REPORT
ON
THE MINERAL EXPLORATION
IN
THE SNAKE HEAD AREA
THE REPUBLIC OF ZIMBABWE

SUMMARY

MARCH 199[illegible]

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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Preface

In response to the request of the Government of Zimbabwe, the Japanese Government decided to conduct a Mineral Exploration in the Snake Head 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 10 October, 1995 to 26 August, 1997.

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

This report is summary of the results of survey that was carried out through three years.

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.

December 1997

Kimio FUJITA

President

Japan International Cooperation Agency

Hiroaki HIYAMA

President

Metal Mining Agency of Japan

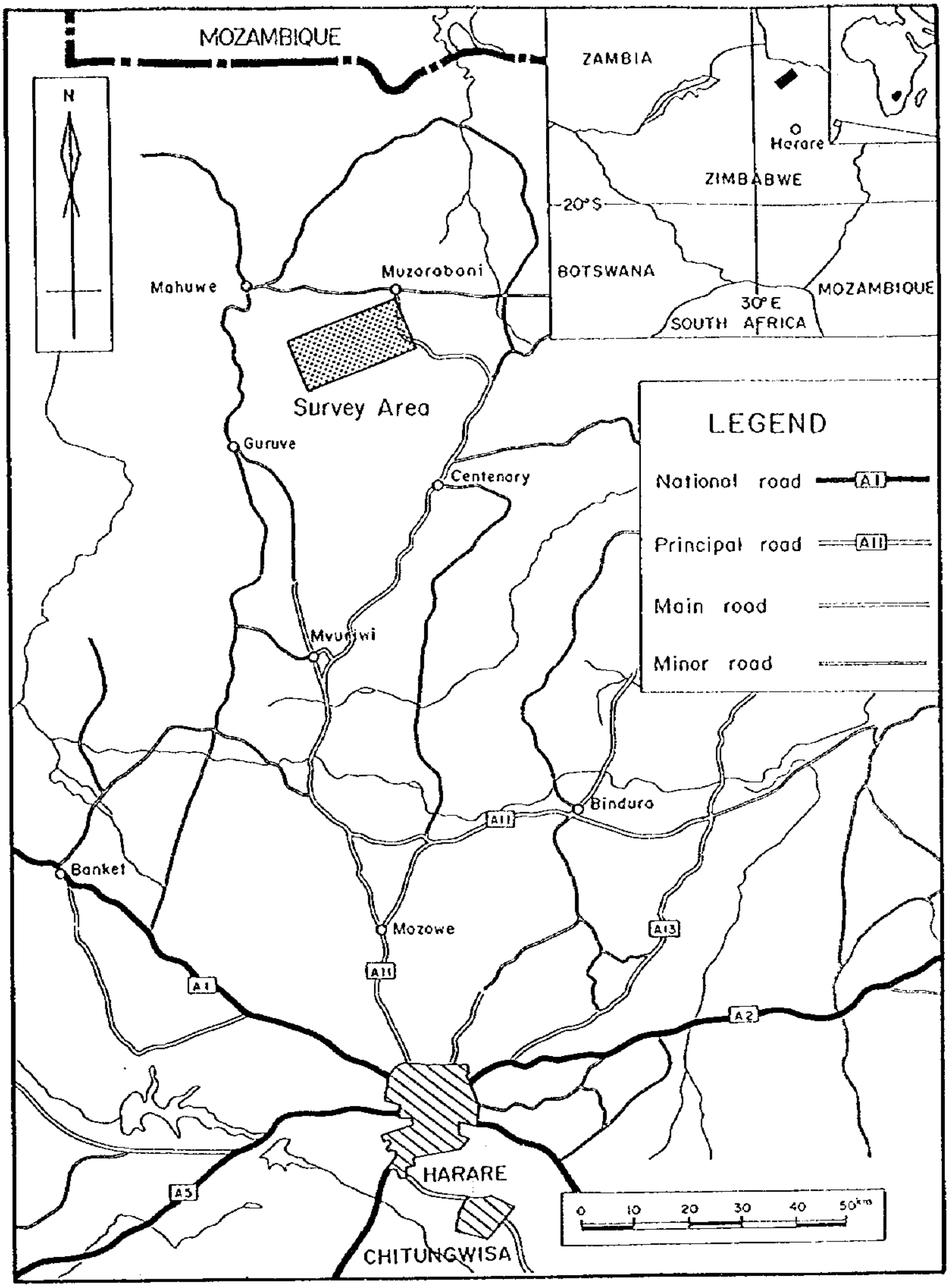

Fig.I-1-1 Locality of the survey area

Abstract

This report is summary of the mineral exploration project in the Snake Head area, Republic of Zimbabwe.

1. Purpose of the survey

This survey was carried out in order to explore new ore deposits of platinum group metals. At the same time, technological transfer from Japan to the related organization of Zimbabwe is one of the important purpose of this project.

2. Summary of works

Trough this survey, literature search, geological survey, rock geochemical exploration, geophysical IP exploration and drilling were carried out.

3. Results of the survey

Through the study of results of Phase I survey, WS area was selected as the most expected target area for drilling.

Drilling of 10 holes was carried out in this area. The results are summarized below.

Sulphide mineralization zone was encountered by all drillings, it is consider that this area has continuous sulphide and PGM mineralization zone. Maximum metal content of PGM in the sulphide mineralization zone is as follows.

Hole No.	Depth(m)	Pt(ppb)	Pd(ppb)	Rh(ppb)	PGM(ppb)
MJZS-1	249.50~250.00	533	434	12	979
MJZS-2	271.00~271.50	389	373	19	782
MJZS-3	348.00~349.00	583	331	14	928
MJZS-5	168.50~169.50	598	147	17	762
MJZS-6	339.00~340.00	541	145	15	701
MJZS-7	469.00~470.00	514	442	27	983
MJZS-8	616.00~617.00	423	301	10	734

Through the survey, maximum PGM content is approximately 1 g/t, on the other hand , the Hartley Mine which is developed recently published their ore reserves and grade as follows.

Reserves : 50.9 million tonnes (proven and probable)

Grading : 2.64g/t Pt, 1.8g/t Pd. 0.21g/t Rh, 0.47g/t Au,

Snake Head area is generally low grade of PGM compared with the Hartley Mine, it is considered that the grade of concentration of PGM may be low in this survey area, it could not be attained to discover the new ore deposit that can expect to develop at present.

4. Recommendation for the future

According to conclusions obtained through the survey results in Phase I to III, the following program will be proposed.

(1) Drilling survey must be carried out in the north-eastern portion of the WN area and the northern portion of the CB area in order to study the probability of the existence of the platinum ore deposit.

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Part I General remarks

Part I General remarks

Chapter 1 Introduction

1-1 Area and purpose of the survey

The Snake Head area is located in the northern part of Zimbabwe as shown in Fig. I-1-1. Travel time by car from Harare are about 5 hours.

The Great Dyke is generally known as the main host area for nickel, cobalt, and platinum group metals in the world. In the Snake Head area, the target area of this survey, is the last expected area where a high potential for existence of Platinum group metals deposit such as those at Hartley, Serious, Zinka, and Mimoza mines can be found. Therefore, the Government of the Republic of Zimbabwe requested the Government of Japan for a Technical Cooperation to carry out mineral exploration in the Snake Head area. The Government of Japan responded to the request and conducted a drilling surveys. A survey team was dispatched to carry out the survey in order to explore for new deposits.

1-2 Method and specification of the survey

Flow sheet of the survey and flow chart of selection of the promising area are shown in Fig. I-1-2 and Fig. I-1-3.

Method and specification of the survey in each Phase are shown in Table I-1-1.

1-3 Terms and members of the survey

Terms and members of the survey in each Phase are shown in Table I-1-2.

Part I General remarks

Part I General remarks

Chapter 1 Introduction

1-1 Area and purpose of the survey

The Snake Head area is located in the northern part of Zimbabwe as shown in Fig. I-1-1. Travel time by car from Harare are about 5 hours.

The Great Dyke is generally known as the main host area for nickel, cobalt, and platinum group metals in the world. In the Snake Head area, the target area of this survey, is the last expected area where a high potential for existence of Platinum group metals deposit such as those at Hartley, Serious, Zinka, and Mimoza mines can be found. Therefore, the Government of the Republic of Zimbabwe requested the Government of Japan for a Technical Cooperation to carry out mineral exploration ln the Snake Head area. The Government of Japan responded to the request and conducted a drilling surveys. A survey team was dispatched to carry out the survey in order to explore for new deposits.

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[FLOWSHEET OF THE SURVEY]

Phase I

Survey area (Snake Head area) 150 km²

↓

Literature seach (Geological compile map, Scale ; 1:25,000)
Geological survey (Geological map, Scale ; 1:25,000)
Soil geochemical survey ; 1,366 Samples
Geophysical IP survey ; 32 line km

↓

Analyses of survey resalts and discussion

↓

Selection of the promising area

↓

Recommendation for the Phase II survey

↓

Phase II

↓

Drilling survey 5 holes total 2,100.74m

↓

Analyses of survey resalts and discussion

↓

Selection of the promising area

↓

Recommendation for the Phase III survey

↓

Phase III

↓

Drilling survey 5 holes total 2,400m

↓

Analyses of survey resalts and discussion

↓

Recommendation for future

Fig. I-1-2 Flow sheet of the survey

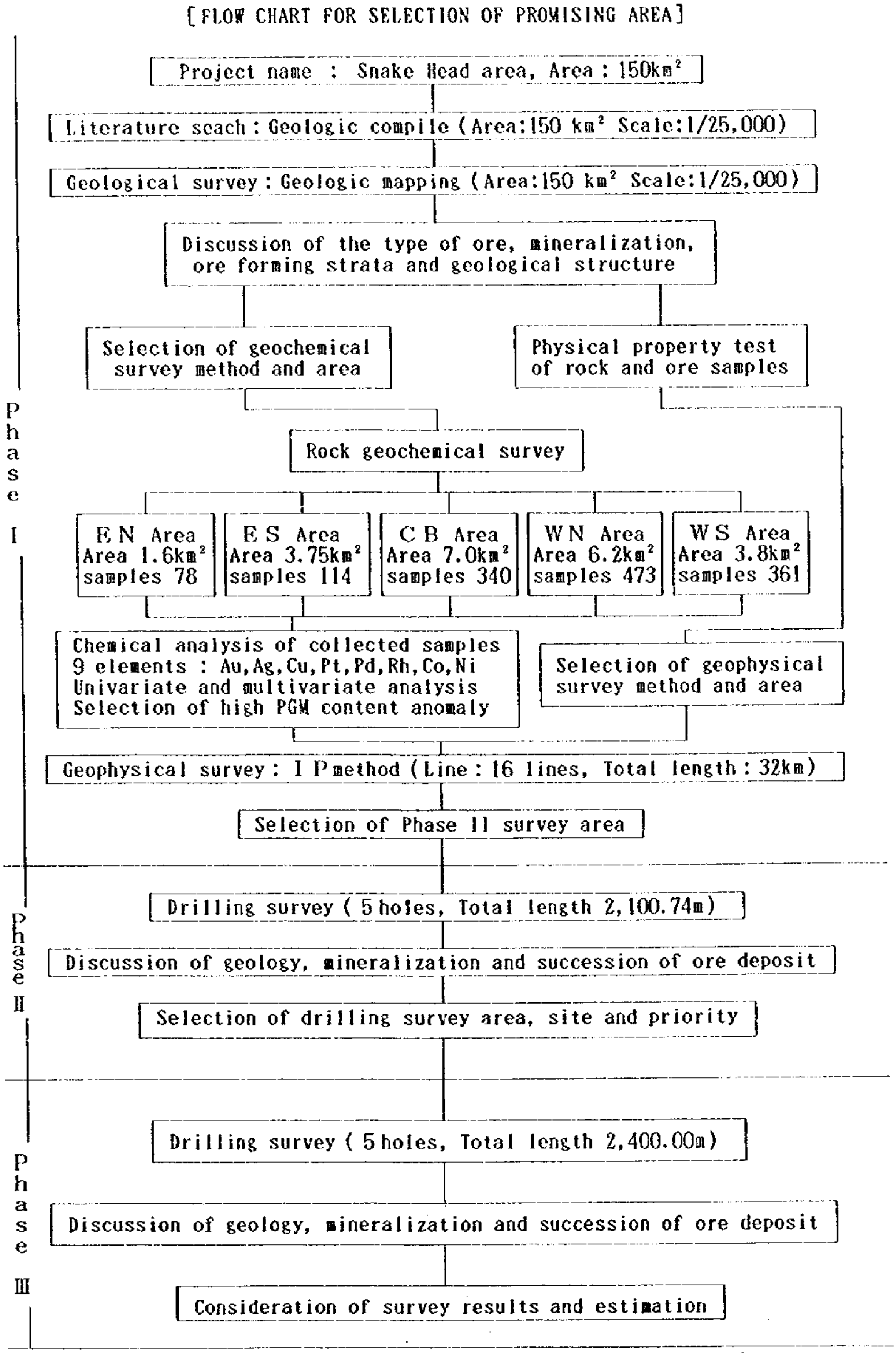


Fig. I-1-3 Flow chart of selection for the promising area

Table I-1-1 Contents of the survey

Phase	Phase I	Phase II	Phase III
Priod	1995.10.6~1996.3.1	1996.6.25~1997.2.28	1997.6.5~1997.12.26
Literature seach	Geologic map 5 sheets E.P.O's reports 1 set Geological documents 1 set Airphoto 15 sheets		
Geological survey	Survey area 150km^2 Extension of survey line 68.3km		
Geochemical survey	Survey area 22.25km^2 Rock samples 1,366		
Geophysical survey	Method ; IP method No. of line ; 16 Total line km ; 32km		
Drilling survey		No.of Drilling 5 Holes Total Depth 2,100.74m	No.of Drilling 5 Holes Total Depth 2,400.00m
Laboratory test	Microscopic observation of rock thin section; 34 Microscopic observation of ore polished samples; 18 X-ray diffraction; 38 EPMA analysis; 6 Rock chemical analysis(Au, Ag, Cu, Pt, Pd, Rh, Co, Ni) 1,366 Measurement of resistivity and chargeability; 36	Microscopic observation of rock thin section; 10 Microscopic observation of ore polished samples; 14 EPMA analysis; 6 Ore chemical analysis (Au, Ag, Cu, Pt, Pd, Rh, Co, Ni, S) 144	Microscopic observation of rock thin section; 7 Microscopic observation of ore polished samples; 13 EPMA analysis; 7 Ore chemical analysis (Au, Ag, Cu, Pt, Pd, Rh, Co, Ni, Cr, S) 135

Table I-1-2 Terms and members of the survey

Phase	Phase I	Phase II	Phase III
Priod	1995.10.6~1996.3.1	1996.6.25~1997.2.28	1997.6.5~1997.12.26
Planning and negotiation	Metal Mining Agency of Japan Mr. Toyo MIYAUCHI Mr. Katsuhisa ONO Mr. Yoichi OKUIZUMI	Metal Mining Agency of Japan Mr. Katsuhisa ONO Mr. Yoshiyuki KITA	Metal Mining Agency of Japan Mr. Yoji SHIBASAKI Mr. Yoshiyuki KITA
	Geological Survey Department of Zimbabwe Mr,S.M.N.NCUBE Mr.Temba Mabasa HAWADI Mr.Forbs MUGUMBATE	Geological Survey Department of Zimbabwe Mr.Wishes MAGALELA Mr.Forbs MUGUMBATE	Geological Survey Department of Zimbabwe Mr.Wishes MAGALELA Mr.Forbs MUGUMBATE
Field Survey	DOWA Engineerig Co.,Ltd. Mr.Yoshioki NISHITANI Mr.Hiroshi YOKOYAMA Mr.Kunio KIMURA Mr.Tadashi NYUUI Mr.Masatoshi MAEKAWA	DOWA Engineerig Co.,Ltd. Mr.Yoshioki NISHITANI	DOWA Engineerig Co.,Ltd. Mr.Yoshioki NISHITANI
	Geological Survey Department of Zimbabwe Mr.Wishes MAGALELA Mr.Forbs MUGUMBATE Mr.F.B.MUPAYA Mr.George KWENDA Mr.Warren MAKAMURE Mr.Manhando MUTENDA Mr.Madgen NHAMBURO	Geological Survey Department of Zimbabwe Mr.Forbs MUGUMBATE Mr.F.B.MUPAYA	Geological Survey Department of Zimbabwe Mr.Forbs MUGUMBATE

Chapter 2 Previous Works

2-1 Outline of Previous Works

As regards the geology of this area and the surrounding area, geological maps of Zimbabwe, distribution map of mineral resources of Zimbabwe on a scale of 1:1,000,000, geological map on a scale of 1:100,000(SIPOLILO, CENTENARY) published by GSD. Southern Rhodesia Geological Survey Bulletin No.47(hereinafter called Bulletin 47) describes the geology and mineralization of the Great Dyke.

As regards the exploration data of this survey area, 2 explorations was carried out by Union Carbide Rhomet (Pvt.) Ltd.(hereinafter called Union Carbide) between 1967 and 1972, and Cluff Resources Zimbabwe Ltd.(hereinafter called Cluff), between 1989 and 1992, under Exclusive Prospecting Orders (hereinafter called E.P.O.).

Bulletin 47 clearly describes all the rock types of the Great Dyke, and mineralization with respect to Nickel, Cobalt, and PGM metals. The Great Dyke is divided in to 5 complexes(Musengezi complex, Hartley complex, Selukwe complex, Wedza complex, and satellite complex), and characteristics of each complex were described. PGM mineralization was described as being confined to the pyroxenite No.1 layer(hereinafter called P1) just under the gabbroic rocks. Distribution of P1 must therefore be considered for exploration.

Union Carbide carried out soil geochemical prospecting with about 30m of sampling distance, and confirmed the layer with PGM mineralization. In addition, trenching survey and detailed geochemical sampling with about 3 to 6m of sampling distance was carried out. Based on this prospecting, drilling was carried out at 4 sites. 2 to 3 zones of mineralization were recognized.

Cluff considered the probability for mining development using the open cast method, high mechanized operation, and large scale of ore processing. For the purpose of this, Cliff carried out detailed topographic mapping on the scale of 1:12,500, constructing an access road, and geological survey confirming the distribution of P1 and main fault system. Based on this survey, drilling was carried out on 5 sites. It was concluded that 2 zones of mineralization occur(0.88 to 1.16g/t,Pt+Pd).

Chapter 3 General geology

3-1 General geology in the survey area

This survey area is located in northern end of the Great Dyke which pass through the center of the Republic of Zimbabwe as shown in Fig.I-1-2.

Geology of this area consists of gneisses and granites of Archaean era which forms the basement, and ultramafic to mafic rocks of the Great Dyke which intruded in to the basement rocks.

The basement rocks mainly consists of augen gneiss with remarkable feldspar, and are distributed in the northwestern and southern side of the survey area.

The Great Dyke is a layered basic intrusion whose geology consists of a topmost layer of gabbroic rocks distributed widely in the center part of the survey area. Gabbro is black to deep green in color, massive, holocrystalline texture. Below gabbro are multi-layers of pyroxenite with deep green to green color, coarse grained, holocrystalline texture. Followed by peridotite(dunite, harzburgite) from top to bottom.

PGM is mainly in the upper most layer(P1) of the multi- layered pyroxenite, and chromite occurs below the lower pyroxenite layers.

3-2 Geological structure in the survey area

The Great Dyke in the survey area is curved like an "S" form due to the structural movements of the Pan-Africa Zambezi Mobile Belt. In addition, the area is cut by fault systems striking in the N-S and E-W direction which resulted in the formation of the western mountain block forming the Botera range, the central mountain block forming the Guyu range, and the eastern mountain block of the east bank of the Musengezi river.

The western block strikes N-S to NE-SW and dips to the E to SE direction whereas the central block strikes N-S and dips towards the E in the northern portion and W in the southern portion. The eastern block shows a N-S to NE-SW strike and W to NW direction of dip.

3-3 Known ore deposit

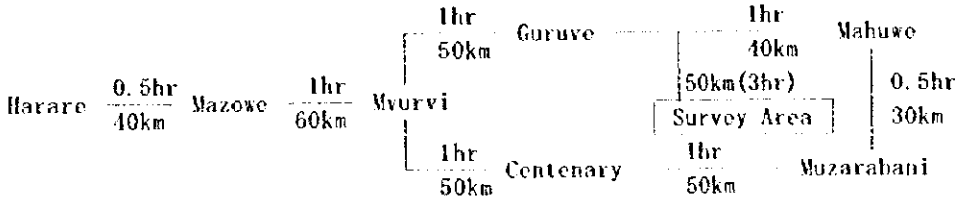
Union Carbide and Cluff resources zimbabwe Ltd. carried out a geological survey and exploration through E.P.O. license areas.

Union Carbide carried out the geochemical soil sampling with sampling distance of 30m at the main sulphide zone(hereinafter called MSZ). For the obtained PGM occurring layer, 4 drill holes of crossing the layer were carried out. As a result, a MSZ(1.4g/t 0f Pt+Pd, thickness 14m) and a lower sulphide zone(hereinafter called LSZ) 50m under from MSZ(1.2g/t of Pt+Pd, thickness over 7.6m) were recognized. Cluff produced a topographic map on the scale of 1:25,000, constructing an access road to the survey area, and a geological map confirming the distribution of the P1 layer and fault systems to decide the priority of drilling. 5 holes of drilling were completed out, and Cu, Ni, Pt, Pd, Rh, Au, As were analyzed. As a result, 2 layers of PGM mineralized zone(0.88 to 1.16g/t of Pt+Pd, thickness 4.2 and 5.2m) were recognized. Distribution of mineralized zones was estimated to cover an area 7km x 4km.

Chapter 4 Physical features

4-1 Location and access

The Snake Head area is located in the northern part of Zimbabwe as shown in Fig.I-1-1. 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 north of Guruve, From north of Guruve to survey area is by gravel road through mountains. Only the 4WD cars can drive in the dry season, however during the rainy season of November to March, it is impossible to access the survey area.

During the field survey, Japanese engineers and counterpart stayed in Guruve. Labours were employed in the survey area.

4-2 Topography and river system

The topography of the survey area is generally affected by fault systems, and shows mountain blocks. Gabbroic rocks and pyroxenite rocks were distributed characteristically along to the mountain range. Elevation is between 500 meters to 1,600 meters. The topography is steep with valleys that were eroded strongly by river system.

Streams and rivers flow parallel to the mountain range with the direction of the south-west or the north-east, and flow into Musengezi river which runs to the north to flow into Zambezi river.

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

4-3 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 March). there is no rainfall in the dry season and maximum rainfall in the rainy season is about 200 to 250mm/month.

As regards vegetation, except short broad-leaved trees as oaks which is distributed in the mountainous district, the vegetation is generally thin in the survey area. Many bamboo trees characteristically grow along the river. The serpentinite zone shows poor vegetation especially with grass only growing on its surface.

Big wild animals like a elephant, antelope and buffalo live in the survey area, and also small amount of carnivorous fierce animals like lions and leopards exist.

Chapter 5 Conclusion and recommendation

5-1 Conclusion

The literature search, the geological survey, the geochemical survey and geophysical survey were carried out as the Phase I of this project. Drillings were carried out as the Phase II and III of this project. Results of this survey are summarized below.

As the result of the literature search and the geological survey, upper gabbroic rocks are widely distribute in the center portion of the survey area. Rock facies move to lower peridotite(dunite, harzburgite) pass through multi layered pyroxenite.

The sulphide mineralization which can be observed with naked eye mainly occur in the P1 layer of the upper most pyroxenite layer. These layering can be pursued in the field.

As the result of the geochemical survey, the mineralization zone of the PGM corresponds well to the concentrate zone of platinum group elements of the drilling survey. The geochemical survey using rock samples is useful for the platinum exploration.

As the result of the geophysical survey, the result of the geophysical IP survey do not show a clear correspondence against the mineralization zones obtained by drillings. The reason may be that the why the sulphide content in the mineralized zone is few, and a clear difference of chargeability between mineralized rock and country rock does not show.

As the result of drillings, Mineralization of PGM was encountered by all drill holes. It is considered that PGM occur in upper most of bronzitite zone and this area may have a continuous mineralization zone.

Moncheite and Sperrylite are observed as a PGM minerals, they are closely assemblaged with sulphide minerals like a pyrrhotite, Pentlandite, chalcopyrite, etc., and occur especially boundary portion between pentlandite and chalcopyrite or sulphide minerals and cumulus minerals.

However, through Phase II and III survey, maximum thickness of sulphide mineralization zone is 42m(MJZS-7) but maximum metal content of PGM is about 1 g/t. On the other hand, the Hartley Mine which developed recently published their ore reserves and grading as follows

Reserves : 50.9 million tonnes (proven and probable)
Grading : 2.64 g/t Pt 1.8 g/t Pd 0.21 g/t Rh 0.47 g/t Au

Snake Head area is generally low grade of PGM compared with the Hartley Mine, it is considered that the grade of concentration of PGM may be low in this survey area, it could not be attained to discover the new ore deposit that can expect to develop at present.

5-2 Recommendation for the future

According to conclusions obtained through the survey results the method of the survey for the future is proposed as follows.

(1) Further drilling survey must be carried out in the north-eastern portion of the WN area and the northern portion of the CB area in order to study the probability of the existence of the platinum ore deposit.

Part II Details of the surveys

Part II Details of the Surveys

Chapter 1 Literature Search

The localities of previous works are shown in Fig.II-1-1. List of the literature is shown in Table II-1-1.

Explorations of PGM ore deposit by Union Carbide and Cluff under E.P.O.s were carried out in the survey area from 1967 to 1992.

Table II-1-1 List of the literature

The leterature	Amount
Geological Maps	
a scale of 1:1,000,000	2 sheets
a scale of 1:100,000	3 sheets
The previous E.P.O.s.	2 (No.193 & 654)
Air Photograph	25 sheets
Others	3 papers

1-1 Geology and Economic Geology

As regards the geology of this area and the surrounding area, geological maps of Zimbabwe(Stagman, 1978), distribution map of mineral resources of Zimbabwe (Bartholomew, 1986) on a scale of 1:1,000,000, geological map on a scale of 1:100,000 (SIPOLILO (Worst,1957, Wiles,1965, CENTENARY(Bace,et,al,1983)) and Southern Rhodesia Geological Survey Bulletin No.47(B.G.Worst,1960) are published by GSD.

As regards the exploration data of this survey area, 2 explorations was carried out by Union Carbide between 1967 and 1972, and Cluff between 1989 and 1992, with E.P.O..

1. Outline of Geology

Geology of this area consists of gneiss and granites of Archaean era which forms the basement, and ultramafic to mafic rocks of the Great Dyke which intruded in the basement rocks.

The basement rocks mainly consists of augen-gneiss with remarkable feldspar, and distributed in the northwestern and southern side of the survey area.

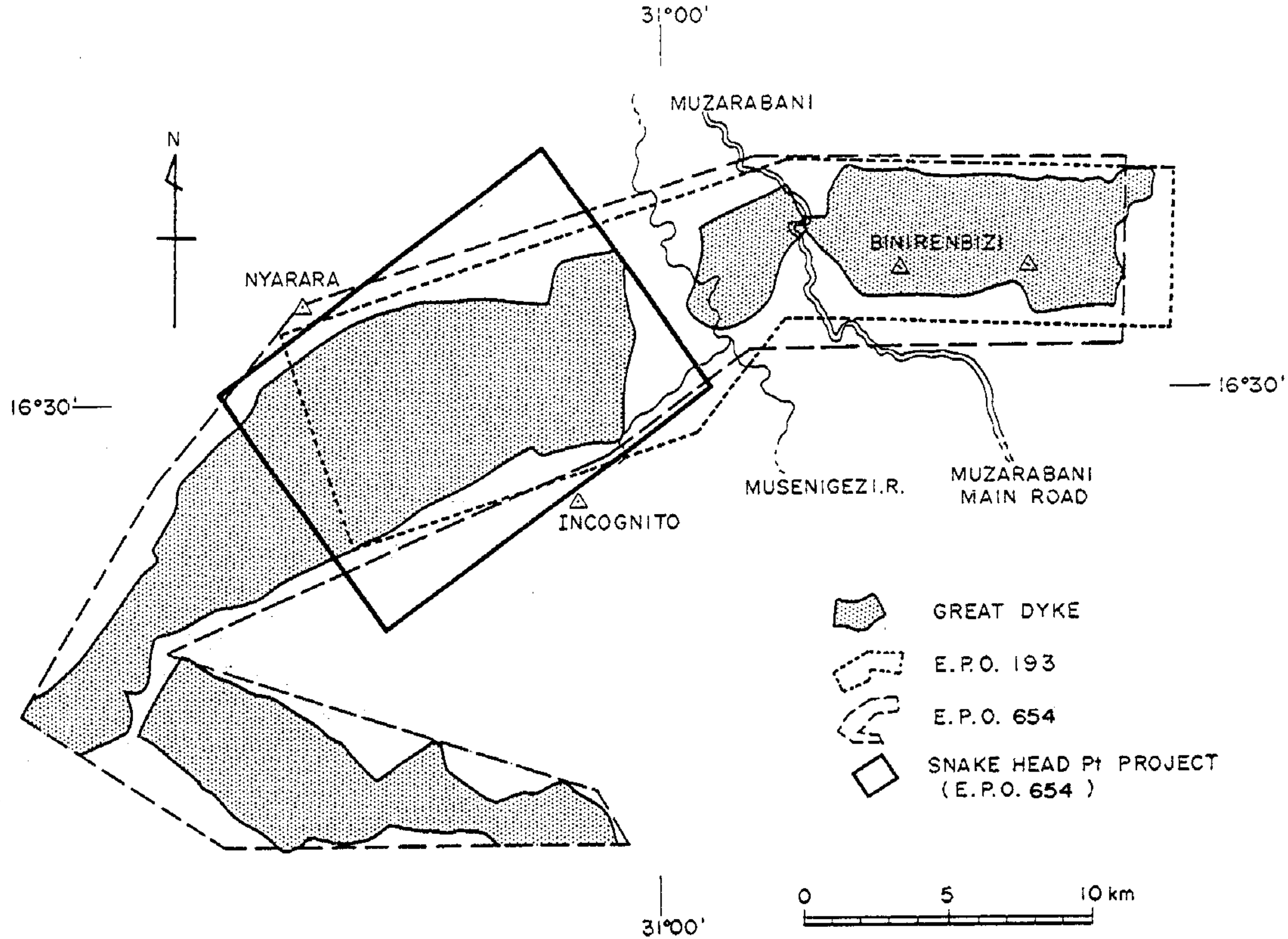


Fig.II-1-1 Locality of previous works

The Great Dyke is a layered basic intrusion. The geology of the Great Dyke change from upper mafick rock to lower ultramafick rocks. Upper gabbroic rocks distributed widely in the center part and northeastern part of the survey area, and shows black to deep green in color, massive, holocrystalline texture. Multi- layer of the pyroxenite with deep green to green color, coarse grain, holocrystalline texture, distribute under gabbroic rocks. Lower peridotite(dunite, harzburgite), in many case, is subjected to serpentinization. Pyroxenite and peridotite shows multi- layer each other, and formed so called cyclic units.

PGM is mainly in the upper most layer(P1) of multi layered pyroxenite, and chromite showing occur in the lower pyroxenite layer(Bulletine,47). Multi zone of sulphide concentration with PGM minerals were recognized in the pyroxenite, upper zone shows higher concentration than lower zone(Allen H.Wilson and Marian Tredoux 1990).

2. Geological structure

The Great Dyke is divided by fault system of N-S and E-W direction to the western mountain block, the central mountain block, and the eastern mountain block of the east bank of the Musengezi river.

The western block strikes a N-S to NE-SW and dip to the E to SE whereas the central block strikes N-S and dips towards the E the northern portion and W in the southern portion, the eastern block shows a N-S to NE-SW strike and N to E direction of dip.

3. The known ore deposits

Expected ore deposits in this area are PGM nickel, cobalt, and copper ore deposits on a view point of the economic feasibility. Union Carbide and Cluff discovered some mineral showing, however, there is no developed mine in the past.

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

The history of mining activities in the survey area is comparatively new. The surveys of ore deposits are carried out under the E.P.O. No.93 and 654. Final reports of surveys are filed in GSD, and are available to examine.

E.P.O. No.93

This E.P.O. was established by Union Carbide between 1967 and 1972.

Union Carbide carried out a soil geochemical prospecting with about 30m of sampling distance, and 15 to 45cm of depth. Then after shook off under 60 mesh, Pt, Pd, Cu, Ni were analyzed from these samples.

PGM mineralization zone was confirmed, in addition, trenching survey and detail geochemical sampling with about 3 to 6m of sampling distance was carried out. based on this prospecting, 4 drilling were carried out. As the results, it is concluded that 2 and 3 zone of mineralized were recognized.

E.P.O. No.654

This E.P.O. was established by Cluff between 1989 and 1992. Cluff considered the probability for mining development using the open cast method, high mechanized operation, and large scale of ore processing. For the purpose of this, Cluff carried out a making of detail topographic map on the scale of 1:12,500, constructing a access road, and geological survey confirming a distribution of P1 and main fault system. Based on this survey, 5 drillings were carried out. As the result, it is concluded that 2 zone of mineralized were recognized(0.88 to 1.16g/t,Pt+Pd).

1-3 Others

1. Air photograph

Airphotographs all covered survey area were published at the Survey General Office.

1-4 Summary

The Great Dyke is the main mining area of the PGM in Zimbabwe. the Mimosa mine in the Wedza complex, the Unki area in the Selukwe complex, and the Zinka, Selous, Hattley mine in the Hartley complex are generally known. These ore deposits are in the upper most of pyroxenite layer just under the gabbroic rocks in these areas. Summary of previous works was shown in Fig.II-1-2. As the results of analysis of the existing data, in the Snake Head area continuous distribution of pyroxenite P1 just under the gabbroic rocks was recognized same to known platinum mining area, and Union carbide and Cluff obtained some platinum showing by the drilling, therefore, it is considered to have high potentiality of occurrence of new ore deposits.

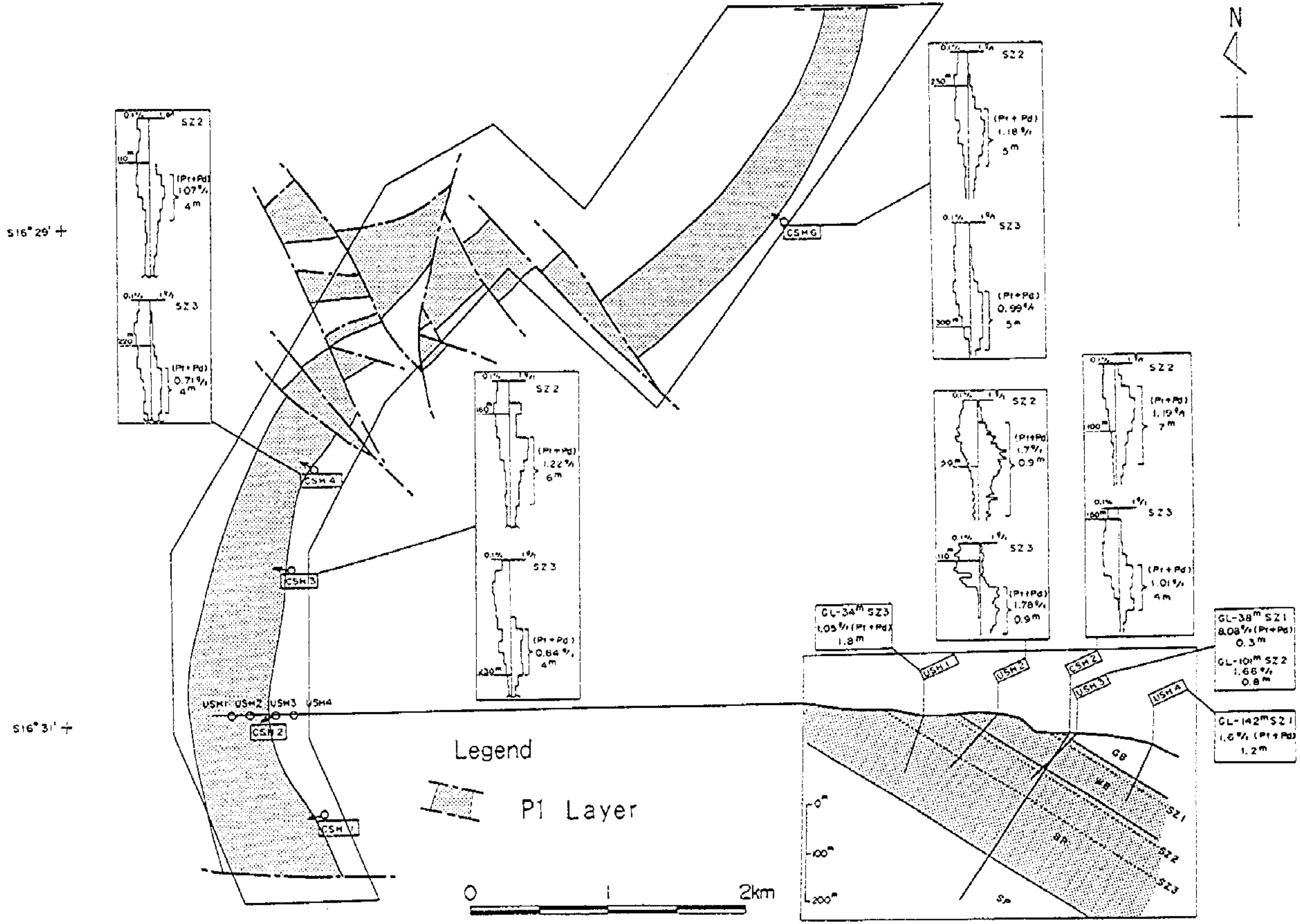


Fig.II-1-2 Summary of previous works

Chapter 2 Geological survey

Outline of the Great Dyke is shown in Fig.II-2-1, the survey area consists of gneiss and granites of Archaean era which forms the basement, and ultramafic to mafic rocks of the Great Dyke which intruded in the basement rocks.

Schematic geological column, geological cross section and geological map are shown in Fig.II-2-2. to II-2-4, respectively.

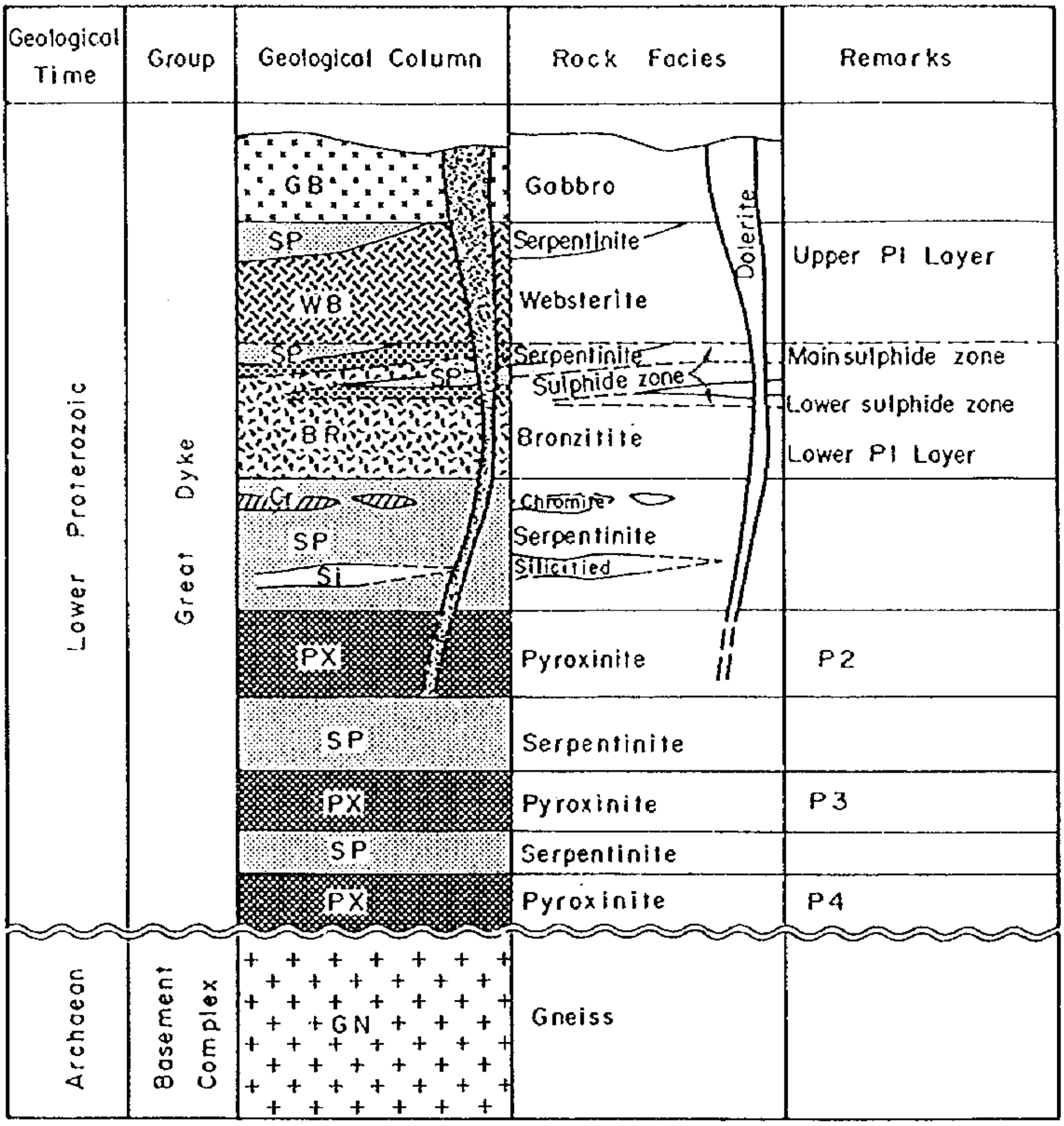


Fig.II-2-2 Schematic geological column

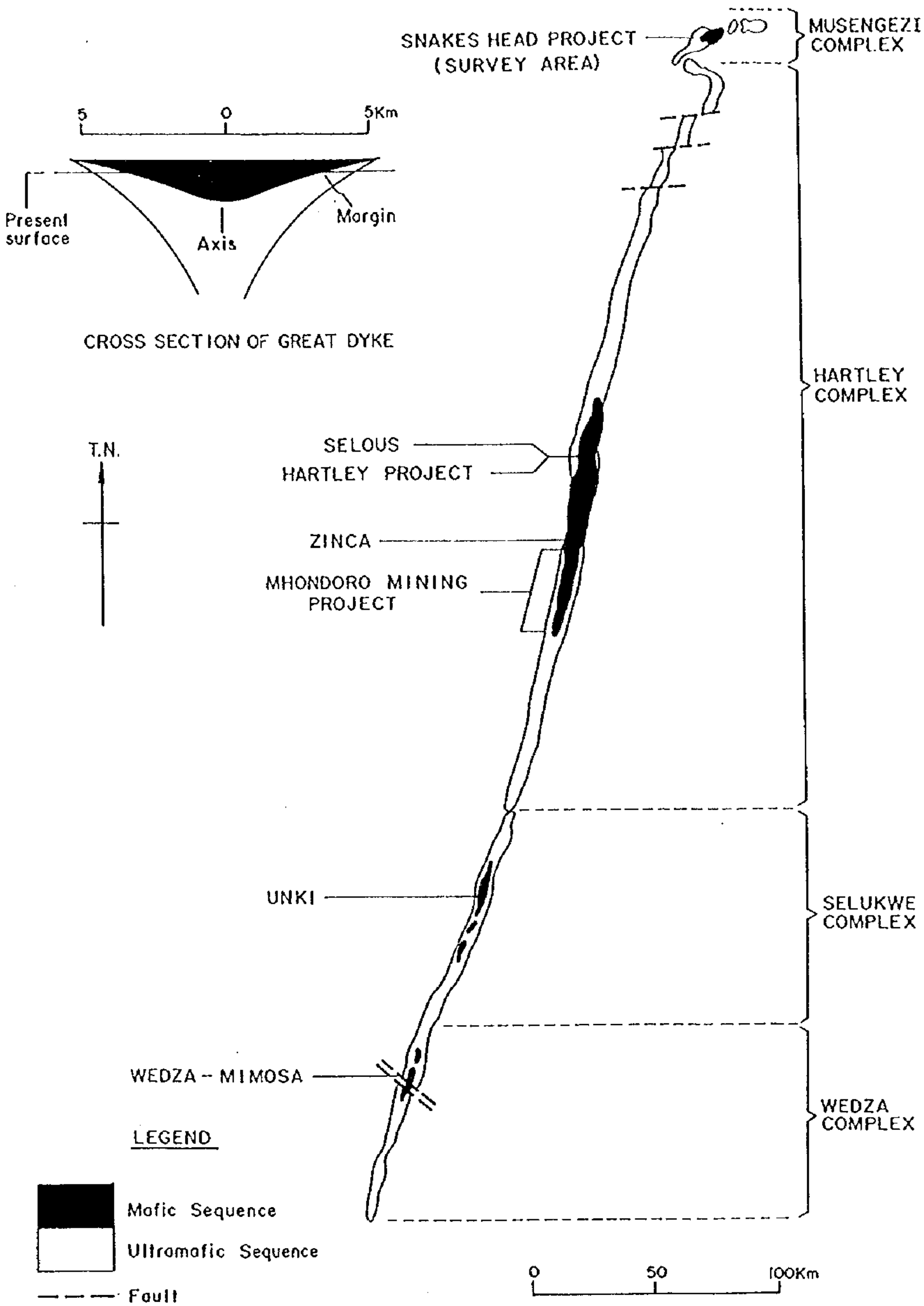


Fig.II-2-1 Outline of the Great Dyke

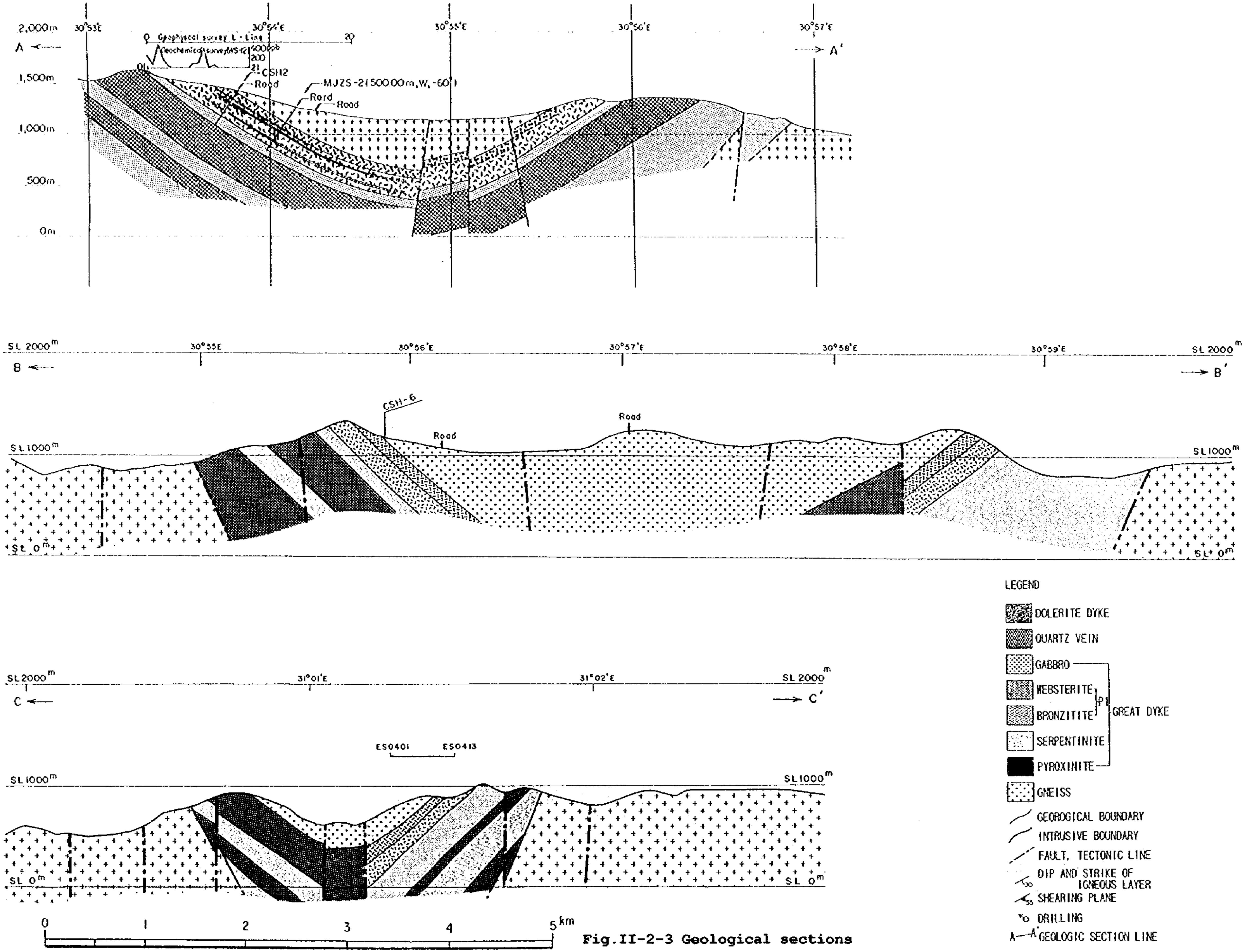


Fig.II-2-3 Geological sections

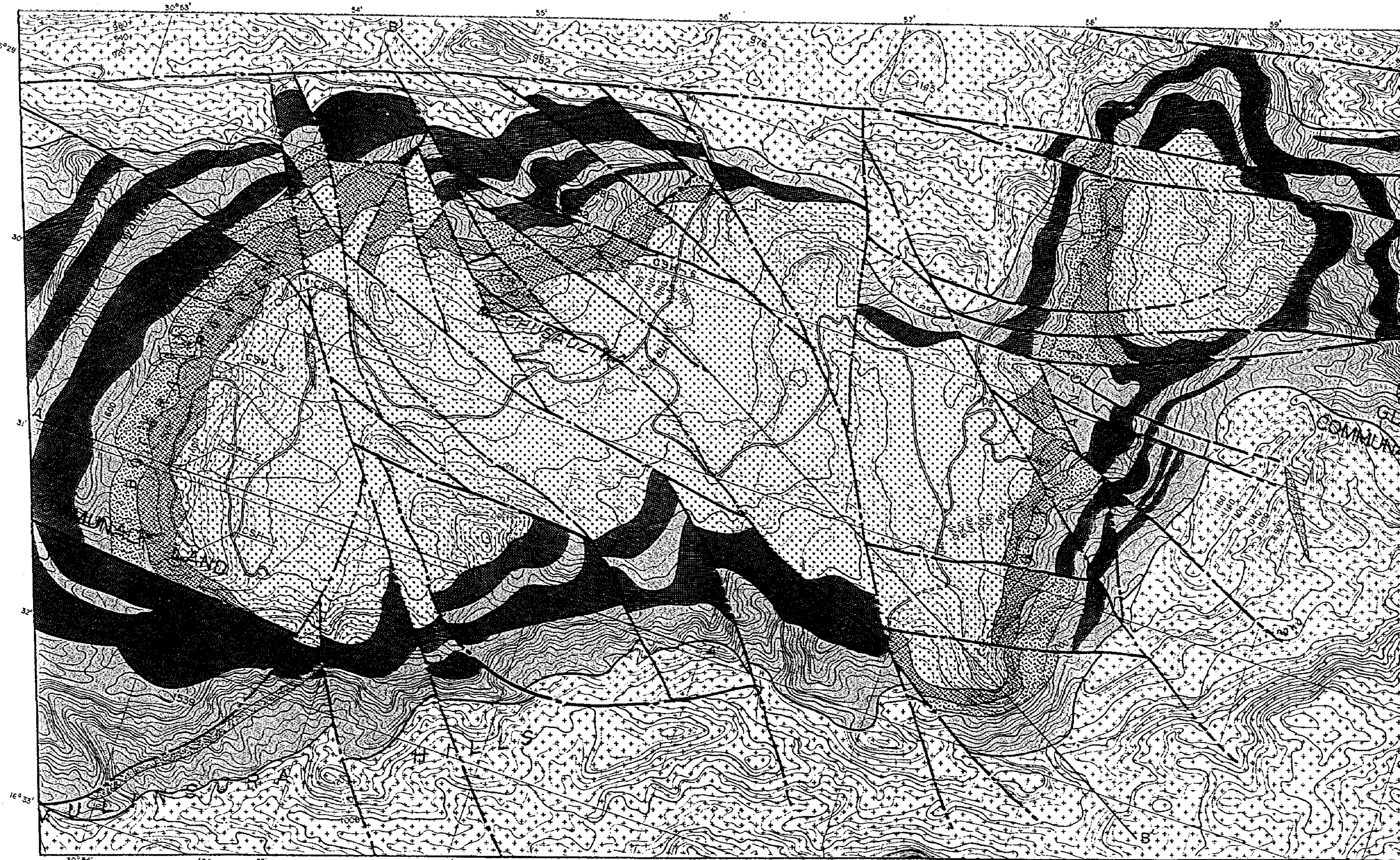


Fig.II-2-4 Geological map

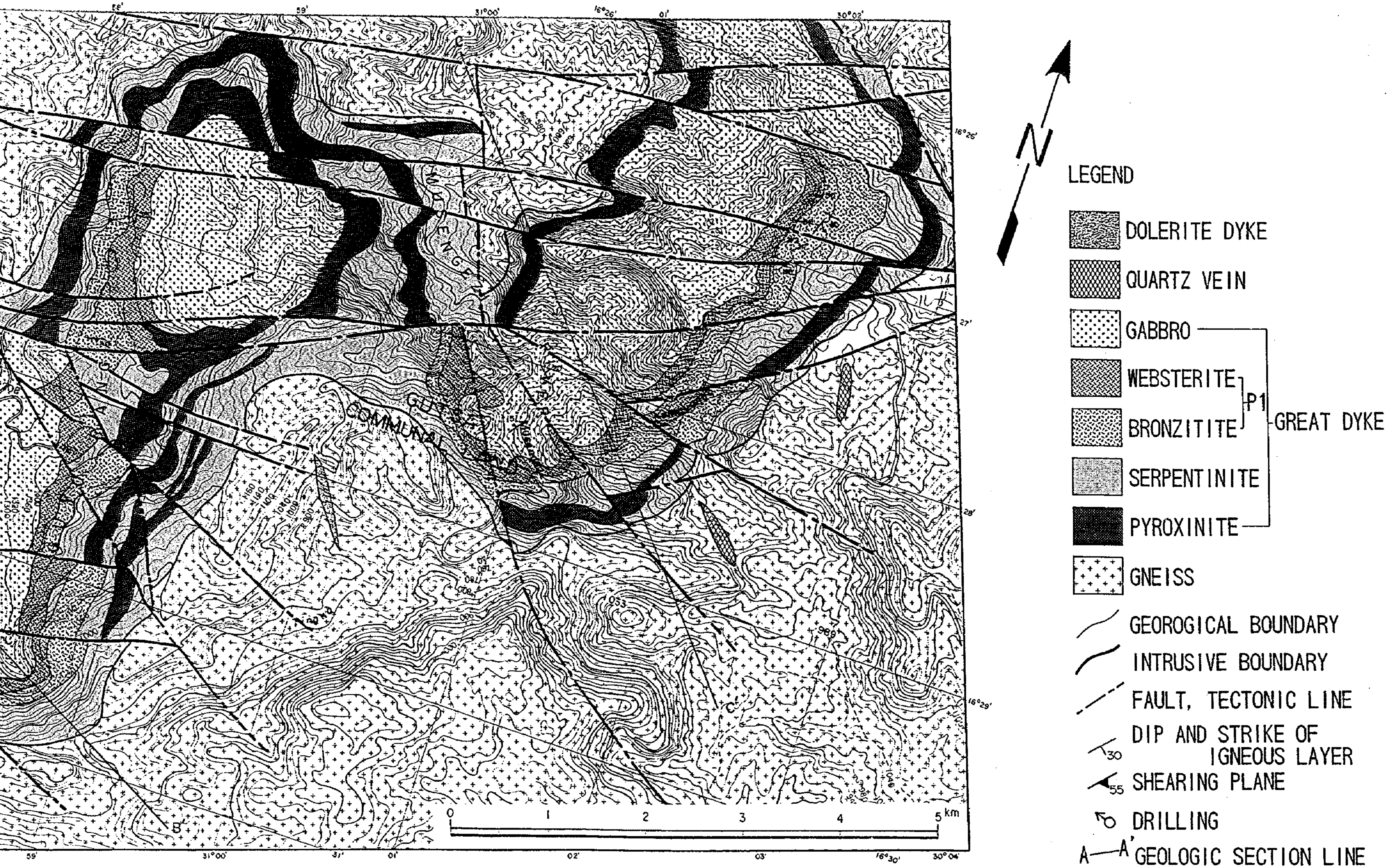


Fig.II-2-4 Geological map

2-1 Basement Rocks

The basement rocks are widely distributed in north western and south eastern part of the survey area.

The basement rocks mainly consists of orthogneiss of granodiorite component and granite. These rocks sometimes shows banded structure with few cm to ten and more cm thick alternation of white felsic part and biotite concentration part, and sometimes formed clear augengneiss in the outcrop.

Microscopic observation is as follows :

They show porphyroclastic texture. Quartz, K-feldspar, microcline and plagioclase are the major component minerals and there are small quantity of muscobite, biotite, allanite, apatite, sphene, zircon and zoisite.

2-2 Great Dyke

The Great Dyke is a layered basic intrusion. The geology of the Great Dyke consists of gabbroic rocks which distributed widely in the center part of the survey area, shows black to deep green in color, massive, holocrystalline texture, multi layer of the pyroxenite with deep green to green color, coarse grain, holocrystalline texture, and peridotite(dunite, harzburgite) from upper to lower.

1. Gabbro

It is distributed widely from Botera range to Guyu range, north east of Guyu range and east bank of Musengezi river.

Gabbroic rocks are situated in upper most of the Great Dyke, increase the thickness in the axial zone.

The main rock facies shows generally dark green to black color, massive holocrystalline equigranular texture. Gabbroic rocks change to the facies from lower gabbro mainly consist of orthopyroxenite, clinopyroxenite and plagioclase to upper quartz diorite with quartz and amphibole , and amphibolite include large quantity of amphibole.

Microscopic observation is as follows :

Lowest portion of gabbro shows holocrystalline equigranular texture. Large to middle quantity of plagioclase, orthopyroxenite and clinopyroxenite are the major component minerals and there are small to extremely small quantity of magnetite, apatite, tremolite chromite. Extremely small quantity of sericite by alteration is also recognized partly.

Upper portion of gabbro shows gabbro to quartz diorite facies with holocrystalline equigranular texture. Large to middle quantity of plagioclase, amphibole, uralite are the major component minerals and there are small to extremely small quantity of quartz, biotite, apatite, magnetite, zoisite, zircon, calcite.

Upper most portion of gabbro shows quartz containing amphibolite facies. Large quantity of amphibole is the major component minerals and there are middle to small quantity of plagioclase, quartz, biotite, opaque minerals, and small to extremely small quantity of apatite, epidote magnetite, zircon.

Result of X-ray diffraction is as follows :

Gabbro mainly consists of orthopyroxenite, clinopyroxenite and there is small quantity of amphibole. Small quantity of talc is recognized in samples from lower portion of gabbro and large quantity of amphibole and quartz are recognized in samples from upper portion of gabbro.

2. Pyroxenite

It is distributed characteristically formed a range of the Botera range, Guyu range and east bank of Musengezi river.

Pyroxenite shows accumulated layer with serpentinite, formed so called cyclic units.

Pyroxenites mainly consist of olivine bronzitite, bronzitite, felspasic bronzitite and websterite From lower to upper(Allen H. Wilson and Marian Tredoux 1990).

The main rock facies are upper websterite which shows generally dark green to black color, medium to fine grain, holocrystalline equigranular texture, and lower orthopyroxenite(bronzitite) which shows generally dark green to green and olive green color, coarse grain, holocrystalline equigranular texture with clear pyroxene crystal in the field.

Microscopic observation is as follows :

Upper websterite shows holocrystalline equigranular texture. Large to middle quantity of orthopyroxenite and clinopyroxenite with 7 to 0.5mm of grain size are the major component minerals and there are small quantity of plagioclase and extremely small quantity of magnetite. Small quantity of uralite and extremely small quantity of sericite by alteration in marginal place of plagioclase are also recognized partly.

Lower orthopyroxenite shows holocrystalline equigranular texture. Large quantity of orthopyroxenite and small quantity of clinopyroxenite, plagioclase filled in a space of pyroxene crystals are the major component minerals and there is small to extremely small quantity of magnetite.

Result of X-ray diffraction is as follows :

Websterite mainly consists of about equal quantity of orthopyroxenite and clinopyroxenite and there is small quantity of amphibole. Orthopyroxenite mainly consists of orthopyroxenite and there are small quantity of amphibole, plagioclase, spinel partly. Extremely small quantity of chlorite, sericite, talk are recognized but there is almost no alteration.

3. Serpentinite

It is distributed along to the range and formed cyclic units with Pyroxenite.

Origin of serpentinite is the dunite and harzburgite(Bulletin 47), (E.P.O.654), (Allen H. Wilson and Marian Tredoux 1990).

The main rock facies shows generally pale yellow to pale brown and pale green color, fine grain. and containing chromite in many case. Fresh dunite and harzburgite are not recognized in this field. some times a range of serpentinite enriched silicate was formed by weathering.

Microscopic observation is as follows :

Small quantity of olivine with 5 to 1mm of grain sizes and serpentine replaced and filled in crack of olivine are the major component minerals and there are small quantity of chromite and small vein of calcite.

Result of X-ray diffraction is as follows :

This mainly consists almost of serpentine. Olivine as a origin remain in only few case. Quartz and pyrophyllite concentrate partly.

4. Chlorite-sericite rock

It is distributed characteristically along to the Fault zone.

This rock shows generally white to metallic silver color, strongly stripped, and soft and soapy.

5. Dyke

Dolerite dyke is recognized in only limited scale.

2-3 Geological structure

The Great Dyke in the survey area is curved like an "S" form due to the structural movements of the Pan-Africa Zambezi Mobile Belt. In addition, the area is cut by fault system striking of N-S and E-W direction to the western mountain block forming the Botera range, the central mountain block forming the Guyu range, and the eastern mountain block of the east bank of the Musengezi river.

The western block strikes N-S to NE-SW and dips to the E to SE direction whereas the central block strikes N-S and dips towards E in the dip in the northern portion and W in the southern portion. The eastern block shows a N-S to NE-SW strike and W to NW direction of dip.

2-1-4 Mineralization

PGM minerals are closely related to the sulphide minerals like the pyrite, pyrrhotite, chalcopyrite and pentlandite, etc., and accompanied with marginal zone of sulphide(E.P.O.654).

Survey of the mineralization zone of PGM was carried out using sulphide mineralization as an indicator.

The sulphide mineralization which can observe with naked eye continuously occur in the upper portion of the P1 layer in the WS area. Small scale of mineralization was recognized in the northeastern portion of the WN area and northern portion of CB area.

Microscopic observation is as follows :

Sulphide mineralization zone in this area generally consist of pyrrhotite, pentlandite and chalcopyrite. these show euhedral to subhedral, coexist with sandwich form. Pyrite also coexist with pyrrhotite, pentlandite and chalcopyrite. There are small quantity of marcasite, magnetite and chromite as accessory minerals. Small to extremely small quantity of violarite, millerite, bornite, covelline and goethite replaced in crack or marginal place of the pyrrhotite, pentlandite and chalcopyrite are also recognized as secondary minerals.

Chapter 3 Geochemical Survey

3-1 Purpose and method of Rock Geochemical Survey

The Great Dyke accompanied with characteristic metal ore deposits, well known as the prominent producing area of PGM, cobalt, nickel and chrome in the world.

From the economical point of view, the metal resources which can be profitably worked are the PGM, cobalt, nickel and copper in the Snake Head area.

The purpose of this survey is to confirm the concentration of these metals using the method of the rock geochemical survey.

3-2 Selection of Areas for Soil Geochemical Survey

The areas of potentialities of PGM ore deposit occurrences are considered to be the distribution area of the P1 layer.

The rock sampling areas were determined based on the results of the existing data analysis and geological survey.

The selected 5 areas based on the above criteria are listed as follows:

The locations where geochemical surveys were conducted are shown in Fig.II-3-1.

① Eastern site : (EN area) (ES area)
② Central site : (CB area)
③ Western site : (WN area) (WN area)

3-3 Sampling

Survey lines were established crossing the P1 layer. The samples were collected in the interval of every 50 meter on the survey line. The locations were positioned with the pocket compass, measuring rope and GPS. When the samples were collected, the rock facies, the tone of colour, and the mineralization were described to understand the adjacent geology.

Summary of the rock sampling is shown in TableII-3-1.

3-4 Indicator Elements

The numbers of the analyzed elements are 8. They are Au, Ag, Cu, Co, Ni, Pt, Pd and Rh. The analyzing methods and detectable limits for all the chemical elements are shown in Table II-3-2.

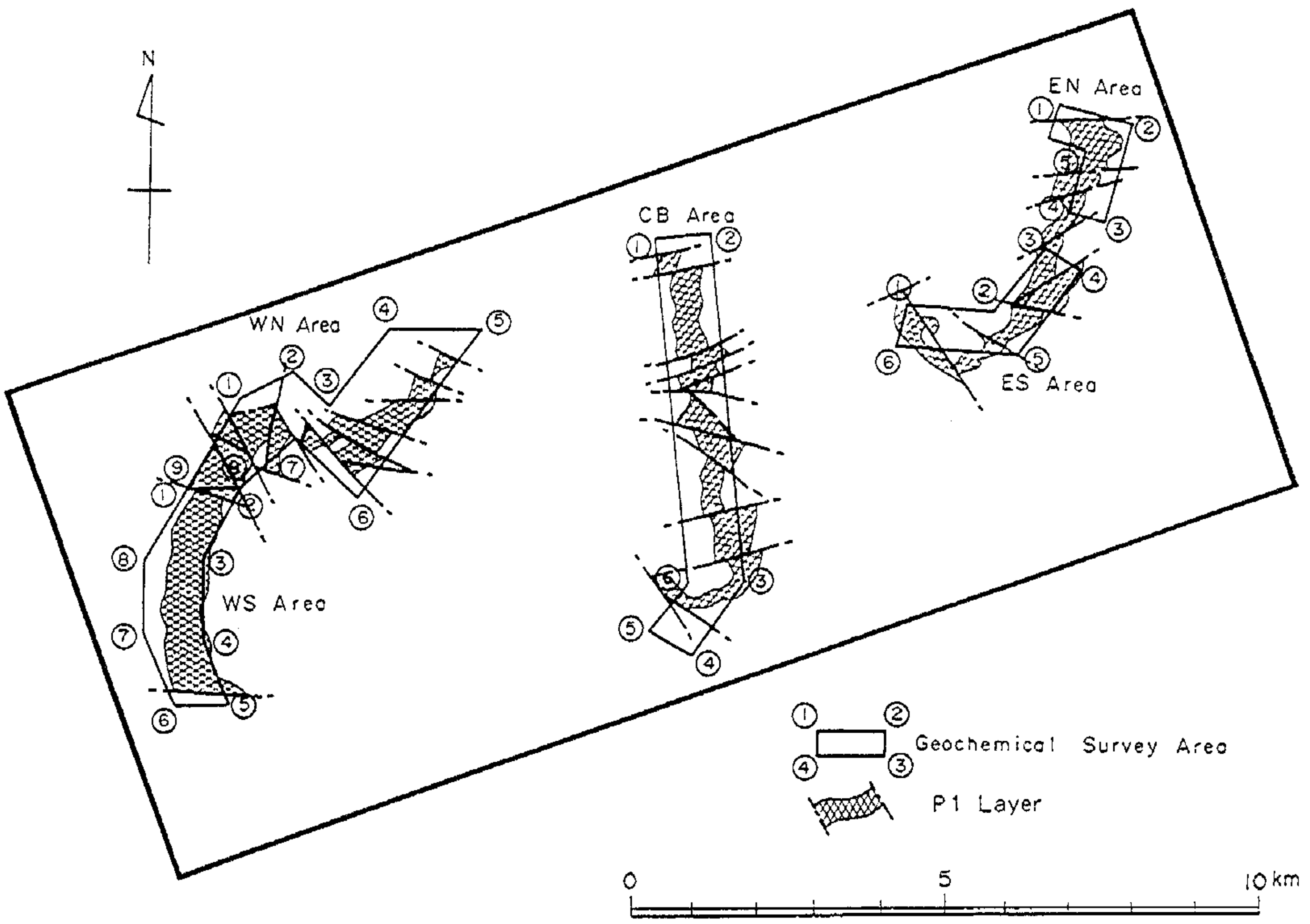


Fig.II-3-1 Locality of the geochemical survey area

Table II-3-1 Outline of the geochemical survey

Area Name	Square (km^2)	No.of lines	No.of samples
EN Area	1.5	6	78
ES Area	3.75	9	114
CB Area	7.0	20	340
WN Area	6.2	23	473
WS Area	3.8	17	361
Total	22.25	75	1,366

Table II-3-2 Analytical methods and detectable limits of the chemical analysis

Element	Analytical method 1)	Detectable limit
Au	AAS (Flameless)	1 ppb
Ag	AAS	0.01 ppm
Cu	AAS	1 ppm
Co	AAS	1 ppm
Ni	AAS	1 ppm
Pt	AAS (Flameless)	10 ppb
Pd	AAS (Flameless)	10 ppb
Rh	AAS (Flameless)	10 ppb

1) AAS: Atomic Absorption Spectrochemical method

3-5 Statistical Processing of the Analyzed Values

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

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

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

Analyzed values less than the detectable limit were treated as the half of the detectable limit shown Table II-2-7. Though 5 areas were studied, the statistical processing was carried out in one lump for all the areas.

The statistical processing was carried out except for the gabbroic rocks, because of these rocks show almost all under the detectable limit of PGM.

3-6 Evaluation of the Rock Geochemical Anomalies

1. Characteristics of univariate analysis

The geometrical mean values, logarithmic standard deviation, and other basic statistical values are shown in Table II-3-3.

Table II-3-3 Statistical parameter of rock geochemistry

	Au (ppb)	Ag (ppm)	Cu (ppm)	Co (ppm)	Ni (ppm)	Pt (ppb)	Pd (ppb)	Rh (ppb)	PGM (ppb)
No of samples	1,029	1,029	1,029	1,029	1,029	1,029	1,029	1,029	1,029
Geometric average	0.67	0.05	31.17	84.94	728.4	6.82	13.00	5.25	30.32
Minimum	0.50	0.01	2.00	0.50	11.00	5.00	5.00	5.00	15.00
Maximum	3,720	0.81	947	441	21,300	965	529	55	1,044
Standard deviation logarithm	0.38	0.55	0.64	0.18	0.28	0.37	0.56	0.12	0.43

The characteristics of the statistical values and frequency distributions of the univariate analysis for all over the area are as follows :

Gold: The geometrical mean value and the maximum value are 0.69 ppb and 3,720 ppb, respectively. The 83.9 % of the population are less than the detectable limit. The 16 % of the population are above the detectable limit. The relative frequency distribution of the Au shows that there are 2 populations whose maximum frequencies occurred at 5.62 ppb, and other populations whose frequencies are less than the detectable limit.

Silver: The geometrical mean value and the maximum value are 0.05 ppm and 9.81 ppm, respectively. The 12.2 % of the population are less than or the detectable limit. The relative frequency distribution of the Ag shows that there are 3 populations whose maximum frequencies occurred at 0.05 ppm shown large group, whose maximum frequencies occurred at 0.50 ppm shown small group of high grade, and other populations whose frequencies are less than the detectable limit.

Copper: The geometrical mean value and the maximum value are 31.2 ppm and 947 ppm, respectively. There is no population less than the detectable limit. The relative frequency distribution of the Cu shows that there are 2 populations whose maximum frequencies occurred at 7.9 ppm, and 200ppm, respectively.

Cobalt: The geometrical mean value and the maximum value are 84.9 ppm and 441 ppm, respectively. Only 2 samples are less than the detectable limit. The relative frequency distribution of the Co shows 1 population whose maximum frequencies occurred at 70.8 ppm, and with small fluctuation.

Nickel: The geometrical mean value, the maximum value, and the minimum value are 728 ppm, 21,300 ppm and 11 ppm, respectively. There is no value less than the detectable limit. The frequency distribution shows that there are a large population with the maximum frequency near 794 ppm and a small population with the peak frequency near 79 ppm.

Platinum: The geometrical mean value and the maximum value are 6.82 ppb and 965 ppb, respectively. The 84.9 % of the population are less than the detectable limit. The frequency distribution shows that there are large but low grade population less than the detectable limit and 2 high grade small population with the peak frequency near 20 ppb and 316ppb.

Palladium: The geometrical mean value and the maximum value are 13 ppb and 529 ppb, respectively. The 58.5 % of the population are less than the detectable limit. The frequency distribution shows that there are large but low grade population less than the detectable limit and 2 high grade small population with the peak frequency near 20 ppb and 79ppb.

Rhodium: The geometrical mean value and the maximum value are 5.3 ppb and 55 ppb, respectively. The 95.8 % of the population are less than the detectable limit. The frequency distribution shows that there are large but low grade population less than the detectable limit and 2 high grade small population with the peak frequency near 20 ppb and 28ppb. Only 43 samples are above the detectable limit. The characteristics of the whole populations are not clear.

PGM: The geometrical mean value and the maximum value are 30.32 ppb and 1,044 ppb, respectively. The 55.1 % of the population are less than the detectable limit. The frequency distribution shows that there are large but low grade population less than the detectable limit and 2 high grade small population with the peak frequency near 50 ppb and 126ppb.

Generally, Gold and silver show low grade except for one sample(Au 3,720ppb). copper has two different population and suggest to the existence of the mineralization. cobalt and nickel show one population with comparatively small fluctuation. PGM divided to large and low grade population less than the detectable limit and high grade small population.

2. Characteristics of the results of bivariate analysis

Characteristics of correlation coefficients each other elements are as follows.

(1) The combinations whose correlation coefficients are more than 0.3 are cobalt-nickel group and PGM group.

(2) The correlation coefficients of gold and copper, gold and platinum are 0.33, 0.49 respectively.

(3) The correlation coefficients between silver, copper group and cobalt, nickel, paradium group are negative.

(4) Silver has no correlation coefficient with other elements.

(5) PGM has correlation coefficient with gold, but has no correlation coefficient with other elements.

3. Characteristics of each area

(1) EN, ES area

Gold: Comparatively high concentration is recognized on the northern end and southern part of the area, however, the distribution is spotted. Concentration zone correspond to upper potion of the P1 layer.

Silver: It is widely distributed with low grade, and does not show the characteristic distribution.

Copper: High copper zone concentrate in northern part of the EN and ES area, and distribute from upper potion of the P1 layer to gabbroic rocks.

Cobalt: High concentration zone above the 1 σ does not occur, low grade zone widely distribute. Concentration zone correspond from lower potion of the P1 layer to lower serpentinite.

Nickel: Distribution form is similar to cobalt, high concentration zone clearly correspond to lower potion of the P1 layer.

Platinum: Comparatively high concentration is recognized on the northern and southern end of the area, however, the distribution is spotted.There is no continuous distribution.

Palladium: Comparatively high concentration is recognized on the east and west end part of the area, however, the distribution is spotted. Continuous distribution can not recognize, high concentrated points are not overlapped to platinum, and correspond to lower potion of the P1 layer.

Rhodium: Analytical values are all less than the detectable limit.

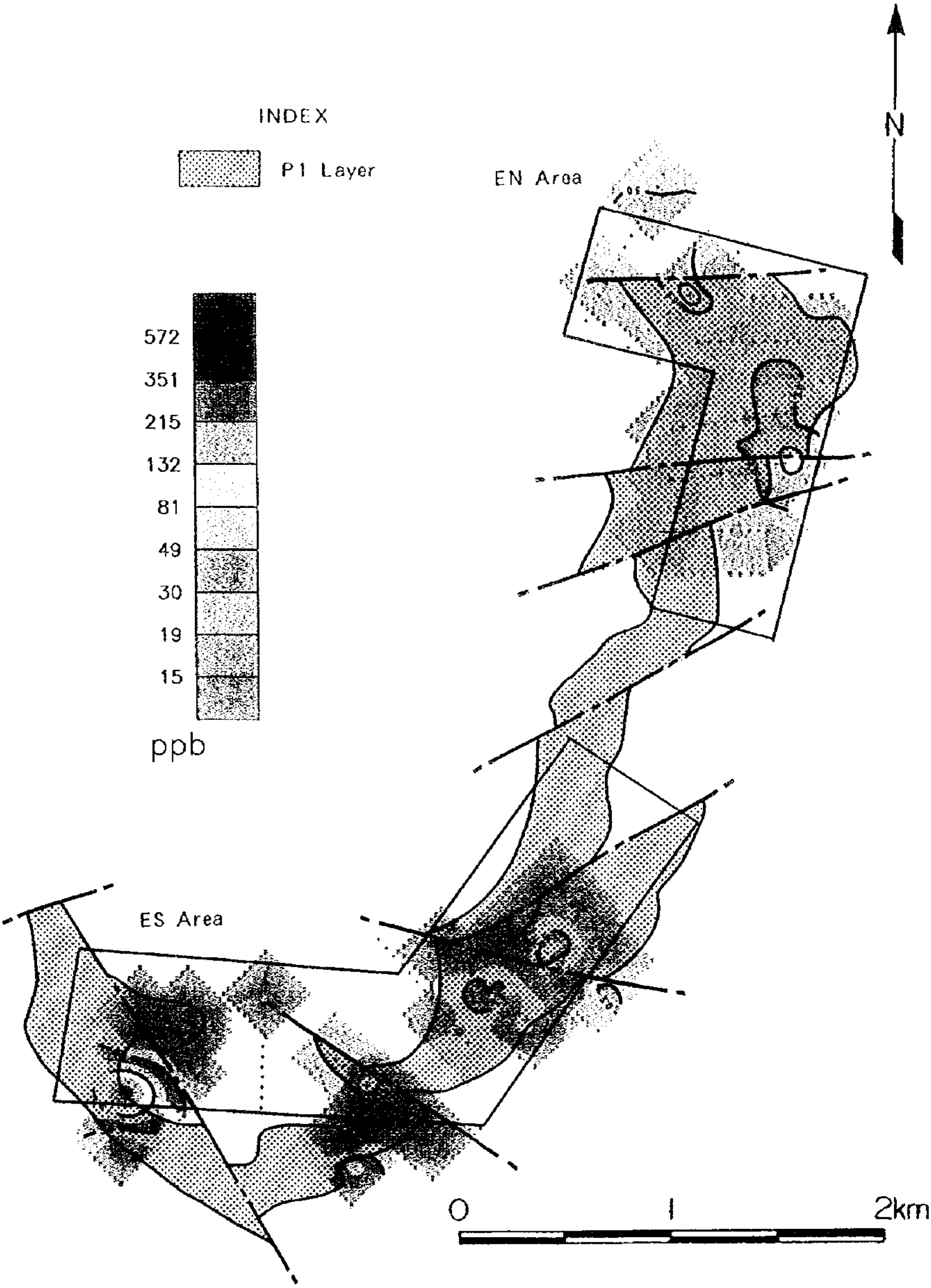
PGM: Summary of the geochemical survey (EN, ES area) is shown in Fig.II-3-2, the distribution is spotted.There is no continuous distribution.

(2) CB area

Gold: Comparatively high concentration is continuously recognized on the northern part of the area, the distribution become spotted on the southern part of the area. Concentration zone correspond to middle to lower potion of the P1 layer.

Silver: It widely distribute with low grade, there is no corresponding with geological situation.

Copper: Wide and continuous high copper zone is recognized in north



Distribution of PGM content

Fig.II-3-2 Summary of the geochemical survey (EN,ESarea)

east part and south west part of the area, and distribute from upper potion of the P1 layer to gabbroic rocks.

Cobalt: Comparatively high concentration is continuously recognized from the central to northern. Concentration zone correspond to lower potion of the P1 layer.

Nickel: Distribution form is similar to cobalt, high concentration zone clearly correspond to lower potion of the P1 layer.

Platinum: Comparatively high concentration is continuously recognized on the northern part and south east end part, the high concentration zone above the 2 σ occur on the northern part of the area and correspond to upper potion of the P1 layer.

Palladium: Comparatively high concentration is continuously recognized on the northern part, the high concentration zone above the 1 $\sigma \sim 2 \sigma$ occur in anomalous zone, Pd distribution in this area is almost overlapped with Pt.

Rhodium: Rh distribution in this area is almost overlapped with Pt, Pd.

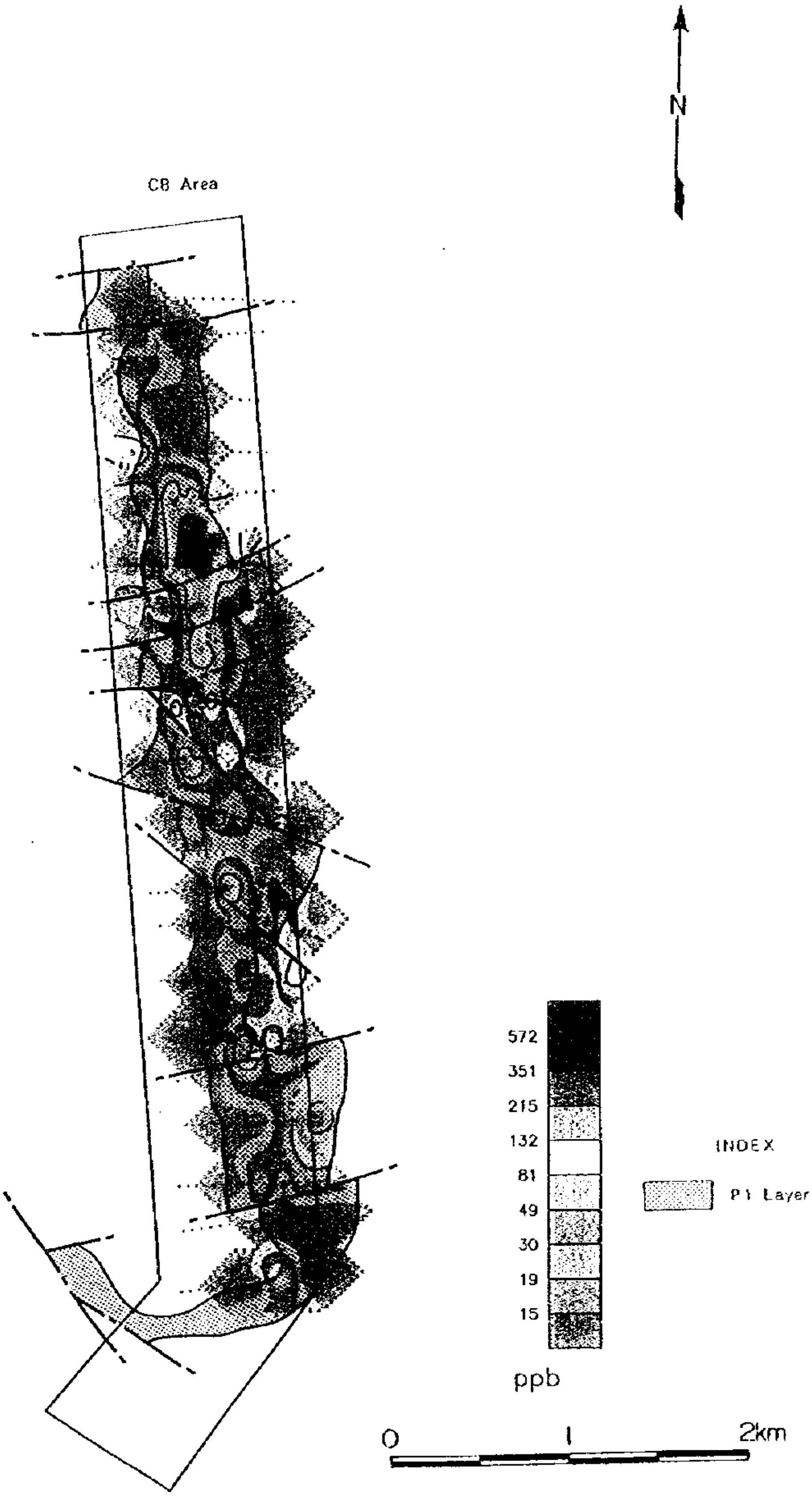
PGM: Summary of the geochemical survey (CB area) is shown in Fig.II-3-3. Comparatively high concentration is continuously recognized on the northern part of the area, the high concentration zone above the 1 $\sigma \sim 2 \sigma$ occur.

(3) WN, WS area

Gold: Comparatively high concentration is spotted, and Continuous distribution does not be recognized in the WN area. Narrow high concentrated distribution occur in the middle potion of the P1 layer with north to south direction in the WS area.

Silver: It widely distribute with low grade, there is no corresponding with geological situation.

Copper: Wide and continuous high copper zone recognized in southeastern part of the WN area and eastern half of the WS area, and distribute from upper potion of the P1 layer to gabbroic rocks.



Distribution of PGM content

Fig.II-3-3 Summary of the geochemical survey (CBarea)

This copper high concentrated zone correspond to the distribution of the sulphide dissemination in the field.

Cobalt: Comparatively high concentration is continuously recognized through the WN and WS area. Concentration zone correspond to lower potion of the P1 layer. The high concentration zone above the 1 σ occur in the lower serpentinite.

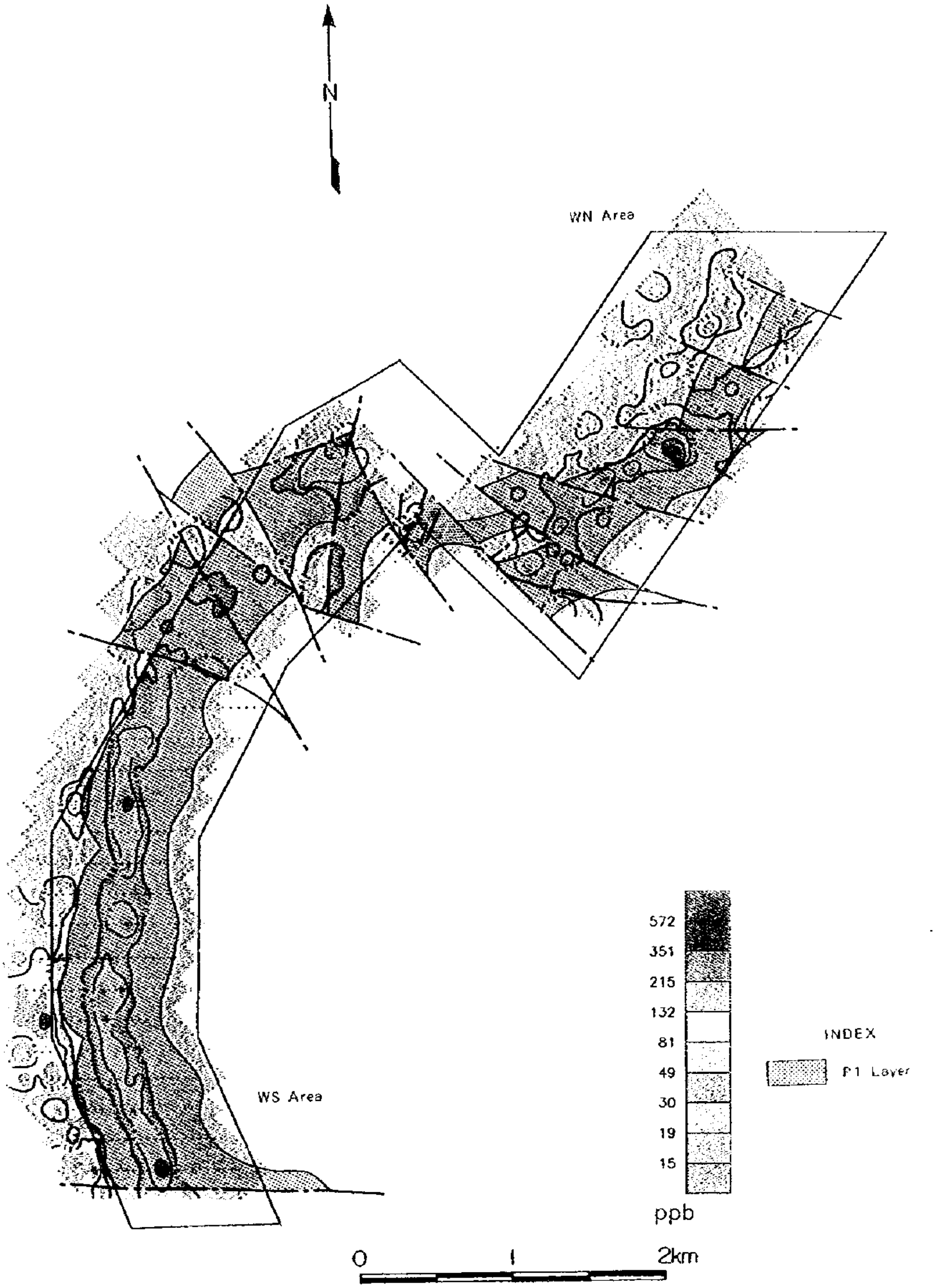
Nickel: Comparatively high concentration is continuously recognized in northeastern part of the WN area and western half of the WS area, The high concentration zone above the 1 σ has a tendency to occur in the lower serpentinite.

Platinum: Comparatively high concentration is continuously recognized in central zone of the WN, WS areas, the high concentration zone above the 1 σ ~2 σ is accompanied and correspond to middle potion of the P1 layer. High concentration is also recognized on the west part of the WN area but the zone is not continuous cutting by fault. the high concentration zone partly occur in the lower serpentinite.

Palladium: Comparatively high concentration is continuously recognized in the center part of the WN, WS area, the high concentration zone above the 1 σ ~2 σ is accompanied and correspond to middle potion of the P1 layer. High concentration of the west part of the WN area is not continuous cutting by fault. the high concentration zone above the 1 σ partly occur in the lower serpentinite. The distribution is almost overlapped to Platinum.

Rhodium: Rh distribution in this area is almost overlapped with Pt, Pd but clear tendency is not recognized.

PGM: Summary of the geochemical survey (WN, WS area) is shown in Fig.II-3-4. Comparatively high concentration is continuously recognized in the center part of the WN, WS area, the high concentration zone above the 1 σ ~2 σ is accompanied, correspond to middle potion of the P1 layer. High concentration is also recognized on the west end of the WN area but the zone is not continuous cutting by fault. the high concentration zone partly occur in the lower serpentinite.



Distribution of PGM content

Fig.II-3-4 Summary of the geochemical survey (WN,WSarea)

4. Summary

(1) Metal concentration and geological position

Gold, platinum, and palladium show a narrow continuous distribution, confined to the middle portion of the P1 layer.

Silver and rhodium show low grade and wide a distribution, not corresponding to geology. Silver has no correlation with other elements, suggesting that it has a different condition of concentration compared to these elements. Distribution of the population of Rhodium is difficult because samples shown above the detectable limit are very few.

Copper is divided into 2 clear deferent populations, continuously concentrated in upper portion of P1 layer. Sulphide dissemination which correspond to high copper concentrated zone is recognized in the field, therefore, copper concentrated zone suggest to existence of mineralization.

Cobalt and nickel show a clear and continuous zone high concentration in the lower portion of P1 layer and lower serpentinite layer. The distribution of cobalt and nickel seem to reflect the geology.

(2) Comparison of each geochemical survey area

As regard gold and PGM elements, the area expected to high concentration of metals is the WS area, followed by the northeastern portion of the WN area and northern portion of CB area. though the southwestern portion of the WN area is divided into small area by faulting, local metal concentration are recognized. Southern portion of the CB area shows weak metal concentrations, distribution of concentrations become patchy. EN and ES areas show no concentration.