. 11. 75-28. 11. 76		Au	
507	Nyaschere Copper	5. 7. 75-18. 2. 77		Cu, Au	
528	Tarrus(Propriety) Ltd	16. 1. 76-5. 2. 81		Cu, Ni, Co, Arsenic, precious metals	

2. E.P.O.Nos. 35, 75 and 106

These E.P.O.s were established in the area including the Old Alaska Mine and the Cedric Mine (the area is located approximate 10 kilometres south from the survey area), the center of the area was 20 kilometres west of Chinhoyi. A series of these E.P.O.s were carried out during 1955 to 1962. The target was the survey of Cu, Pb, Zn and noble metals.

Mapping based on the past survey, SP survey, magnetic survey and 25 drillings were carried out as the 1st year's survey in E.P.O. No.35 around the Old Alaska Mine. The same surveys were carried out around the Cedric Mine in the second year. Soil sampling of 4,641 with the sampling interval of 30 metres x 120 mtres, the aeromagnetic survey and the radioactivity survey were carried out as the final years of this E.P.O. Only copper was analyzed in soil samples. Site of sampling and method of analysis is unknown.

Soil sampling, SP, resistivity, IP, pitting, trenching and diamond drilling were carried out under E.P.O. No.75, and the mineralization area with malachite was discovered within arkose in the southern part of the Alaska Mine.

The detailed survey of E.P.O. No.106 was carried out around the mineralization area which was discovered in E.P.O. No.75. IP, resistivity and ground magnetic survey were carried out with the length of survey line at 550 metres, and trenching and drilling were also carried out. Several layers of the mineralization area were detected within arkose and a grade of copper of 1.0 % was recognized in the area of 15 metres x 30 metres.

The surveys were carried out for a comparatively large scale and high grade ore body near the surface. Geochemical survey was not established in the sampling depth, the particle size of sieves and methods of analysis. No ore body could be detected by geophysical survey.

3. E.P.O.Nos. 61, 62, 71, 74, 101, 122 and 137

The target area of these E.P.O.s covered widely near the Shamrocke Mine to the Alaska Mine from the north to the south. The survey was carried out by Rhodesia Selection Trust Exploration Limited (hereinafter called RSTE Ltd.). The term of survey was during 1957 to 1966. Geochemical survey was widely carried out and 277,070 soil samples and 17,000 samples of stream sediments were collected.

The surveys area was located along the eastern margin of the Magondi basin. Geology of the area consists of slate of the Piriwiri Group, dolomite and quartzite of the Lomagundi Group and arkosic rock of the Deweras Group.

In E.P.O. No.61 and No.62, the contact part of the Magondi basin with the basement granite was considered to be the best environment for the formation of copper mineralization of the strata bound deposit. The geochemical survey of soil and stream sediments were mainly carried out. Pits, trenchings and diamond drillings were carried out in the position where geochemical anomalies detected. Many anomalies were extracted by geochemical survey, and some anomalies were caused by the existence

of mafic rocks.

E.P.O. No.122 was established in the southern geochemical anomaly area of E.P.O. No. 61. Although copper with the grade of 0.1 % to 0.3 % was recognized near the surface by diamond drilling, it was sub-economic.

The wide area survey was carried out in the area of the Alaska Mine to the Mangula Mine under E.P.O. No.74. Soil geochemical survey same as other E.P.O.s was carried out and many anomalous places were detected. The anomalies with no relationship to the mineralization of strata bounded ore deposits was summarized as the following:

1) Copper is concentrated in lateritized clayish soil
2) High background concentration of copper in dolomite and shale compared to arkose
3) Mafic intrusive rocks
4) Copper contained quartz vein
5) Pollution by old copper ore refining.

167,728 soil samples were collected and many geochemical anomalies were detected under No.137, and they were verified by pittin, trenching, wagon drilling and diamond drilling. Avondale, East Freda, West Freda, Kanami, West Muni, Oswa, Shackleton and East Shackleton within these anomalous places were kept as claim blocks after finishing the term of the E.P.O..

The RSTE group closed up Rhodesia after finishing the survey of these E.P.O.s. Instead of RSTE, MTD Co., Ltd. which developed the Shackleton Mine and the Avondale Mine took over the activities.

4. E.P.O. No.80

The survey area was located approximate 70 kilometres north of Karoi. There is the Shamroke Mine within the area. The Deweras Group, the Lomagundi Group and the Piriwiri Group are widely distributed around the area and they were affected by metamorphism of the Zambezi Mobile Belt. As the geologcal map was not published by the GSD at the time of commencement of survey, the survey commenced from the stage of geologcal mapping and construction of roads whose length reached 290 kilometres. Geology of this area was divided into 1) the upper part mainly composed of quartzite and dolomites, 2) pelitic rock consisting of phyllite, calcareous schist, granulite and amphibolite and 3) sandy series consisting of quartzite, arkosic sandstone and paragneiss. Major geologcal structure were also revealed.

The survey was conducted in two stages, detailed survey around the Shamrocke Mine and regional survey over a wide area of 1,300 square kilometres.

Analyses of aerophotographs, airborne magnetic survey and radioactive survey were carried out in the survey over a wide area. Analyses of Cu and Ni of stream sediments were conducted with the sampling interval of 0.4 kilometres.

Geological mapping on a scale of 1:5,000, soil sampling with the sampling interval of 7.5 or 15 metres x 60 metres, trenching which total length were 3,000 metres and 42 drilling which total length was 12,300 metres in detail survey were carried out around the Shamrocke Mine. 40 underground drillings were carried out in 1960.

As the result of the survey, ore body whose size is 400 metres and 450 metres in direction of strike and dip, ore reserves of 6,000,000 tons with an average grade of 1.3 %, were estimated. It was found out that the major sulphide minerals were chalcopyrite, pyrrhotite and cubanite with associated arsenopyrite and sphalerite as accessory minerals.

5. E.P.O. No.152

The area of this E.P.O. was approximate 258 square kilometres, the centre of this area is approximate 16 kilometres south-west of Chinhoyi. The Alaska Mine, the Alaska South, the Alaska East, the Hans and the Cedric Mines were known mineralization areas at the time. The geochemical survey and geological survey were carried out as the part of survey. No geophysical survey was carried out.

Sampling of stream sediments and soil were carried out. Sampling density of stream sediments was approximate 7.7 samples/sq.km.. Analyses of Cu, Co, Ni and Zn were carried out after putting through under 80 mesh of sieve. Soil geochemical survey was carried out covering for 16 areas within 35 areas where were extracted by the anomalies with sampling density of 30.5 metres x 244 metres. Analyses of Cu, Co, Ni and Zn were carried out after putting through under 200 mesh of sieve.

Total area of 78 kilometres of anomalous places were extracted and detail soil geochemical survey, pit, trenching, wagon drilling and diamond drilling were carried out. Kenilworth within these anomalous places was claimed as the most promising place.

6. E.P.O. No.249

The area includes the Shamrocke Mine. E.P.O. No.80 was the former survey in the same area.

This E.P.O. was conducted as the feasibility survey for the strata bounded copper deposit. The survey commenced from geologcal mapping on a scale of 1:50,000. Soil sampling with the interval of 150 metres x 15 metres was carried out. Analyses of Cu, Ni, Pb, Zn and Co were carried out and Cu anomalies were set up in each rock facies. Geochemical survey of stream sediments was carried out in the northern part of this area. Systematic soil sampling with the interval of 30 metres x 8 metres, pitting, trenching and diamond drilling were carried out in the second stage of survey. As no useful result was obtained in surface magnetic survey, the survey was terminated. IP survey was not carried out because of the existence of graphite schist.

7. E.P.O. No.297

The survey area was located in 40 kilometres north of Chinhoyi and 15 kilometres south of

Mhangura. The area is 85 square kilometres. It is located on the crest of anticline structure in the distribution area of the Deweras Group and the Lomagundi Group. Soil geochemical survey with the interval of 8 metres x 150 metres was carried out in the central part of the survey area. Analyses of Cu, Ni, Pb, Zn, Co and V were carried out by atomic absorption method. Statistical processing of the results was carried out and the range of anomaly was fixed.

The anomaly areas of the maximum of 130 ppm and 240 ppm were discovered in Riversdale and Two Tree Hill in the southern part of this area, respectively. Although pit and trenching were carried out in the anomaly areas, detailed results were unknown. Cu Anormalies of 340 ppm were discovered in the northern part of the area. V Anormaly of 600 ppm was discovered in Piringani. Although soil sampling with a close interval and diamond drilling with the total length of 3,040 metres in addition to trenching were carried out in the Cu anomalous area, but the details are unknown.

8. E.P.O. No.351 and 377

The survey was carried out in the area of 375.55 square kilometres including the Shamrocke Mine under these E.P.O.s. The term of the survey was from 1972 to 1975. Geology of this area consists of the Deweras Group and the Lomagundi Group. Geological analyses with aerophotographs on a scale of 1:25,000 and soil geochemical survey were carried out all over this area. Soil geochemical survey was carried out with the interval of 15 metres x 50 metres, initially. The interval was stretched up to 15 metres x 100 metres, later. Cu analysis of 406,700 samples and Ni analysis of 1,852 samples were carried out by the atomic absorption method after putting through under 100 mesh sieve. Besides the survey, magnetic survey, electromagnetic survey and radioactivity survey were carried out as airborne geophysical survey.

21 anomalous areas were extracted by soil geochemical survey. Re-sampling in close interval, pit, trenching, wagon drilling and diamond drilling were carried out for the areas. Wagon drilling were carried out totally at 538 points and diamond drilling was carried out at 44 points and total length of drilling was 5,540 metres. Cu anomalies of soil were found out in various kinds of rocks.

9. E.P.O. No.396

The area was approximately 460 square kilomtres with a centre was about 60 kilometres north-east of Karoi.

Geology consists of meta-arkose, quartzite, sandy schist and amphibolitic intrusives.

Soil geochemical sampling with the interval of 200 metres were carried out. More detailed soil sampling were carried out in two areas. Electromagnetic survey and geomagnetic survey were carried out in one area of the above two areas.

10. E.P.O. No.414 and 514

The area was 802.89 kilometres in the area from the Mangula Mine to the Alaska Mine, from the

north to the south. The survey of this area was carried out by the Messina Group Company and RSTE Ltd under E.P.O.s No.3, 4, 5, 6, 16, 20, 21, 35, 42, 43, 71, 74, 75, 76, 82, 83, 101, 106, 137, 152 and 351 before the survey on these E.P.O.s.

At the time when these E.P.O.s were established, there were areas such as the Mhangura, the Shackleton, the Avondale, the Angwa, the Hans and the Alaska which are the areas of profitable mines or economically high potentiality, mining companies set up many claim areas.

The survey initially commenced from the compiling of geologcal map on a scale of 1:25,000, and soil sampling with the intervals of 100 metres x 50 metres. A Cu anomaly map with the ranges of 15 to 30 ppm, 31 to 50 ppm, 51 to 100 ppm and over 100 ppm was made based on Cu analysis.

During the survey, airborne magnetic survey and radioactivity survey were carried out. The interval of flight survey line was 150 metres, average altitude of flight was 60 metres and ground speed was 140 kilometres/hour. Mapping on a scale of 1:25,000 was carried out using the results.

Several surveys of pit, trenching, detail geological survey and surface geomagnetic survey were carried out in the areas and were extracted by the method above listed. Wagon drillings and diamond drillings were carried out for the anomaly area in the distribution area of sedimentary rocks. Most of the detailed survey results were not described in the final reports.

11. E.P.O. No.422

This E.P.O. was established by MTD Co.,Ltd., however, no survey was carried out.

1-3 Others

1. Nationwide survey

Airborne magnetic survey was carried out through the financial assistance of CIDA (Canadian International Development Agency) and technical cooperation of GSC (Geological Survey of Canada) for the federal government on a scale covering the whole country. The survey results are published as a Magnetic chart on a scale of 1:50,000 by the Geological Survey Department. The magnetic chart was based on the survey during May to June, 1983, and during October, 1990 to February, 1991 in the compiled area. The survey was carried out by the Kenting Earth Science Inc. and Intra Kenting. The surveyed data was converted to the mesh of 125 square metres and contouring was carried out.

The aeromagnetic map is shown in Fig.II-1-4. Although the original contour chart is every 5 gammas, this map is simplified by the contour of every 50 gammas. Generally, the chart reflects the geological structure of the Magondi Supergroup. It is noteworthy that there are low anomaly areas near the Mangula Mine, the Angwa Mine and the Hans Mine which occur with a comparatively shallow horizon.

2. Study for the doctoral theses

Underground and surface surveys have been carried out for doctoral theses (including master's

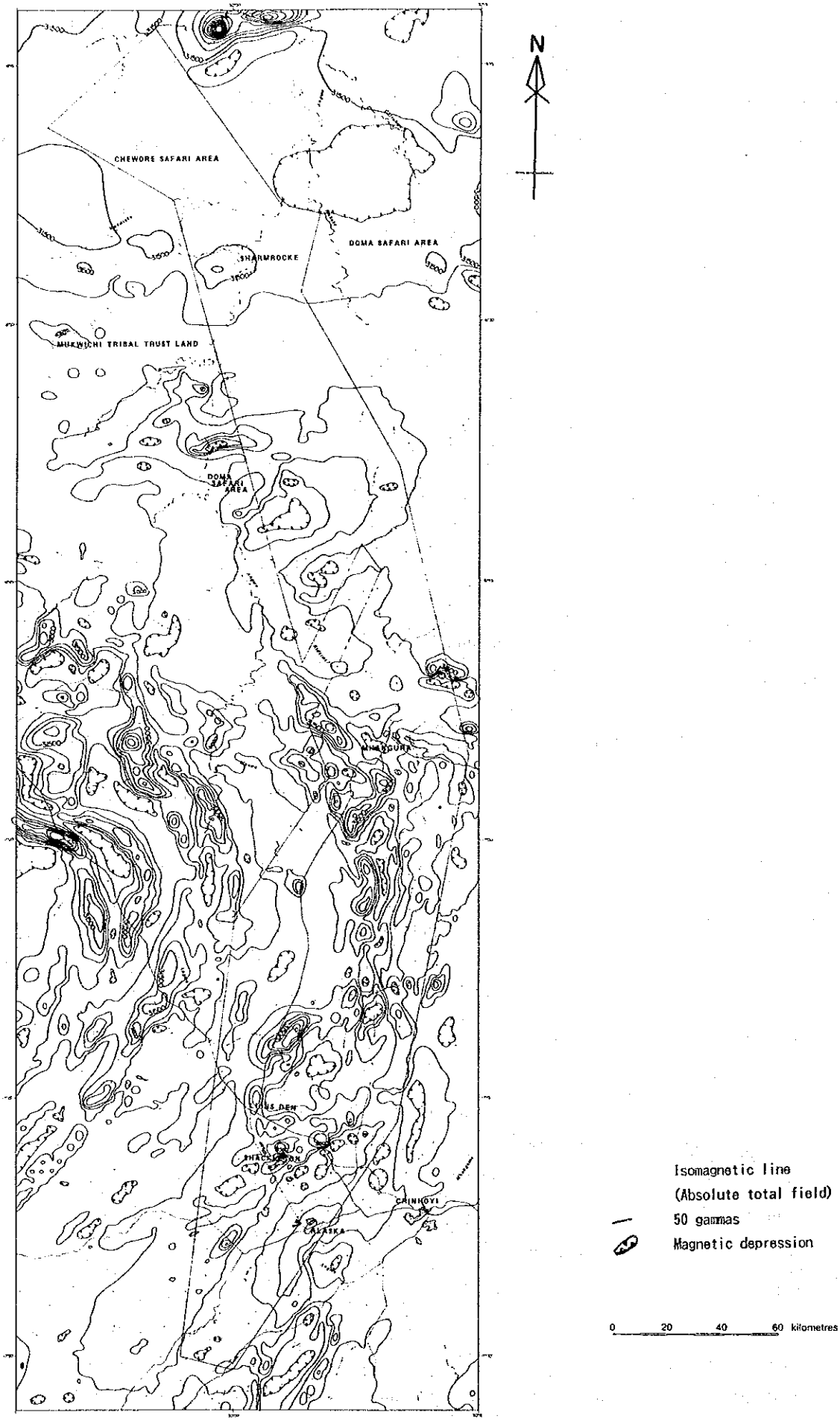


Fig.II-1-4 Aero-magneitcs map.

course's theses and graduation theses) in this area. Many of the graduation theses and master's course's theses on the Magondi Supergroup at the University of Zimbabwe are to make geologcal maps (Mundondo, 1987 ; Shoko, 1985 ; Vinyu, 1985 and Jacobsen, 1962). As regards the geological survey and study of ore deposits, there are the following papers on the survey of the Shamrocke Mine (kyle, 1972) and the Mangula Mine (Muchenje, 1987 ; Tsomondo, 1980). As regards the doctral theses, there are the following detailed studies about the Shamrocke mine (Thole, 1974) and the Mangula to Alaska Mines (Master, 1991).

Almost all the papers are available in the library of the Geological Survey Department.

3. The report of ZMDC

The Mangula Mine (Miriam and Norah ore deposits), the Norah Mine, the Shackleton Mine (Avondale ore deposit) and the Angwa Mine are in operation at present in the survey area. All these Mines are managed by ZMDC. Depletion of the resources gives cause to anxiety in recent years. ZMDC commenced the survey planning to summarize the pervious works' results, and made recommendations around the Shamrocke Mine (Simpson, 1988) and also made the future guiding principle of survey for the area from the northern part of the Mangula Mine to the southern part of the Alaska Mine (Simpson, 1990). The survey program according to the guiding principle is commencing.

Many anomalous places have been extracted in the Shamrocke area. These Cu anomalies cause deformation and removal by metamorphism. There are no profitable ore deposits except the Old Mine Office area in these anomalous places. Exploration cost is considered to be expensive, because of the steep topography of this area. Therefore, as a result, the survey of this area must be carried out after the survey fails in all the other expected areas (Simpson, 1988).

A part of E.P.O. data which was carried out in the area of the northern part of the Mangula Mine to the south of the Alaska Mine by the old Messina Group is kept in the Mangula Mine. The study of the data commenced at the end of 1989, and "Report on the Work done and Recommend in the Area from North of Mangula to South of Alaska" was reported (Simpson, 1990).

The above report contains all the files, mine data and knowledge of mining engineers. It is one of the best summaries about this area. The discussions and recommendations in the report highly deserves to be examined in order to better carry out survey of this area.

Occurrences of ore deposits are classified into the following two. One is sedimentary environment of country rock, and the other is controlled by geological structure.

Miriam style deposits–

1) Basement – sediment contact.

2) Alluvial fan with fine sediment transgression.

3) Possibly an anticline warp.

Norah – Shackleton – Angwa style deposit–

1) Cyclic graded bedding of a river of delta complex.

2) Anticlinal warp to act as trap (similar to modern oil traps).

As regards geological environment for re-evaluation of potentiality on a wide scale, following points were noticed :

1) Cyclic sedimentation associated with the building of alluvial fan, streams, deltas,etc.
2) Earlier anticlinal fold axis which are formed before the lithofication of sediments
3) Airborne magnetic and soil geochemical trend which transgress the N-S basin in the NE-SW direction.
4) Early strike slip faults parallel to the basin edge which could act as feeders in a NE-SW direction.

Based on the above expression, the areas necessary to explore are as follows:

1) Geological mapping of the known structural trends crossing the basin;
   a) Wari-Shackleton-Avonshack-Nijiri
   b) Kenilworth-Hans-Angwa
   c) Muni West-Muni-Munwa
   d) Valdesia
   e) North and South Greenfields
2) Reconnaissance mapping from airphotos of areas not covered above.
3) Test surveys by several geophysical methods to see it known ore bodies can be found.
4) Drilling of the Wari, Muni West and Kenilworth zones down plunge from present intersection.
5) Drilling of Muni under Muni West will require good surface mapping before hole placement.
6) Drilling of Valdesia and Nijri based on surface mapping of the known mineralized areas
7) Study of known ore bodies by geochemical and mineralogical methods to see if there is a marker alteration to the ore zones. This could be done by the University of Zimbabwe as several undergraduate projects or a graduate degree. Possibly a company geologist could do a Master Degree on it part time.

1-4 Summary

The surveys which were carried out during the late 1940's to 1970's were emphasized in geochemical surveys because of to poorly outcrops. As regards chemical analyses, Cu analysis of most of the samples were carried out, however, chemical analyses of Ni, Co, Pb and Zn were also partly carried out. There are geochemical anomalies in this area due to mineralization of Cu, mafic dykes and volacanics. Therefore, it is difficult to distinguish by Cu anomalies. As regards geochemical anomalies, verifications of origin of anomalies were carried out by trenching, pitting, wagon drilling and diamond

drilling. Judging from the past intensive survey in E.P.O.s, it is not too much to say that extraction of the Cu anomalous places of surface by geochemical survey have almost completed the purpose to identify potential copper resources, in the area of the northern part of the Mhangura Mine to the southern part of the Alaska Mine and the Shamrocke Mine.

The summary of previous works in the survey area is illustrated in Fig.II-1-5. The list of claim areas by E.P.O. are shown in Table II-1-6. There are 54 claim areas which indicate Cu anomalies in sedimentary rocks in the area of the northern part of Mhangura to the southern part of Alaska by results of the previous works. Many mineralization areas exist in the survey area found by previous works. Within these areas, the existence of ore deposits can be expected as profitable mining instead of known ore deposits.

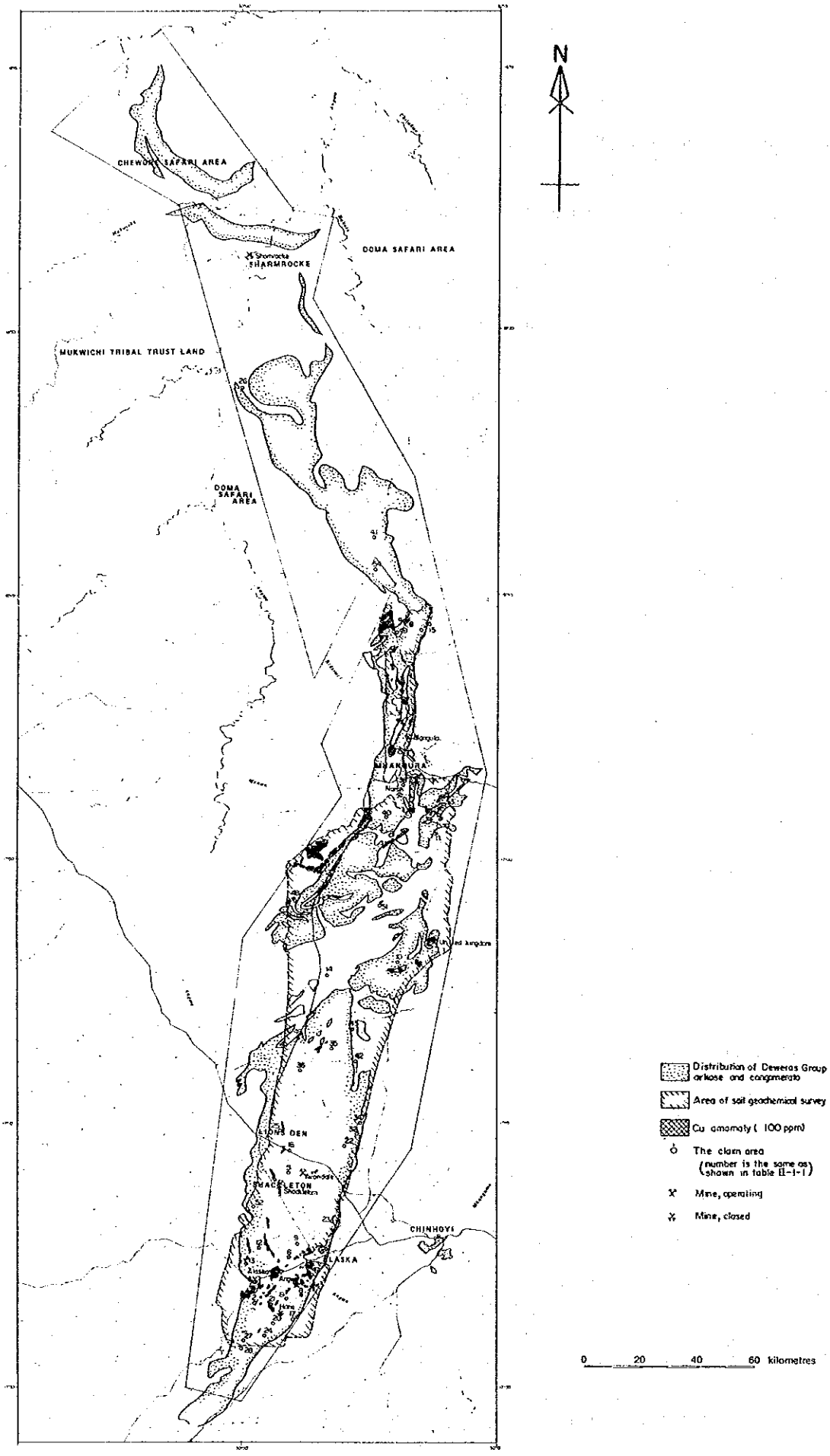


Fig.II–1–5 Summary of previous works.

Table II-1-6 List of the claim area by the E.P.O.s.

No.	Claim name	Recommendation				Previous works					Remarks
		I	II	III	IV	Pit	Trench	Wagon D.	Diamond D.	Geophysics	
1	Alaska Mine										
2	Alaska South	○			○				2,000m(12)	IP	
3	Angwa Mine										
4	Avondale Deposit										
5	Avonshack Deposit										
6	Belltrees North	○						(41)			
7	Belltrees West	○						(38)			
8	Blackwood	○						○			
9	Chetenham	○									
10	Dedsi	○				63	○	(296)	394m(7)		
11	Dichwe	○									
12	Freda East	○						○			
13	Freda West	○		○	○				2,525m(21)		
14	Gordinia	○						(7)			
15	Greenfields			○					2,183m(16)	GM	
16	Grey Cats	○						1,940m(118)	1,102m(6)		Similar to the Shackleton anomaly
17	Hans East	○							○		
18	Hans Mine				○						
19	Hans North	○		○					○	GM	
20	Hans South	○								IP	
21	Hans West	○						○			
22	Hillrise	○						1,350m(142)	336m(2)		On the Shackleton to Nijri trend
23	Kanami					○		(200)	296m(2)		The area could be opencast.
24	Kenilworth	○			○				3,783m(25)		Similar to the Hans Mine
25	Lions Den	○			○			○	1,801m(12)		
26	M and D	○									
27	Magog	○						67m(76)			
28	Magog South	○						792m(88)	202m(2)		
29	Mangula Mine										
30	Mhangura Mine										
31	Miriam Mine	○							602m(7)		
32	Mkowi North	○									
33	Molly Mine										
34	Msina	○						1,920m(118)			
35	Muni	○			○				4,038m(22)	IP	
36	Muni West	○							2,349m(12)		
37	Nijri	○			○	39		(6)	58m(1)	Re	
38	Norah East			○					560m(6)		IP survey
39	Norah Mine				○						
40	Norah South	○	○	○			○		229m(3)		
41	Ona Patari	○				81	○		697m(2)		
42	Oswa	○	○		○			○	(6)		
43	Oswa North	○						(75)	146m(3)		
44	Shackleton Mine										
45	Shamrocke Mine										
46	Sheepridge	○				5			145m(2)		
47	Sionia's Drift	○									
48	Two Tree Hill	○		○					125m(2)		
49	Umboe	○							949m(9)		
50	United Kingdom										
51	Veldesia	○			○	7			189m(2)		
52	Wari	○			○		○	(100)	1,000m(14)		
53	Whindale	○									Pb-Zn mineralisation
54	Wolwekoheok	○	○								Similar to the Whindale anomaly

Recommend

I :Detail geological and structural survey　II :Geochemical sampling

III :Geophysical survey　IV :Diamond drilling

Previous survey

○ means the survey was done but not known details.

Pit: numbers of pits

Wagon D.: the total depth and numbers of wagon dirillings.

Diamond D: the total depth and numbers of diamond drillings.

Chapter 2 Geological survey

Locality of geological survey area is shown in Fig.II-2-1.

2-1 Outline of geology

Geological map, geological cross section, schematic geological column and locality of sampling sites of rocks analyzed in the survey area is shown in Fig.II-2-2. to II-2-5, respectively.

The archaean Basement Rocks, Paragneiss, the Bulawayan Group, the Shanvaian Group and the Pre-Magondi Intrusive Rocks, the Magondi Supergroup, the Guruve Metamorphic Complex, the Post-Magondi Intrusive Rocks and the Sijarira Group of proterozoic era, the triassic Upper Karoo Formation and quaternary sediments are the member of this area in ascending order. The Magondi Supergroup is divided into the Deweras Group, the Lomagundi Group and the Piriwiri Group in ascending order. This Supergroup is the sediments in the Magondi sedimentary basin which was formed by extension of the rift valley.

This area was affected at least three stages of metamorphism through the period of the Magondi orogenic movement to Pan-Africa Zambezi orogenic movement. The last metamorphism (Pan-Africa Zambezi orogenic movement) develops only in the northern part of this area.

2-2 Geology

The result of the microscopic observation of thin sections is shown in Table II-2-1. Microphotography of the thin section is shown in Appendices A-1.

2-2-1 Basement Rocks

The basement rocks are widely distributed in Doma Safari area in the north western part of the survey area.

The basement rocks mainly consists of orthogneiss of granodiorite component and is accompanied with paragneiss of sedimentary origin. The origin of paragneiss is considered to be sandstone and shale. It sometimes shows banded structure with few cm to ten and more cm thick alternation of white felsic part and biotite concentration part in the outcrop.

Microscopic observation is as follows :

Orthogneiss is petrologically identified as epidote (clinozoisite)-biotite gneiss (sample Nos. KR34 and KR36) which shows granoblastic texture. Quartz, plagioclase, orthoclase and biotite are the major component minerals and there are small amounts of iron oxides, sphene, rutile, apatite and zircon. There are two types of paragneiss. One is epidote-biotite gneiss (KR37 and KR40) which shows granoblastic texture and the other is hornblende-epidote-muscovite gneiss which shows blastopsamitic texture (KR41). The former consists of quartz,plagioclase, orthoclase, muscovite and epidote with small

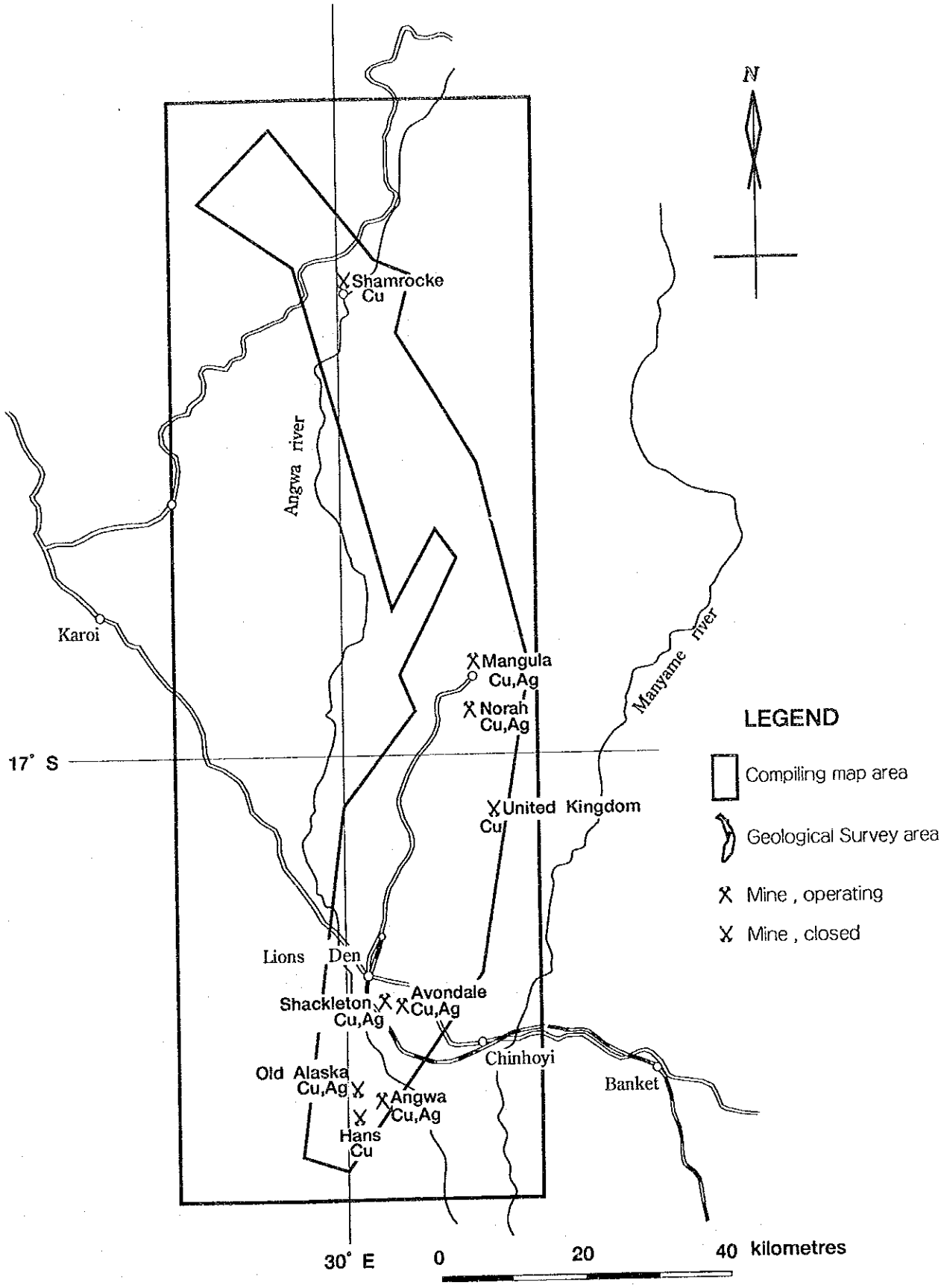


Fig.II-2-1 Locality of geological survey area.

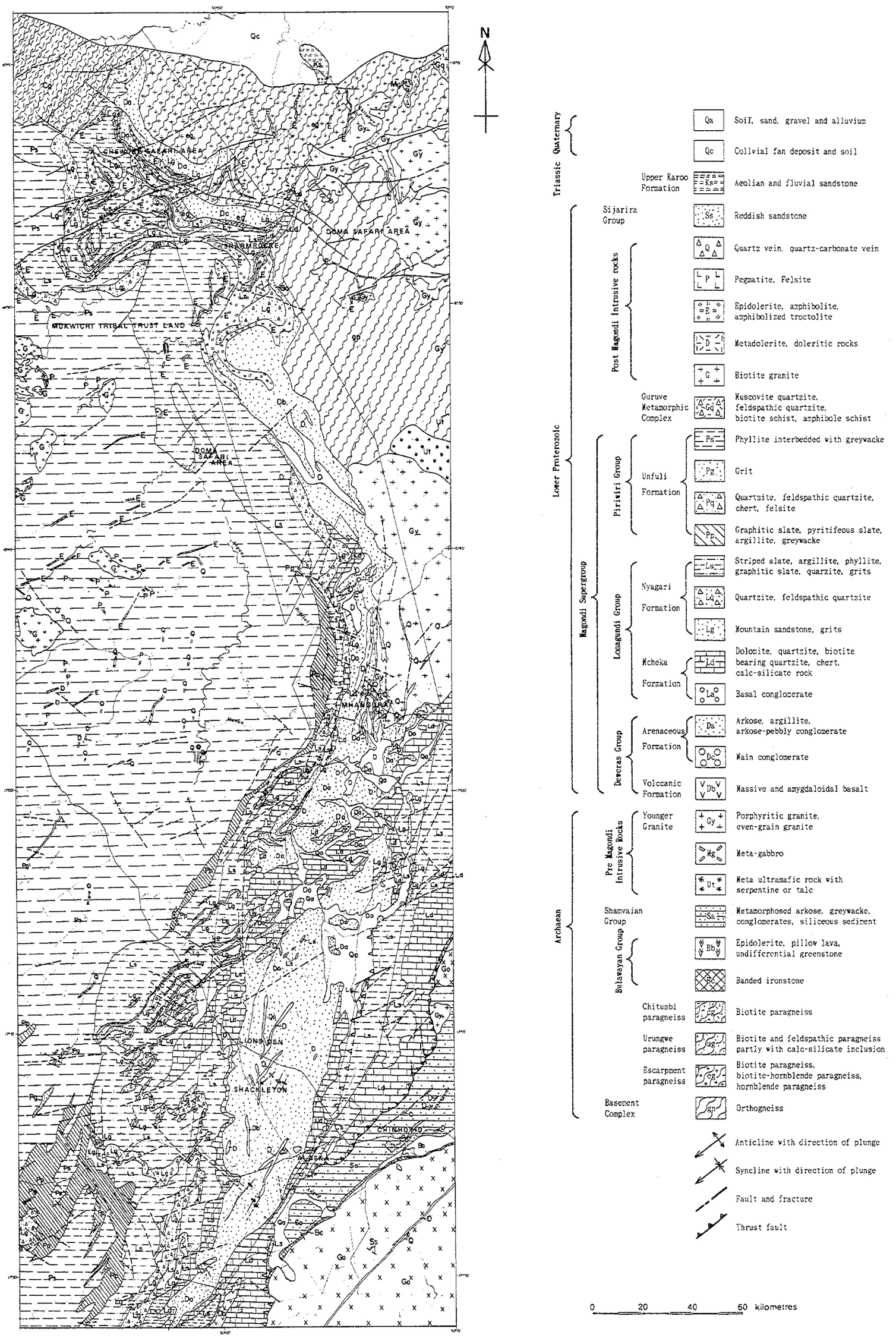
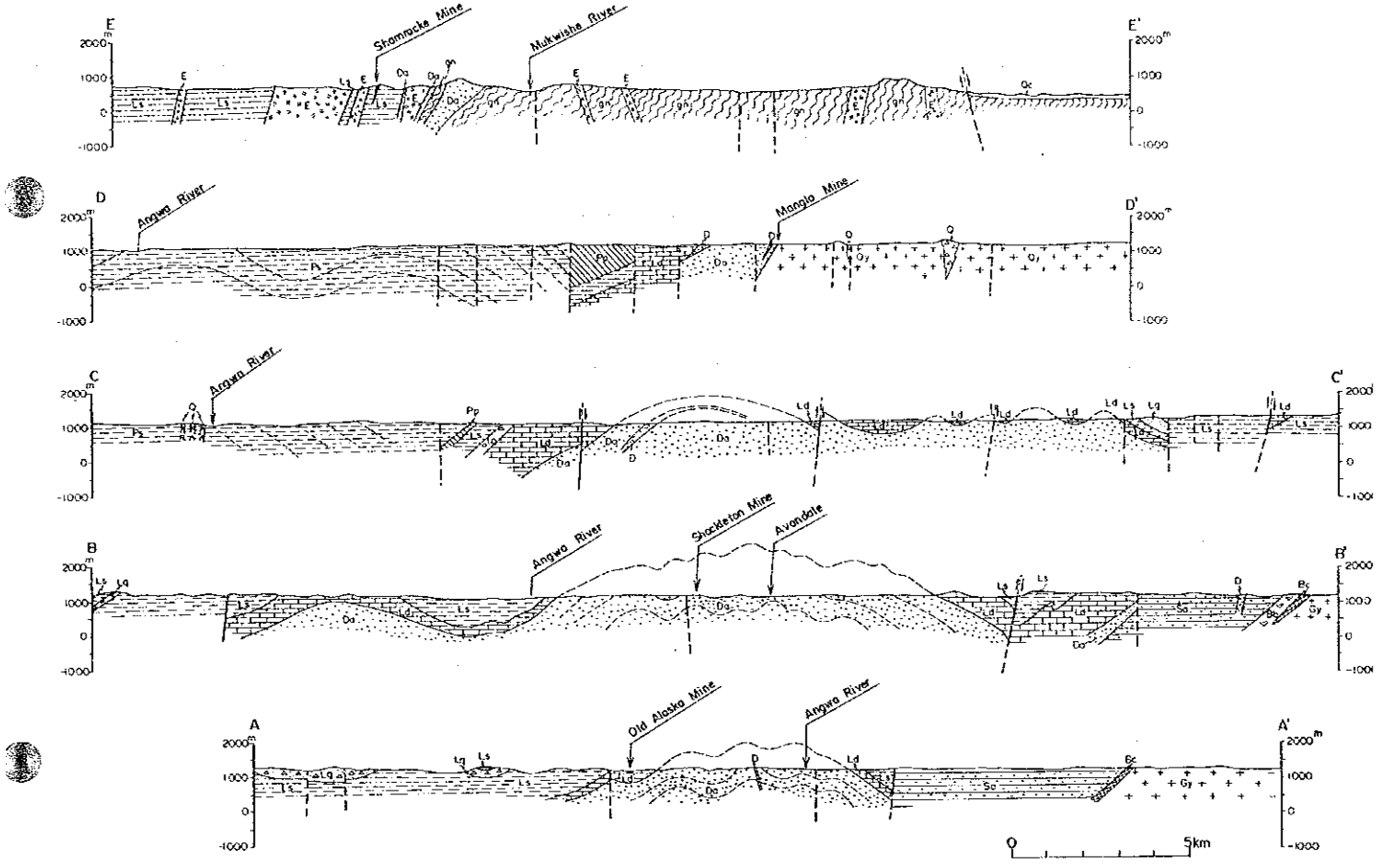


Fig.II-2-2 Geological map.



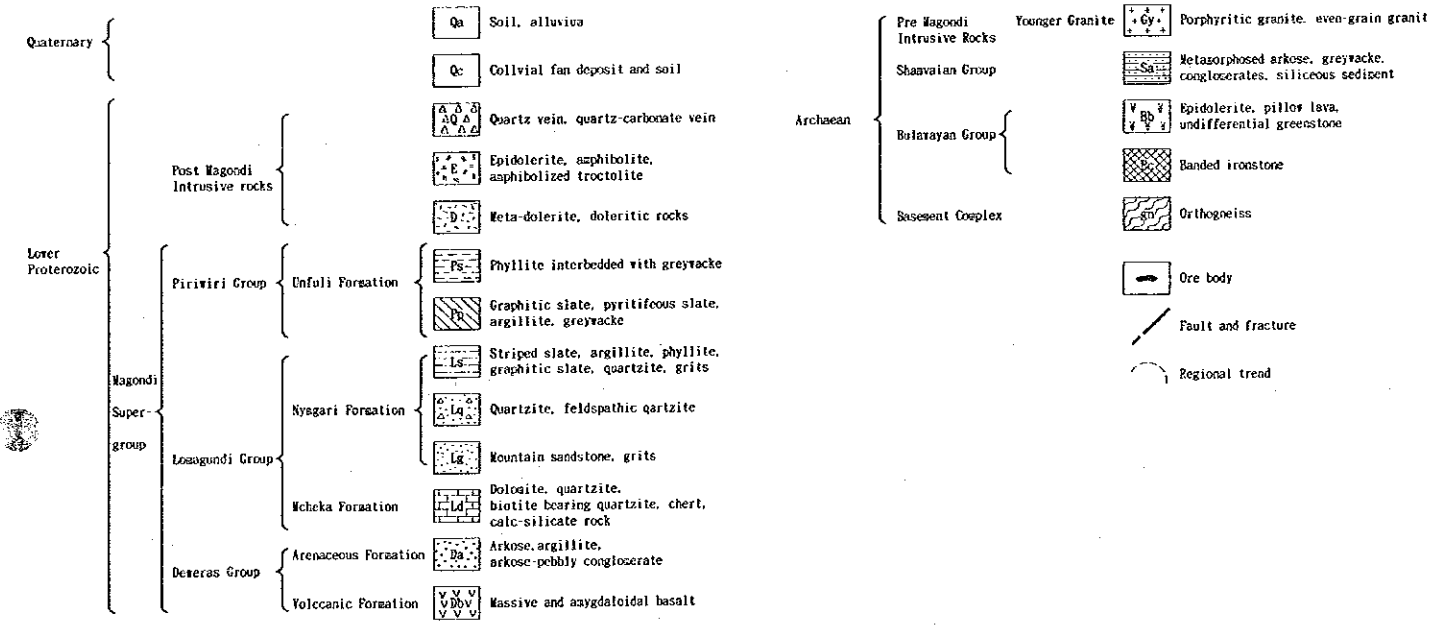
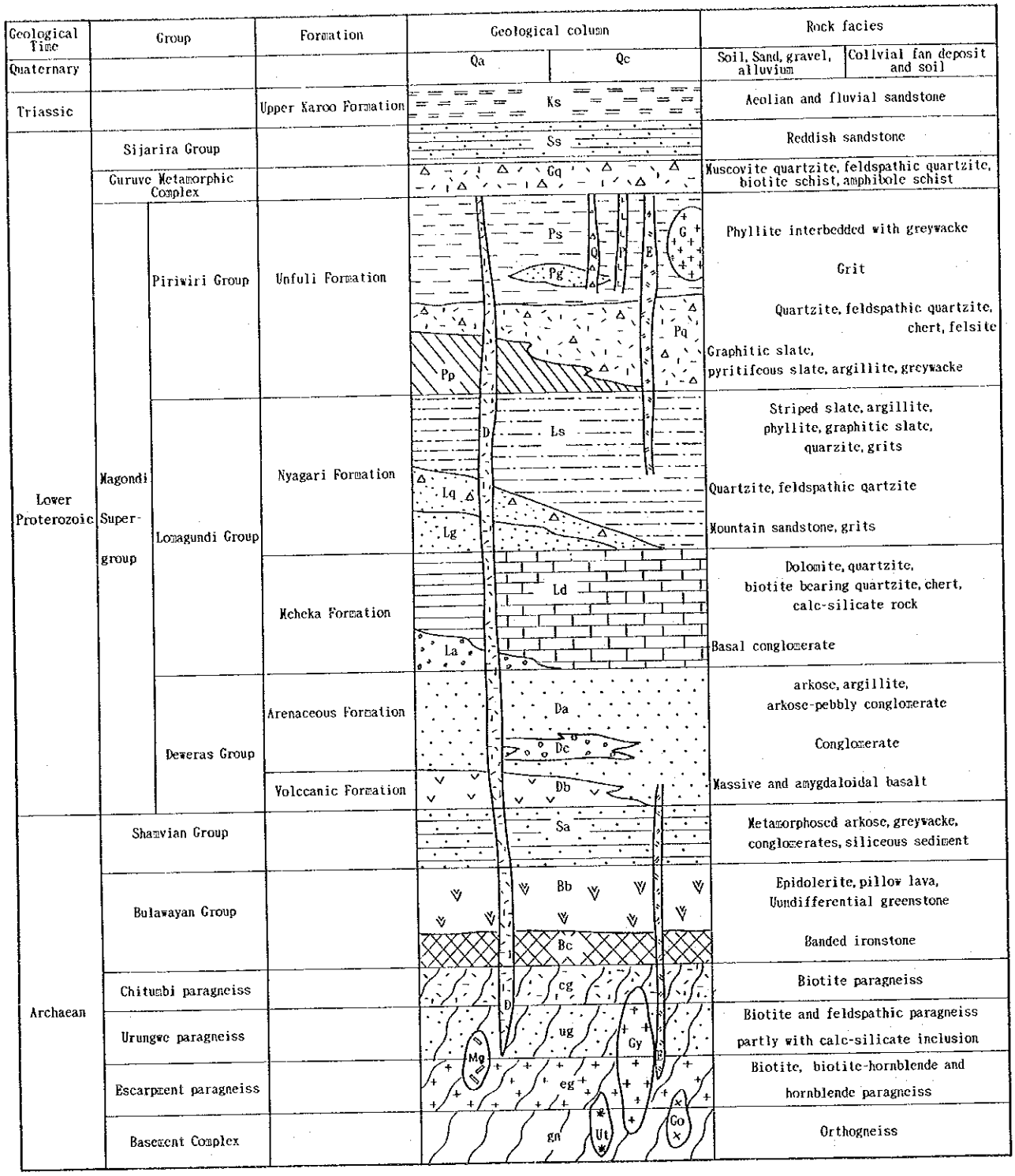


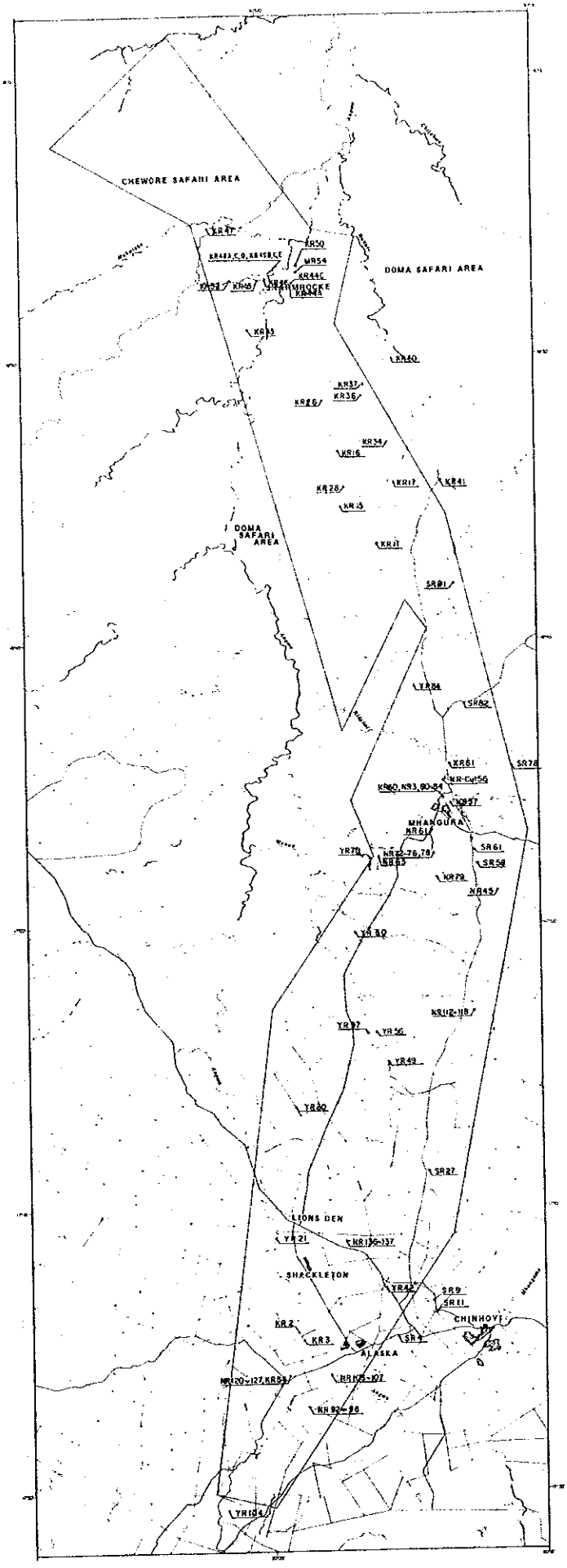
Fig.II-2-3 Geological sections.



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.II-2-4 Schematic geological column.



No.	S	P	A	R	Remarks
KR 2	●			●	
KR 3	●			●	
KR 11	●			●	
KR 15	●				
KR 16	●				
KR 17	●				
KR 26	●				
KR 28	●				
KR 34	●				
KR 36	●				
KR 37	●			●	
KR 39	●			●	
KR 41	●			●	
KR 43	●				
KR 43A		●	●	●	
KR 43C		●			
KR 45	●				
KR 46	●				
KR 47	●				
KR 48A		●	●		
KR 48C		●	●	●	
KR 48D		●	●		
KR 49B		●	●		
KR 49C		●	●		
KR 49E	●		●		
KR 50	●			●	
KR 52		●	●		
KR 54	●	●	●	●	
KR 60		●	●		
KR 61		●	●		
MRS 4	●				
NR 3			●		
NR 45	●			●	
NR 56	●			●	
NR 57	●			●	
NR 61	●			●	
NR 63	●			●	
NR 72	●	●	●	●	
NR 73		●	●	●	
NR 74			●		
NR 75		●	●		
NR 76			●	●	
NR 78		●	●		
NR 79		●	●	●	
NR 80		●	●	●	
NR 81			●	●	
NR 82	●	●	●		
NR 83		●	●	●	
NR 84		●	●		
NR 92			●		
NR 93			●		
NR 94	●		●	●	
NR 95			●		
NR 96			●		
NR 97			●	●	
NR 98			●		
NR103		●	●		
NR104	●	●	●	●	
NR106		●	●	●	
NR107		●	●		
NR112			●		
NR113		●	●		
NR114			●	●	
NR115			●		
NR116			●		
NR117			●		
NR118			●		
NR120			●		
NR121			●		
NR122			●		
NR123		●	●		
NR124		●	●		
NR125			●		
NR126		●	●	●	
NR127	●		●	●	
NR136	●	●	●	●	
NR137		●	●	●	
SR 4	●			●	
SR 9	●			●	
SR 11	●			●	
SR 27	●			●	
SR 58	●			●	
SR 61	●				
SR 78	●				
SR 82	●			●	
SR 91	●				
YR 21	●			●	
YR 30	●				
YR 42	●			●	
YR 49	●				
YR 56	●				
YR 57	●				
YR 60		●			
YR 70	●			●	
YR 84	●	●			
YR104	●			●	

S: Thin section
P: Polished section
A: Chemical analysis of ores
R: Appearent resistivity and percent IP effect

0 20 40 60 kilometres

Fig.II-2-5 Locality of sampling sites of rocks analyzed.

Table II-2-1 Result of the microscopic observations of thin sections.

No.	Rock name defined by micorscopic observation	Origin	Formation	Locality	Latitude	Longitude	Mineral assenblages																							Texture
							Qtz	Pl	Ab	Kfs	Bt	Ms	Phl	Hbl	Tr	Pmp	Ep	Czo	Di	Grt	St	Chl	Cld	Tol	Cal	Dol	Gr	Ir	Sp	Ru	Ap	Zr	
KR 2	Mu-Bi schist	arkose	Deweras	Manyamba Estate	17 °21.56 '	S30 ° 1.33 '	E	◎	○		△	○	△				・								○			・					blastopsammitic
KR 3	Hbl schist	basalt	Deweras	Freda	17 °22.43 '	S30 ° 1.57 '	E	△	◎			△		◎			△				△		△				△	・		・	・	blastoporphyritic
KR 11	Ep-Hbl gneiss	arkose	Deweras	Chipungu A	16 °39.83 '	S30 ° 6.32 '	E	◎	◎		○			△			△											・	・		・	blastopsammitic
KR 15	Bi-Mu gneiss	arkose	Deweras	Impala Downs	16 °37.86 '	S30 ° 4.35 '	E	◎	○		○	△	◎				△							・				・	・		・	blastopsammitic
KR 16	Di gneiss	calcareous sandstone	Deweras	Innisfree	16 °34.94 '	S30 ° 4.21 '	E	◎	○	○	○						・	○					○					・	・		・	blastopsammitic
KR 17	Banded Hbl-Ep gneiss	calcareous shale	Deweras	Nirvana	16 °36.58 '	S30 ° 7.30 '	E	○	○			△		◎			◎											・	△		・	blastopsammitic
KR 26	Ep amphibolite	mafic rock	Dyke	Doma Safari Area	16 °32.22 '	S30 ° 3.33 '	E	◎	◎			△		◎			○											・	・		・	granoblastic
KR 28	Ep amphibolite	mafic rock	Dyke	Chipiri	16 °36.81 '	S30 ° 4.49 '	E	○	○			・		◎			△											△	△		・	granoblastic
KR 34	Ep-Bi gneiss	pultonic rock	Gneiss	Innisfree	16 °34.45 '	S30 ° 6.92 '	E	◎	◎		○	△						△										・	・		・	granoblastic
KR 36	Czo-Bi gneiss	pultonic rock	Gneiss	Doma Safari Area	16 °31.94 '	S30 ° 5.50 '	E	◎	◎		○	△					△											・	・		・	granoblastic
KR 37	Banded Ep-Bi gneiss	sandstone & shale	Gneiss	Doma Safari Area	16 °31.40 '	S30 ° 5.64 '	E	◎	○		△	◎	△				○											・	・		・	granoblastic
KR 40	Ep-Bi gneiss	sandstone & shale	Gneiss	Doma Safari Area	16 °30.02 '	S30 ° 7.30 '	E	◎	○		○	○					○											・	△		・	granoblastic
KR 41	Hbl-Ep-Mu gneiss	calcareous sandstone	Gneiss	Nirvana	16 °36.56 '	S30 ° 9.87 '	E	◎	○		○		○	△			○											・	・		・	blastopsammitic
KR 43	St-Grt-Bi schist	pelite	Lomagundi	Mukwichi Communal Land	16 °28.50 '	S29 °59.33 '	E	◎	○			◎							○	△		・	・	・				・	・		・	granoblastic
KR 45	Bi-Gr schist	pelite	Lomagundi	Mukwichi Communal Land	16 °25.85 '	S29 °59.90 '	E	◎	◎			○	・			・										○		・	・		・	-
KR 46	Phl-Qtz dolomite schist	impure dolomite	Lomagundi	Mukwichi Communal Land	16 °25.77 '	S30 ° 0.28 '	E	○					△											◎				・			・	granoblastic
KR 47	Mu schist	arkose	Deweras	Mukwichi Communal Land	16 °23.14 '	S29 °57.25 '	E	◎	◎		◎	・	△															・	・		・	granoblastic
KR 49	Bi-Hbl gneiss	sandstone	Lomagundi	Sharmrocke Minc	16 °25.80 '	S30 ° 0.28 '	E	◎	◎		○	・	・	△							・							・	・	○	・	granoblastic
KR 50	Bi amphibolite	mafic rock	Dyke	Doma Safari Area	16 °25.87 '	S30 ° 1.73 '	E	◎	◎			△		◎														△	・		・	granoblastic
KR 54	Bi-Mu schist	shale-fine sandstone	Lomagundi	Old Alaska Mine	17 °32.87 '	S30 °11.24 '	E	◎	○		○	○	◎										△					・	・		・	granoblastic
MRS 1	Tr dolomite	dolomite	Lomagundi	Doma Safari Area	16 °25.40 '	S30 ° 2.02 '	E						△		○										◎		・	・			saccharoidal
NR 45	Quartzite	chert	Lomagundi	Cotswold Estate A	16 °58.27 '	S30 °12.62 '	E	◎																△				・				granoblastic
NR 56	Mu schist	shale - sandstone	Deweras	Chirombozi	16 °52.43 '	S30 ° 9.80 '	E	◎	○		○		△															△	・		・	granoblastic
NR 57	Mu-Bi adamellite	adamellite	Younger Granite	Alfa A	16 °53.61 '	S30 °10.20 '	E	◎	◎		◎	△	△				・				・			・				・	・		・	hypidiomorphic
NR 61	Mu gneiss	sandstone	Deweras	Plateau	16 °55.03 '	S30 ° 9.12 '	E	◎	◎		◎		△															・	・		・	blastopsammitic
NR 68	Mu-Gr schist	graphitic pelite	Piriwiri	Robbsdale	16 °56.44 '	S30 ° 6.15 '	E	○	○		△		△													◎	◎	・	・			
NR 72	Ep amphibolite	mafic rock	Dyke	Norah	16 °56.21 '	S30 ° 9.16 '	E	○	○		△		・	◎			・					○		・				△	△		・	
NR 82	Chl-Mu gneiss	sandstone	Deweras	Manguia Mine	16 °53.31 '	S30 ° 9.59 '	E	◎	◎		◎		・									△		・				・	・		・	porphyroblastic
NR 94	Bi-Mu schist	sandstone	Deweras	Hans Mine	17 °22.47 '	S30 ° 1.95 '	E	◎	○		○	△	◎				△											・	・		・	blastopsammitic
NR104	Chl-Mu schist	sandstone	Deweras	Angwa Mine	17 °23.96 '	S30 ° 3.37 '	E	◎	◎		◎		△									・		・				△	・		・	blastopsammitic
NR127	Chl-Mu schist	coarse sandstone	Lomagundi	Old Alaska Mine	17 °23.87 '	S30 ° 9.87 '	E	◎	○		△	○										△		・				・	・		・	-
NR136	Mu-dolomite	impure dolomite	Deweras	Avondale Mine	17 °17.86 '	S30 ° 4.11 '	E	○	△			△	○												◎			・	・		・	granoblastic
SR 4	Bi-Mu schist	coarse sandstone	Lomagundi	Strathcona	17 °21.75 '	S30 ° 6.88 '	E	◎	○		◎	△	○															・	・		・	blastopsammitic
SR 9	Phl dolomite	impure dolomite	Lomagundi	Kings Peak	17 °19.85 '	S30 ° 8.85 '	E	○	△		△			・											◎			・				saccharoidal
SR 11	Quartzite	chert	Lomagundi	Sinoia Citrus Estate	17 °20.43 '	S30 ° 9.04 '	E	◎	△		△		・															・	・			granoblastic
SR 27	Quartzite	chert	Lomagundi	Geluk	17 °13.05 '	S30 ° 8.70 '	E	◎			・		・									・											granoblastic
SR 58	Ep amphibolite	dolerite	Dyke	Whindale Ranch	16 °56.75 '	S30 °11.63 '	E	○	◎					◎			◎					△		・				△	△		・	blastoporphyritic
SR 61	Amphibolite	dolerite	Dyke	Whindale Ranch	16 °56.07 '	S30 °11.45 '	E	△	△					◎								○						・	・	・		blastoporphyritic
SR 78	Mu schist	quartz arenite	Quartz Vein	Sunkist	16 °51.60 '	S30 °13.58 '	E	◎					◎															・				lepidoblastic
SR 82	Bi-Mu adamellite	adamellite	Younger Granite	Nyamanyoko A	16 °48.31 '	S30 °10.99 '	E	◎	◎		◎	・	△									・						・	・		・	hypidomorphic
SR 91	Mu-Bi gneiss	pultonic rock	Younger Granite	Takoma	16 °41.97 '	S30 °10.49 '	E	◎	◎		◎	△	△		・			○										・	・		・	hypidomorphic
YR 21	Bi schist	black shale	Lomagundi	Hillpass	17 °16.56 '	S30 ° 0.20 '	E	◎	△		・	◎	・													○		・	・		・	
YR 30	Quartzite	chert	Lomagundi	Elmly Park	17 ° 9.60 '	S30 ° 1.39 '	E	◎				・										・						・	・			granoblastic
YR 42	Dolomite	dolostone	Lomagundi	Baruka	17 °19.23 '	S30 ° 6.28 '	E	△																	◎			・				saccharoidal
YR 49	Mu schist	sandstone	Deweras	Urume	17 ° 7.24 '	S30 ° 6.59 '	E	◎	○		○		◎										・					△	・		・	blastopsammitic
YR 56	Tr schist	dolostone	Lomagundi	Highbury Estate	17 ° 5.62 '	S30 ° 5.91 '	E	△							◎										◎			・	・			decussate
YR 57	Hbl granophyre	granophyre	Vein	Highbury Estate	17 ° 5.65 '	S30 ° 5.42 '	E	○	◎		○			△														△	・		・	micro-graphic
YR 70	Mu schist	pelite	Piriwiri	Robbsdale	16 °56.42 '	S30 ° 5.71 '	E	△	△			◎		△								○						・	・		・	decussate
YR 84	Ep-Hbl schist	calcareous shale	Deweras	Chimsenga	16 °47.39 '	S30 ° 8.30 '	E	△	○		△		○	◎			○						・					△	・		・	nematoblastic
YR104	Ep-Chl schist	basalt	Deweras	Bandira	17 °30.91 '	S29 °57.42 '	E	△	◎								△					◎		◎				△	・		・	blastoporphyritic

Abbreviation of mineral names

Qtz:quartzite Pl:plagioclase Ab:albite Kfs:potassium feldspar Bt:biotite Ms:muscovite Phl:philogopite Hbl:hornblende Tr:tremolite Pmp:pumpellyite Ep:epidote Czo:clinozoisite
Di:diopside Grt:garnet St:staurolite Chl:chlorite Cld:chloritoid Tol:tourmaline Cal:calcite Dol:dolomite Gr:graphite Ir:iron oxides Sp:sphene Ru:rutile Ap:apatite Zr:zircon

to rare amounts of hornblende, iron oxides, sphene, apatite and zircon. The latter is composed of quartz, plagioclase, orthoclase, biotite and epidote with small or rare amounts of muscovite, iron oxides, sphene, apatite and zircon.

2-2-2 Paragneiss

1. The Zambezi Escarpment Paragneiss

It is distributed along the Zambezi escarpment in the northern part of the survey area.

The main rock facies is biotite-hornblende gneiss which is considered to be originated from sedimentary rocks such as arkose, quartzite and graywacke (Fey and Broderick, 1990).

2. The Chitumbi Paragneiss

It is distributed along Zambezi escarpment in the north-western marginal part out of the survey area.

The main rock facies is biotite gneiss (Fey and Broderick, 1990).

2-2-3 The Bulawayan Group

It is distributed along the marginal part of Younger Granite which describes later in the southern part out of the survey area.

The description about this Group in the survey area was made by Stagman (1961). The Group consists of banded iron layer which overlies the basement and green rocks. Banded iron formation generally shows blackish colour with fine alternation and grading of quartz and magnetite. Green rock layer consists of altered basaltic volcanics.

2-2-4 The Shanvaian Group

It is distributed surrounding to Bulawayan Group. The centre of the area is Chinhoyi City which is located in the southern part out of the survey area.

The description of this Group in the survey area was made by Stagman(1961). It consists of many layers of conglomerate and sandstone. Most of gravels are granite origin. However, there are some green coloured or banded iron gravels. It is affected by regional metamorphism. Biotite, chlorite and hornblende was formed by component change of iron-magnesium ratio.

2-2-5 The Pre-Magondi Intrusive Rocks

1. Ultramafic rocks

They are distributed along the boundary part of the Basement Rocks and the Younger Granite in the eastern central part, outside the survey area.

They are the western extending part of Chipingabadza complex rock body (Hahn and Steiner,

1990). According to the adjoining map, they are dark greenish coloured, medium-grained massive rock body which are hornblendized pyroxenite. Pyroxenes are replaced by hornblende, serpentine and chlorite (Hahn and Steiner, 1990).

2. Meta-gabbro

It is distributed within the basement rocks as small rock bodies with approximate 1 kilometres of diameter in the north-eastern marginal part out of the survey area.

The detailed description about the rock body was made by Chenjerai (1988). According to this description, the grain size changes from medium to coarse grained from the marginal part to the centre. Feldspar phenocryst grows over 1 centimetre. By microscopic observation, main rock forming minerals are hornblende and feldspar. Feldspar altered into diopside and hornblende with garnet.

3. The Younger Granite

The distribution is divided into two part. One is in the south-eastern part out of the survey area and the other is in the eastern part of the centre of the survey area.

In the survey area the rock is pink coloured, medium-grained biotite-muscovite (or muscovite-biotite) adamellite.

Microscopic characteristics are as follows:

The specimens (NR57 and SR82) which were sampled at the north-east of Mangula Mine shows hipidomorphic texture. The main rock forming minerals are quartz, plagioclase, orthoclase with biotite, muscovite, iron oxides, sphene, rutile, apatite and zircon. They are sometimes accompanied with epidote, chlorite and calcite.

2-2-6 The Magondi Supergroup

1. The Deweras Group

(1) Volcanic Formation

It is distributed between the Shackleton Mine and the Old Alaska Mine. A part of dolerite on the geological map is possible to be classified into this member. Basalt lava in the Freda Farm shows dark greenish to greenish gray colour, and is observed amygdaloidal texture. As the outcrop of this rock facies is narrow, detailed occurrence is indistinct.

Microscopic characteristics are as follows:

The specimen (KR3) collected at the Freda Farm shows blastoporphyritic texture. It is mainly composed of plagioclase and hornblende. In addition to them, quartz, biotite, epidote, tourmaline and iron oxides, and rare amounts of sphene, apatite and zircon. On the other hand, the specimen (YR104) collected at the southern edge of the area has no hornblende and biotite, and comparatively larger amounts of chlorite and calcite grow.

(2) Sandy Formation

It is distributed stretching from the north to the south in the central part of the survey area.

It is the main country rock of copper ore deposits in this area. In the southern to the central part of the area it is sometimes affected to weak metamorphism with poor cleavage observed by the naked eye. The grade of metamorphism becomes higher from the central part toward to the northern part in the survey area. The southern to central part of the area lies in the Magondi Mobile Belt. On the other hand, the northern part lies in the Zambezi Mobile Belt.

It mainly consists of arkose which includes conglomerate with mainly consists of granite gravels. The characteristic is the development of graded bedding and cross-bedding. This formation covered the Younger Granite of the Pre-Magondi Intrusive Rocks unconformally along the Brenville Farm of the northern part of Mhangura. The sedimentary cycle from coarse-grained arkose to shale, evaporites composed of anhydrite and thin layer of dolomite are observed in the underground tunnel of the Avondale Mine. This formation consider to be alluvial fan sediments, river sediments and playa sediments (Master, 1991).

Characteristics by microscopic observation are as follows :

Arkose shows blastopsamitic texture, and mainly includes quartz, plagioclase and orthoclase with biotite and muscovite, and includes small to rare amounts of iron oxides, sphene, apatite and zircon. Comparatively large amounts of hornblende and epidote are formed in the specimens at the northern part of the survey area (KR11, KR15 and KR26). In the same specimen, tourmaline and diopside are partly observed.

2. The Lomagundi Group

(1) The Mcheka Formation

It is distributed in both the side of the Deweras Group in the southern part of the survey area, and is distributed along western wing of the same Group in the central to northern part of the area.

It is composed of dolomite, quartzite and biotite bearing quartzite. The distribution of basal conglomerate is not recognized in this survey area.

Dolomite shows white to grayish colour and is composed of fine to coarse grained carbonate minerals and quartz grains. Grading is sometimes observed partly. The typical quartzite of this formation is called "pock-marked" quartzite by its spotted texture of brownish to reddish brown colour. Chemical component of dolomitic rocks of this member varies from dolomite to dolomitic quartzite (Tennik, 1976, Stagman, 1961).

Microscopic observation is as follows :

Dolomite specimens (SR9, YR42 and YR52) show saccharoidal or decussate texture, and includes dolomite and quartz with rare amounts of iron oxides, sphene, apatite or zircon. It sometimes includes

small amounts of plagioclase and orthoclase. Phlogopite sometimes grows with tremolite in the recrystallized specimens around Shamrocke Mine (KR46 and MR34). Quartzite specimens (NR45, SR11 and SR27) show granoblastic texture, and includes quartz with plagioclase, orthoclase and muscovite and quartz with carbonate minerals. Both the samples include rare amounts of iron oxides and sphene.

(2) The Nyagari Formation

It is widely distributed surrounding the Deweras Group and the Mcheka formation. It consists of sandstone, quartzite, slates and banded iron oxides. The sandstone is called "mountain sandstone" and shows dark grayish colour and massive structure with no bedding. Quartzite is distributed within slates in the southern part to the central part out of the survey area and forms folded hilly country. Slates are called "striped slate". They show black colour and developed cleavages crossing to bedding plane. Scattered euhedral pyrites are observed. Boulders of banded iron ore are observed in Rivington Farm area. But, no outcrop is observed.

Characteristics of microscopic observation are as follows :

Main rock forming minerals of the sandstone specimen (NR127 and SR4) are quartz, plagioclase, orthoclase with biotite and muscovite. Slate specimen (YR21) includes fine grain quartz, biotite and graphite with small amount of plagioclase and orthoclase. In the specimen (KR43) at the northern part of survey area, staurolite and garnet are formed. Banded iron ore specimen (YR60) shows banded texture of sandy rock part mainly with quartz and euhedral magnetite by microscopic observation. Magnetite changes to hematite along the crystal surface.

3. The Piriwiri Group

It is widely distributed in the western part of the area.

This Group consists of graphitic schist, quartzite, sandstone, graywacke and phyllite. Graphitic schist shows black colour and developed lamination. Quartzite is cherty quartzite within slate. Sandstone and graywacke alternates in phyllite. Phyllite shows various tones of colours and textures (Tennick, 1976).

Characteristics of microscopic observation are as follows :

Graphitic slate specimen (NR63) is composed of graphite, quartz, plagioclase as main minerals, and includes orthoclase, muscovite, iron ore and sphene. Phyllite specimen (YR70) shows decussate texture and mainly includes muscovite and chlorite. In addition to them, quartz, plagioclase, hornblende, iron ore, sphene and apatite are observed.

2-2-7 The Guruve Metamorphic Complex

It is distributed along the Zambezi Escarpment in the north-eastern margin out of the survey area.

Rock facies varies such as marble, felsic to arkosic sandstone, meta-arkose, meta-graywacke, and meta-sediments including amphibolite (Hahn and Steiner, 1990)

2-2-8 The Post-Magondi Intrusive Rocks

1. Granite

It is distributed as several stocks on a scale of several km in the north-western part out of the survey area.

It consists of biotite granite and gneissose granite. Both the types of granite have similar petrographic characteristics (Wiles, 1961).

2. Dolerites

They are distributed in the southern to the central part of the survey area, and intruded into the formations of the Bulawayan Groups to the Piriwiri Group in ascending order. The distribution within the Deweras Group was compiled on the maps based on the distribution of the outcrops, airborne magnetic survey and E.P.O. surveys. A part of this rock which was shown on geological map is possible to be the volcanic formation of the Deweras Group.

It shows dark greenish to dark grayish colour and has massive structure.

Characteristics by microscopic observation are as follows :

The specimen collected at the southern part of Mangula Mine (NR72, SR58 and SR61) shows blastoporphyritic texture. It is composed of hornblende, plagioclase, quartz as main rock forming minerals and iron ore, sphene and apatite as accessory minerals. Growth of epidote, chlorite, tourmaline and calcite crystals are sometimes observed.

3. Amphibolites

They are distributed as many dykes and sheets in the central part to the northern part of the survey area.

The amphibolites are considered to be mafic volcanics origin, because of the same component of dolerites which are distributed in the southern part of the area. The difference of rock facies is considered to occur due to difference of metamorphic grade.

Characteristics by microscopic observation of this rock are generally the same in those of dolerites. However, amphibole shows oriented arrangement, the amount of quartz is slightly much more than in dolerites, and biotite is growing as one of the characteristics.

4. Pegmatite

It is distributed within gneiss in the north-eastern part of the survey area and within the Piriwiri Group in the western part out of the area on a small scale.

It composed of quartz, orthoclase, muscovite, tourmaline and beryl. Muscovite occurs with block like shape within pegmatite the western part out of the area. Pale bluish coloured and transparent beryl is mined as aquamarine by small workers on a small scale (Wiles, 1961).

5. Quartz vein

It is distributed as veins within the Younger Granite which is the intrusive rock of the Pre-Magondi Group in the central part of the survey area and the western part from the area.

It consists of milky white to white transparent massive quartz, and partly changes to granophyre like texture. Iron oxides mainly composed of hematite with dark grayish metal luster are developed as network in the southwest of Nyamanyoko farm.

Characteristics by microscopic observation are as follows :

The specimen of quartz vein within the Younger Granite in Glen View Farm (SR78) shows lepidoblastic texture, and includes mainly quartz and muscovite with small amounts of iron ore and apatite. The specimen at Alpha A Farm in the west of the Mangula Mine (YR57) is granophyre with micrographic texture. It includes mainly quartz, plagioclase and orthoclase with hornblende, iron ore, sphene and apatite.

2-2-9 The Sijarira Group

The distribution is observed in the Younger Granite area on a small scale in the south-eastern part out of the survey area.

It is composed of reddish sandstone (Stagman, 1961).

2-2-10 The Upper Karoo Formation

It is distributed under the Zambezi fault scarp on a small scale in the northern part out of the survey area.

It is composed of alternation of sandstone with cross-bedding, siltstone, and conglomerate with lenticular shape pebbles. It is calcarious (Chenjerai,1988).

2-2-11 Quaternary sediments

Alluvial fan sediments with pelitic and sandy pebble, and talus deposits under Zambezi escarpment are widely distributed.

2-3 Geological structure

Many studies about the history of geological structure of the survey area and their detailed examination were carried out (Stagman, 1961; Jacobson, 1962; Blaiss, 1970; Stowe, 1978; Sutton, 1979; Treloar, 1988; Simpson, 1990; Master,1984,1991 etc). These studies were carried out mainly