REPUBLIC OF [illegible]

REPORT ON THE COOPERATIVE MINERAL EXPLORATION OF [illegible] AREA

SUMMARY

FEBRUARY [illegible]

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY

REPUBLIC OF ZIMBABWE

REPORT ON THE COOPERATIVE MINERAL EXPLORATION OF SHAMVA AREA

SUMMARY

FEBRUARY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

PREFACE

At the request of the Government of the Republic of Zimbabwe, the Japanese Government planned a mineral exploration programme consisting of several survey methods to examine the possibility of the existence of mineral deposits in the Shamva District located in the northeastern part of the country. The Japanese Government entrusted the execution of the general plan to the Japan International Cooperation Agency (JICA), and in turn JICA entrusted the execution of this survey to the Metal Mining Agency of Japan (MMAJ), since this survey was a professional survey programme of mineral exploration.

The surveys were conducted during the period from 1983 to 1985 for three years, and completed as scheduled with the cooperation of the Zimbabwe Government, particularly the Geological Survey Department of the Ministry of Mines.

This report describes the summary of the results of the all programmes of the Shamva Project.

Lastly, we would like to express our heartful gratitude to the members of concerned of the Zimbabwe Government, the Ministry of Foreign Affairs of Japan, the Ministry of International Trade and Industry of Japan, Japanese Embassy in Zimbabwe, and all of whom extended their kind cooperation to us in executing the above mentioned survey.

February, 1986

Keisuke ARITA
President,
Japan International Cooperation Agency

Masayuki NISHIIE
President,
Metal Mining Agency of Japan

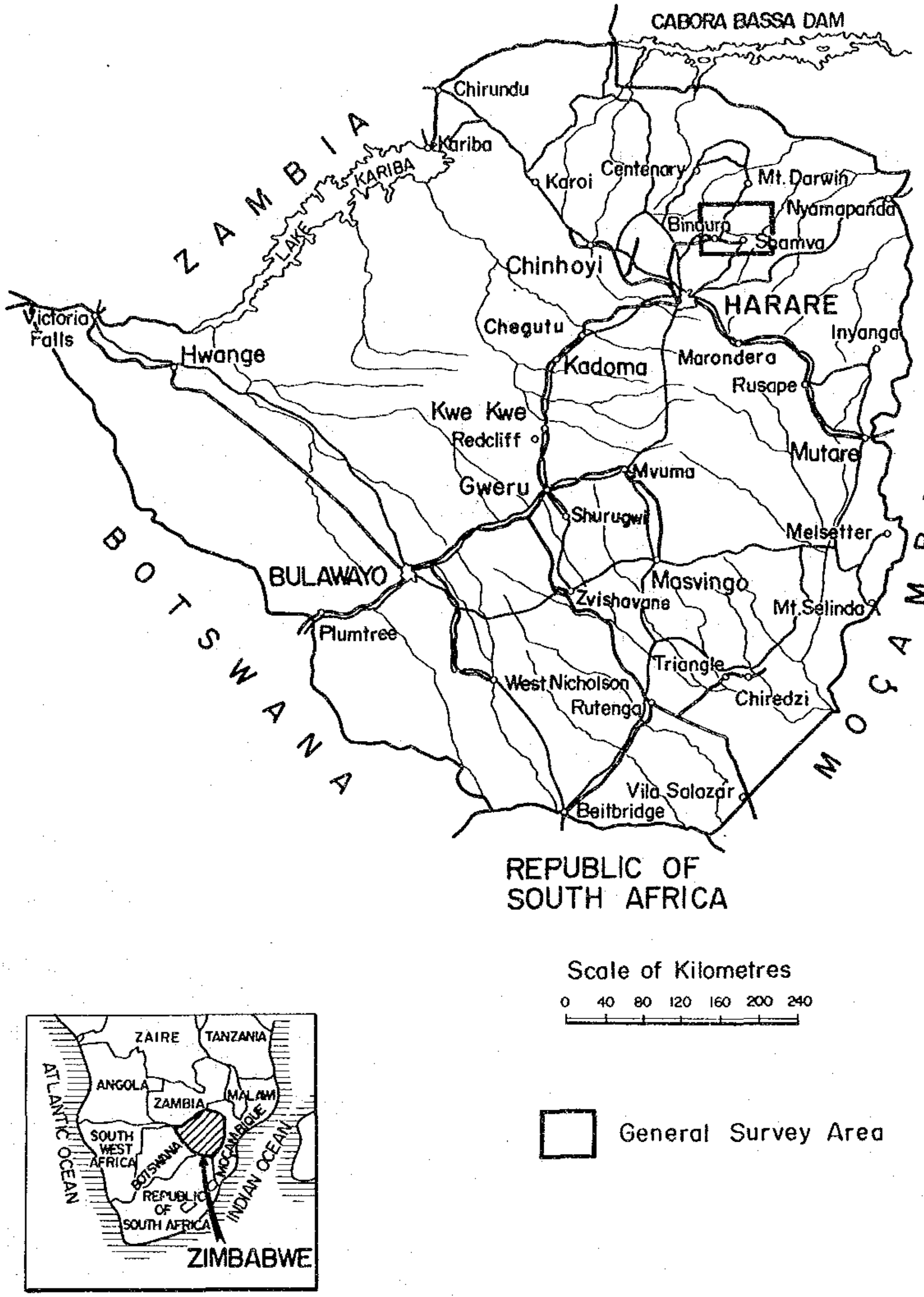
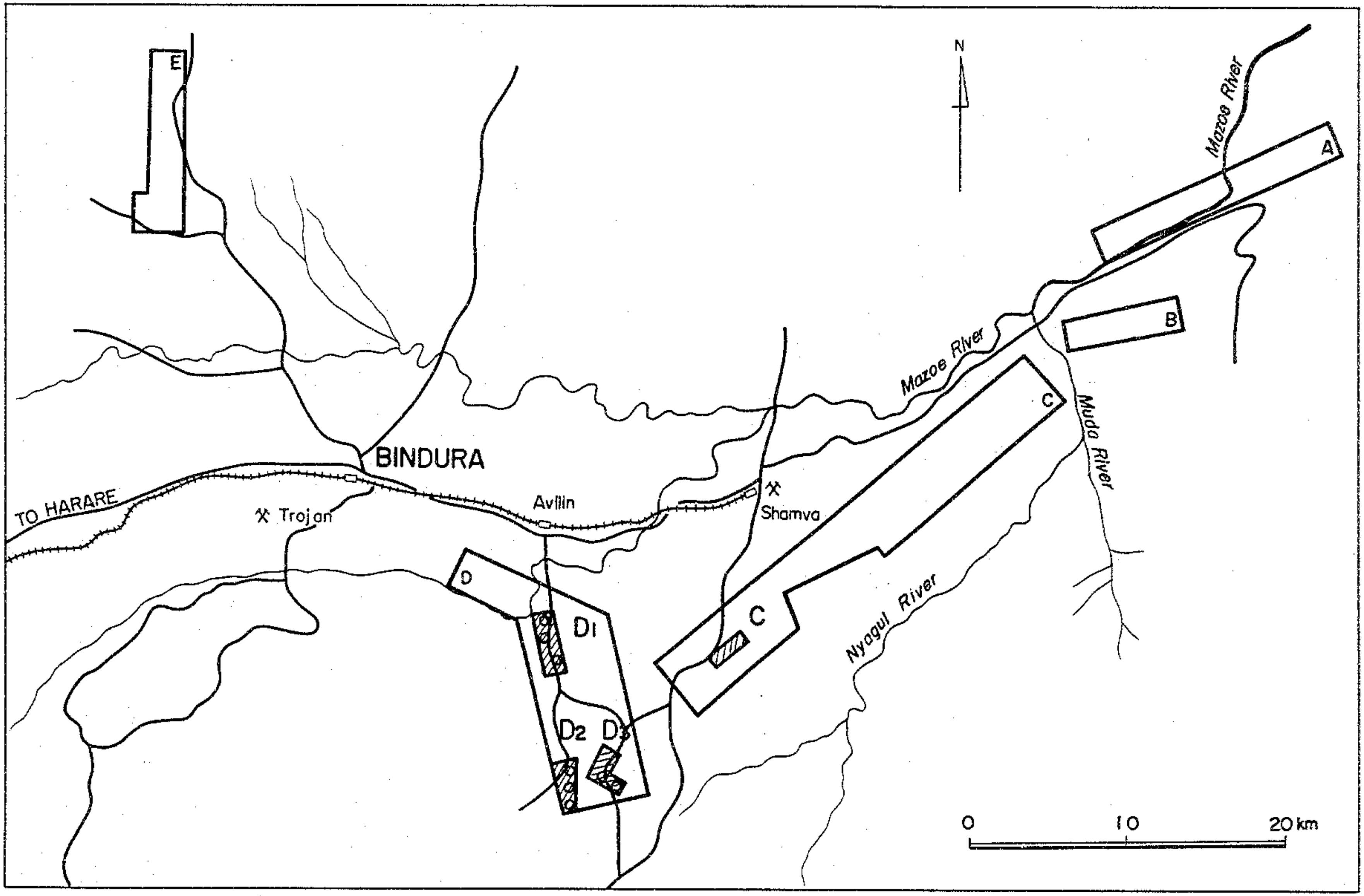


Fig. 1 Location Map of Schamva Area



Phase I (1983) Survey Area (Geological and Geochemical Surveys) ∘ Phase III (1985) Drilling

Phase II (1984) Survey Area (Geophysical Survey)

Fig. 2 Location Map of Survey Areas

CONTENT

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

ABSTRACT

The Shamva project in Zimbabwe started in 1983 to examine the potential for economic ore deposits.

In the first year's programme (1983), geological and geophysical surveys were conducted to clarify the distribution of the existing mineral occurrences and their geological settings, to select promising areas for further exploration activities, and to find better exploration methods for those areas.

In the second year's programme (1984), geophysical surveys (CSAMT and SIP) were conducted to find out drilling targets in the selected areas based on the results of the previous year's work.

In the third year's programme (1985), a drilling survey was implemented to examine mineral potential in the target anomalies detected by the various previous surveys.

The results of the survey programmes in the five areas are as follows.

1. Areas A, B, and E have low potential for economic ore deposits judging from the geological and geochemical results.
2. Area C has slightly higher potential for economic ore deposits than the above because of better geological, geochemical and geophysical responses.
3. Area D has the highest potential, and gave the most favourable geological, geochemical and geophysical indications. Core from the drilling programme based on this promising information showed some pyrrhotite in four of the eight holes drilled. Holes MJZ-3 and MJZ-7 are especially significant.

Therefore, it is concluded that the areas surrounding these holes are the most attractive ones for further exploration activities.

PART I.

GENERAL DESCRIPTION

CHAPTER 1 OUTLINE OF THE SURVEYS

1-1 Purpose of the Survey

The Republic of Zimbabwe is a land-locked country in the south of the Continent of Africa. After having experienced various historical changes, the young Republic of Zimbabwe was born on April 18, 1980.

Zimbabwe has maintained a comparatively stable economy next to that of the Republic of South Africa, attaining an annual economic growth rate of 4 to 5 percent. Zimbabwe's key industries are agriculture, mining and manufacturing and production rates of these industries in GDP in 1982 are 17.8%, 5.2% and 26.5% respectively. On the other hand, the foreign currency income generated by these industries in 1982 is 33%, 45% and 18.5% respectively, showing that this country is highly dependent upon primary industrial products.

Most of the land of Zimbabwe has geological conditions consisting of the so-called craton of the Precambrian era. The country is blessed with abundant mineral resources and produces more than 40 kinds of mineral products. Particularly, gold, chromium, asbestos, nickel, copper and coal are the six major mineral products of this country. In addition, lithium, beryllium, tungsten, corundum, platinum, silver, iron, graphite and phosphate rock are also important mineral products. The share of the mining section in total GDP was 5.2% in 1982, ranking third after manufacturing and agriculture. Most of the mineral products are expoted and produced 45% of the foreign currency in 1982. With the importance of the technical cooperation from Japan for a survey and development of mineral resources in Zimbabwe, when prime minister Mugabe visited Japan in April, 1981, he requested positive technical cooperation to Japan.

The Metal Mining Agency of Japan dispatched a representative staff from Nairobi to Zimbabwe in July, 1981 to explain System of the Cooperative Mineral Exploration to the Zimbabwe Ministry of Mines. The ministry showed deep interest in the system and sent a request in April, 1982 to carry out cooperative mineral exploration project in five districts, Shamva, Harare, Chakari and Gatoma West, Bulawayo, and Macdougall. When Vice-Minister of Mines of Zimbabwe, Mr. C. Ushewokunze visited Japan in May, 1982, he again requested the need for this survey.

The Japanese Government received this request, and dispatched a project investigation mission. Based on the results of this survey, the Shamva district was selected, and in addition, five geologically promising areas in this district were selected. On April 29, 1983, a field survey agreement was concluded between the Japan International Cooperation Agency and Metal Mining Agency of Japan, and the Geological Survey Department of the Ministry of Mines of the Republic of Zimbabwe on implementing a cooperative mineral exploration.

The purpose of this project was to evaluate the geological setting and potential for mineral resources in the Shamva area.

The principal purpose of the first year programme (1983) was to select promising areas for further exploration programmes by mean of clarification of the distribution of ultramafic rocks which may host Trojan type nickel sulphide ores, and mineral occurrences of nickel sulphides, rare metals associating with pegmatites, gold, etc.

The principal purpose of the second year programme was to examine the possibility of the existing of mineralized zones in selected areas by mean of finding geophysical anomalies.

The principal purpose of the third year programme was to examine the possibility of the existing of mineralized zones in selected drilling targets.

1-2 Outline of Surveys

1-2-1 First Year Survey (1983)

The geological survey was planned to be carried out over an area of 250 km^2, but the area was reduced to 242 km^2 because of the existence of a dangerous shooting zone, the Police training ground. The geological survey was carried out on the same routes as those used for geochemical survey, and 1:25,000 scale route maps and geological maps were made.

During geochemical survey which was also carried out over the same 242 km^2 area, soil samples were collected in places at a line spacing of 300 m and a sampling interval of 200 m. However, in areas which seemed to be covered by ultramafic rocks or mineralized zones, soil samples were collected at a sampling interval of 50 m. Because of the nature of geochemical exploration, soil samples were not collected from Quaternary sediments or from farmland.

The number of soil samples analyzed was 4,501. The places where the samples were collected are shown on PL I-1-1 - 2 in the Vol. 1 report.

The Period of the survey from the time the party left Japan to the time it returned was 78 days. The number of working days required for the geological and geochemical surveys in Zimbabwe was 68 days, ranging from July 14 to September 19, 1983. In carrying out the surveys, various data obtained in the country, which had been prepared in the past, were fully utilized both for field works and the interpretation of the survey results.

During the surveys, the samples shown in the following table were collected for geochemical assay.

Table I-1-2-1 Statistics of Soil Sampling

Area	Number of Samples	Analysed Element
A	690	Au, Cu, Zn, Ni, Cr, Nb
B	263	Au, Cu, Zn, Ni, Cr, Nb
C	1,562	Au, Cu, Zn, Ni, Cr, Nb
	of which (124)	Additional Elements Co, Sn, As, Li, W, Pt, Be, Ce, S, Ta
D	1,498	Au, Cu, Zn, Ni, Cr, Nb
	of which (276)	Additional Elements Co, Sn, As, Li, W, Pt, Be, Ce, S, Ta
E	488	Au, Cu, Zn, Ni, Cr, Nb
Total	4,501	

1-2-2 Second Year Survey (1984)

The survey programme was conducted from July 6 to November 19, 1984.

As an initial program, a CSAMT survey was conducted to detect low resistivity zones favourable for hosting some conductive sulphide minerals. During the next stage, a SIP Survey was conducted to follow up the low resistivity zones by finding IP anomalies.

Three hundred and six points were measured in the CSAMT survey, and, in the SIP survey, 10km survey lines with 300 survey points were measured.

Laboratory SIP test work was conducted in Japan after the completion of the field work on 22 typical rock specimens taken from the survey area.

The survey work was done by the team with the cooperation of the Geological Survey Department of the Ministry of Mines of Zimbabwe which dispatched a geophysicist and geophysical technician to the team.

Table I-1-2-2 Geophysical Survey Plan

(Field Work)

Method	Area	Plan
CSAMT	Area C	Area : 2.7 km^2 Survey Point : 44
	Area D	Area : 18.3 km^2 Survey Point : 260
SIP	Area D	Survey Line Length : 10.0 km Survey Point : 300

(Laboratory Work)

Item	No. of Samples
Laboratory SIP Sample Test	20

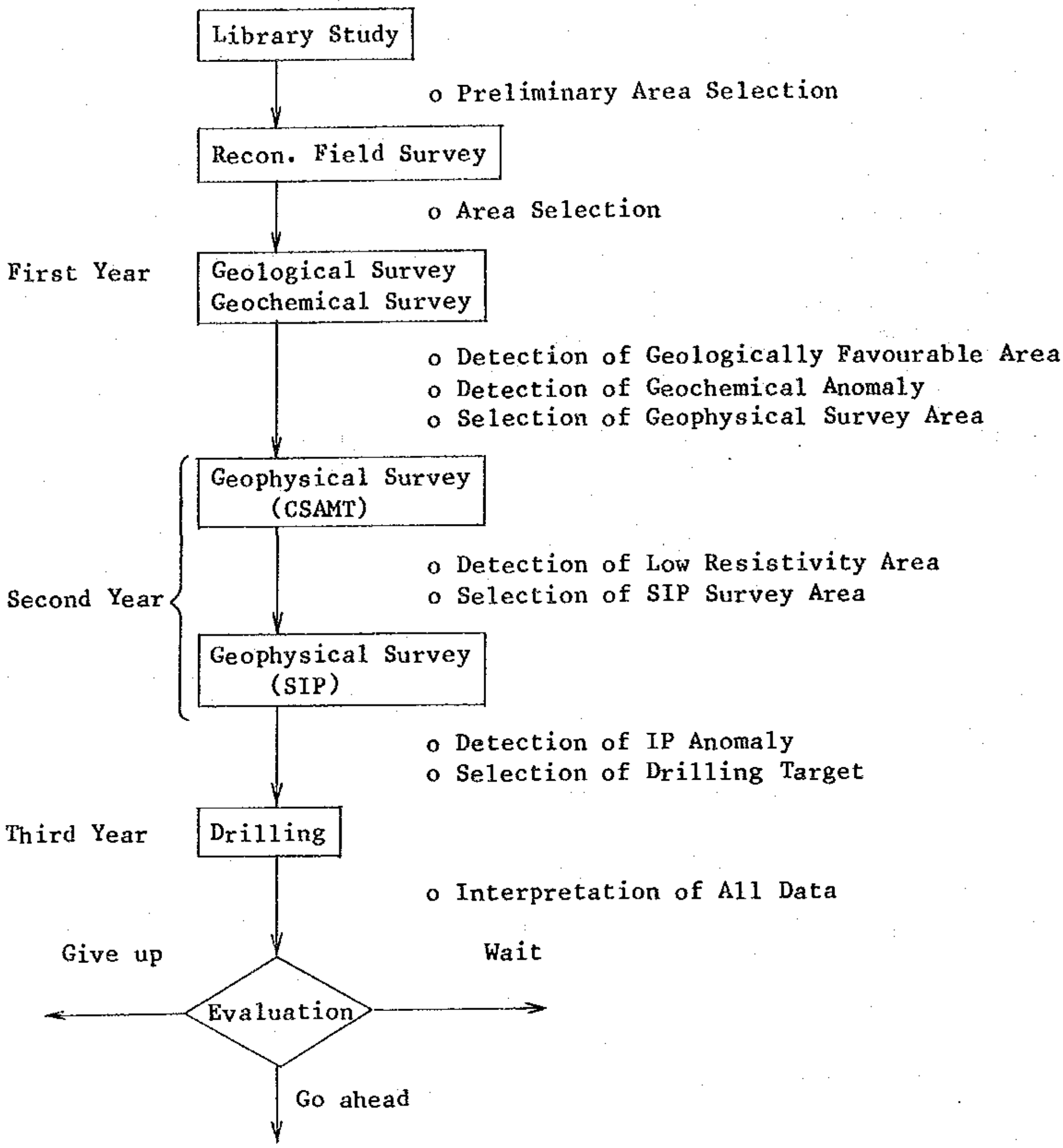
1-2-3 Third Year Survey (1985)

The survey programme was conducted from June 21, to November 8, 1985 during the period of 139 days. The drilling work was contracted by R.A. Longstaff (Pvt) Ltd., based in Harare, and core logging, assay sample preparation, correlation of geology between the surface and the bore holes were done by the survey team.

The drilling programme consisted of eight drilling holes, total length of 1, 650 meters. Numbers of assay samples were 80 for Cu, Ni and Co, 20 for Nb, Ta and Sn, 50 for Au, and 101 rock samples for geochemical assay for Ni, Co, Mn, Mg, Fe and S.

The survey programme was completed by the team with the cooperation of the staff of the Geological Survey Department of Zimbabwe, as the counterpart.

Table I-1-2-3 Flow Chart of the Project



1-3 Organization of the Survey Teams

The members who were involved in the planning, managing, and field surveys were as follows.

(1) Planning and Managing

Japanese Members

Metal Mining Agency of Japan

1983	1984	1985
Makoto ISHIDA	Makoto ISHIDA	Makoto ISHIDA
Ken NAKAYAMA	Ken NAKAYAMA	Toshio SAKASEGAWA
Takahisa YAMAMOTO	Takahisa YAMAMOTO	Takahisa YAMAMOTO
Yosuke SUZUKI	Yosuke SUZUKI	Yoshiyuki KITA
		Yosuke SUZUKI

Japan International Cooperation Agency

Tadaaki EZAWA

Ministry of International Trade and Industry

Shinichi MIZUSAWA

Zimbabwean Members

Geological Survey Department

1983	1984	1985
E.R. MORRISON	E.R. MORRISON	E.R. MORRISON
D.E.H. MURANGARI	D.E.H. MURANGARI	D.E.H. MURANGARI
C.B. ANDERSON	C.B. ANDERSON	C.B. ANDERSON

(2) Field Survey Teams

Japanese Members

Dowa Koei Co., Ltd.

1983	1984	1985
Hirojiro KURONUMA	Akiyoshi KOMURA	Akiyoshi KOMURA
Akiyoshi KOMURA	Yasuo ENDO	
Kazuyoshi MASUBUCHI	Toshiie TSUBAKITA	

Zimbabwean Members

Geological Survey Department

1983	1984	1985
Owen NYAMANA	Peter ZHOU	
	Mabasa HAWADI	

CHAPTER 2 GENERAL CIRCUMSTANCES OF THE SURVEY AREA

2-1 Location and Transportation

The survey area is located 14km to 25km southeast of Bindura which is 70km northeast of the capital city, Harare. It takes about one hour to travel 87km from Harare to Bindura by car on a good highway. A good road network is available from Bindura to the survey area, although some parts are dirt roads. From Bindura, it takes about one and half hours to the eastern end Area B and 20 minutes to the nearest Area D.

2-2 Topography and Climate

The survey area is located in the Southern African Plateau at an altitude of 1,000m to 1,200m above sea level. Topography well reflects the geology. Andesitic to basaltic lavas, serpentines, and banded ironstones are found in the area which features significant elongated narrow mountain ranges rising 200m to 300m from the background areas. the surrounding, flat, areas are suitable for farming. In the mountain ranges, scarce shrubs grow. Granite-gneiss complexes are found associated with rounded hills in significant contrast to the former region where the survey area is mainly located.

The climate of the survey area is not tropical because of the high altidude, despite the latitude of 17° south. Seasons are clearly divided into two, dry from April to October and wet from November to March. Precipitation per year is usually 700mm to 900mm. This year's survey work was done in the dry season, when the temperature was 25°C to 30°C in the day time, and below 10°C at night. October is the hottest month of the year, and the temperature never fell below 30°C day and night for several days. In November, the climate changed very suddenly. It rained almost every afternoon, and the temperature fell to about 18°C in the day time. 1984 was expected to have normal rainfall.

2-3 General Social Circumstances

Five years have passed since independence in 1980. The society has been changing toward socialization, and the departure of white people is continuing (at present only 70,000 still remain in the country). The international trade balance is becoming serious as a result of the world wide recession and three year's drought. Inflation is accelerating, and the value of the Zimbabwean Dollar quickly declining (as of November 1985 Z$1= US$0.6). The government is endeavouring to improve the situation.

The result of the general election held in July 1985 showed a land-slide victory of the majority party ZANU, and the minority party NAPU supported by Matabere tribes is standing in very unstable basis now.

The infrastructure of the survey area, transportation (railway, road), communication (mail, telephone), electric power, labour, accommodation, etc., is well prepared. Bindura is a center of commerce and agriculture in this area. It is easy to procure supplies and parts for agricultural machinery, but mining.

Therefore it can be said that general social circumstances in the survey area are good.

CHAPTER 3 GENERAL GEOLOGY

3-1 Geology

The Mazoe-Shamva Greenstone Belt is an east-west trending arcuate zone of tightly folded and regionally metamorphosed up to amphibolite facies, and consists of volcanic and sedimentary rocks of the Archean Bulawayan and Shamvaian Groups.

In the south it is bounded by the granite and gneiss complex of the Chindamora Batholith, and in the north by other granodiorite and gneiss complex.

The greenstone belt is subdivided into the following units.

Groups	Formation	Rocks
Shamvaian		pelitic to conglomeratic sedimentary rocks, pyroclastic rocks
Bulawayan	Upper Bulawayan (Upper Greenstones)	mafic volcanic rocks serpentinite, pyroclastic rocks, banded ironstone, limestone
	Lower Bulawayan (Lower Greenstones)	mafic to felsic pyroclastic rocks, banded ironstone, limestone

The Lower Greenstones, forming the base of the greenstone belt in the general area, are exposed on the southwestern corner of the area. They consist mainly of felsic to mafic pyroclastic rocks, mafic lavas, limestone, and banded ironstone (dark grey chert with interbeded oxide iron, and tuffaceous layers). The thickness of the formation in this area is less than 1,000 meters.

The Upper Greenstones are the most extensively distributed rocks in the area, and overlie the Lower Greenstones uncomformably. The main lithological constituents are andesitic, basaltic, and komatiitic volcanic rocks, pyroclastic rocks, banded ironstone and limestone. Regional metamorphism is of lower greenschist to amphibolite facies, and contact metamorphism of the mafic rocks by intrusive granites has produced a recrystalized hornblende hornfels which is often schistosed.

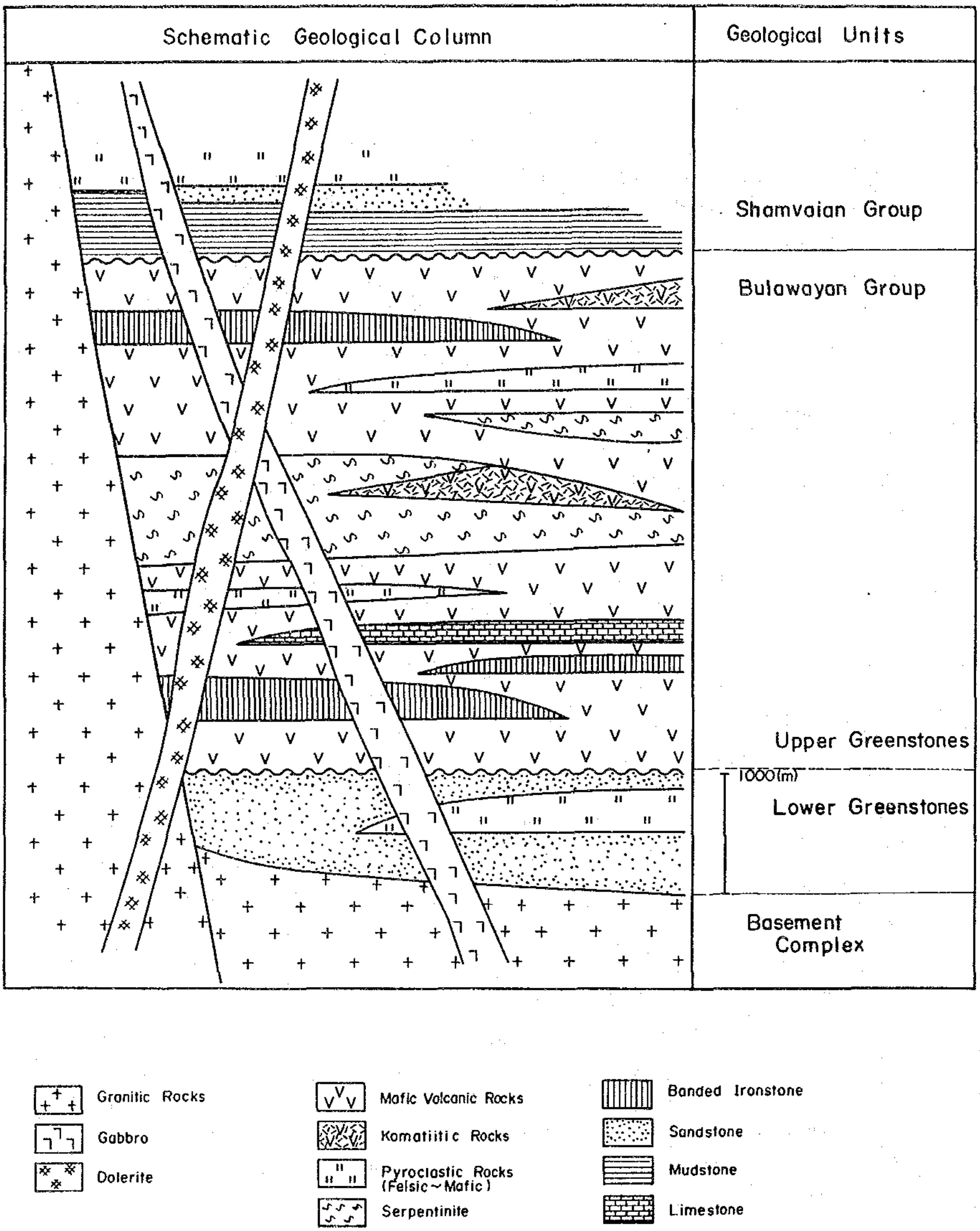


Fig. I-3-1-1 Schematic Geological Columnar Section of Shamva Area

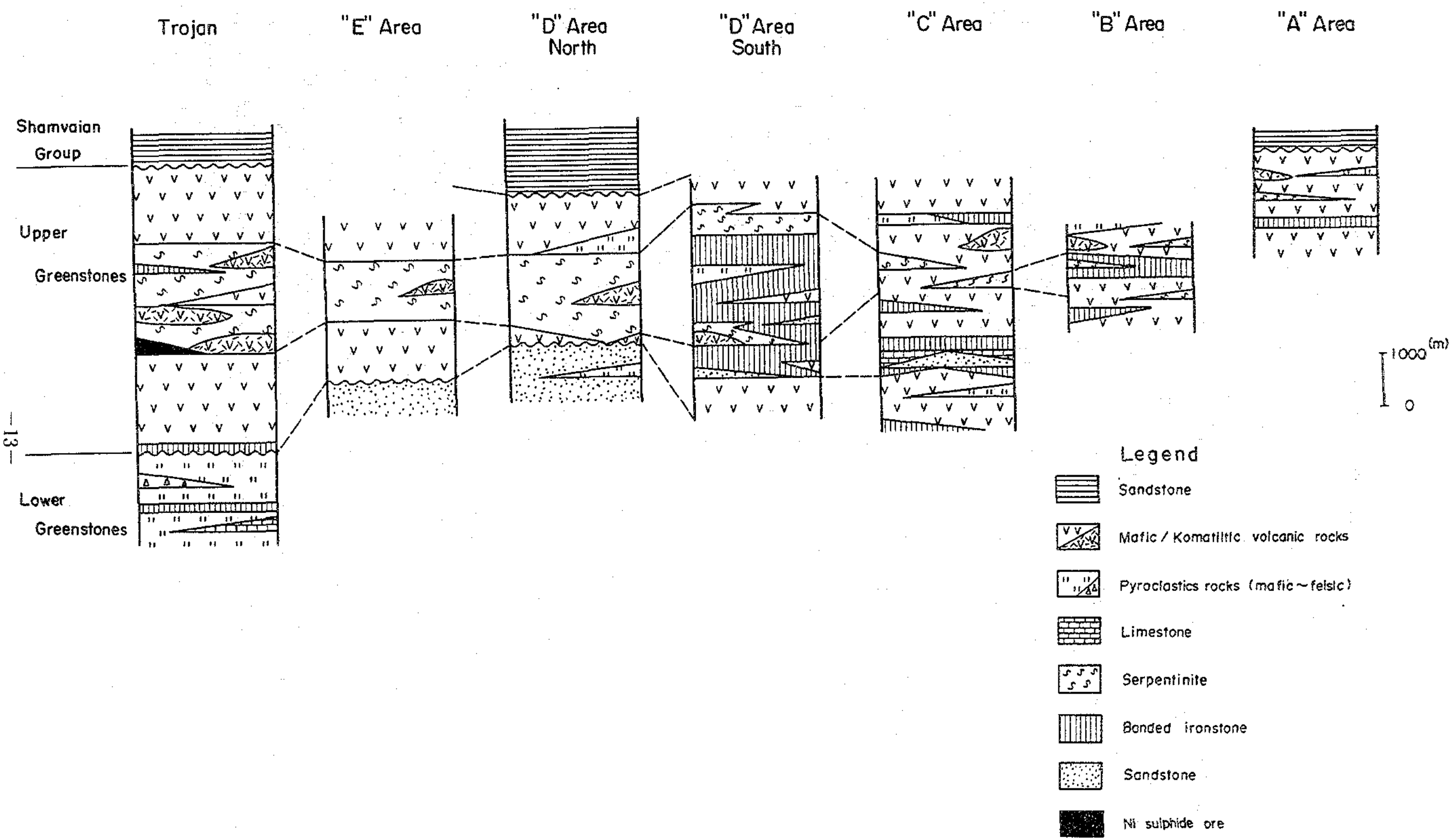


Fig. I-3-1-2 Correlation of Geological Columns of Each Area

Ultramafic intercalations, outcropping as sheard serpentinite and actinolite-tremolite schist, are distributed throughout the area. The formation in this district is up to 5,000 meters thick.

The Shamvaian Group is distributed in the central part of the district, trending east-west, and in its middle parts occupying a regional synclinal axis. Rocks represented are greywacke, pebbly greywacke, conglomerate, felsic to mafic pyroclastic rocks, and agglomerate. The group in this district is up to 7,000 meters thick.

A schematic geological columnar section of the Shamba area is shown in Fig. I-3-1-1.

Following are the descriptions of ultramafic rocks and other volcanic rocks in the greenstone belt, intrusive gabbro and dolerite, and granitic rocks surrounding the greenstone belt.

Ultramafic Rocks

Included in this group are the massive serpentinites, talc-carbonates, the talc-tremolite chlorite rocks, and komatiitic rocks.

The serpentinites fall into two groups: medium grained greyish green rocks with chlorite veinlets and carbonate patches, and fine grained dark bluish massive variety. Under the microscope, the fine grained type is observed to consist of partly to wholly serpentinized olivine crystals. Antigorite is the main alteration product of olivine, but talc is also present.

The talc-tremolite chlorite rocks are mostly greyish green schistose rocks where actinolite is present and the rock presents greyish brown in colour. the talc-tremolite chlorite rocks have chemical affinities (Mg-rich, Ca-poor) with the associated serpentinites. Under the microscope, it is recognized that the original rocks of these are mainly wehrlite, lherzolite, and dunite. But from the mode of field occurrences of the rocks it can be said that at least a part of the bodies was originally komatiitic lava flows, the name applied to mafic rocks with exceptional Mg contents.

These serpentinite group rocks have been extensively subjected to regional metamorphism which affected all over the greenstone belt. it is supposed that the metamorphosed temperature was between 400°C and 650°C, because no brucite is present and tremolite and talc are commonly present. (from Winker's diagram 1973) There is no evidence of olivine being recrystalized. Actinolite is not observed under the microscope.

Typical komatiite units, which have beautiful spinifex texture consisting of olivine blades with some magnetite, tremolite, and chlorite, have been observed in several parts of the greenstone belt. Under the microscope, small crystals of amphibole, tremolite, chlorite, and plagioclase are observed with biotite, epidote, sphene, and iron minerals as accessory minerals. In some cases, blast-spinifex texture can be seen.

On hundred samples of ultramafic rocks, which were recognized as komatiitic rocks and serpentinites presumably altered from komatiitic rocks, were sampled for whole rock chemical analysis.

Based on the result, the relation among Al_2O_3-(FeO+Fe_2O_3+TiO_2)-MgO is shown in Fig. I-3-1-3.

Lavas in the greenstone belt

The main constituent rock of the belt is mafic basaltic rock, but some thin lava flows of dacitic to andesitic rocks and thin layers of various pyroclastic rocks are intercaleted.

The basalt has been metamorphosed into amphibolite facies, and mainly consists of amphibole, plagioclase, epidote, and chlorite. Some parts of the basalt show andesitic components.

The dacite has been metamorphosed into quartz-feldspar schist.

Granite and Pegmatite

The granite and gneiss are most commonly exposed in south and north of the greenstone belt. Lithologically, the granites are extremely variable, incorporating all types from tonalite to adamellite. Grain size and mafic mineral content show considerable differences and the structure varies from massive to well-foliated.

The granites contain xenoliths consisting of felsic volcanic rocks, greenstones, ultramafic rocks, and ironstones. On the other hand, in the lower part of the Lower Greenstones, the volcanic breccia contains granite pebbles. Hence, it is possible to say that there were various igneous activity stages of the granites, from pre-greenstone to post-greenstone. But all the granites in contact with the greenstone belt in

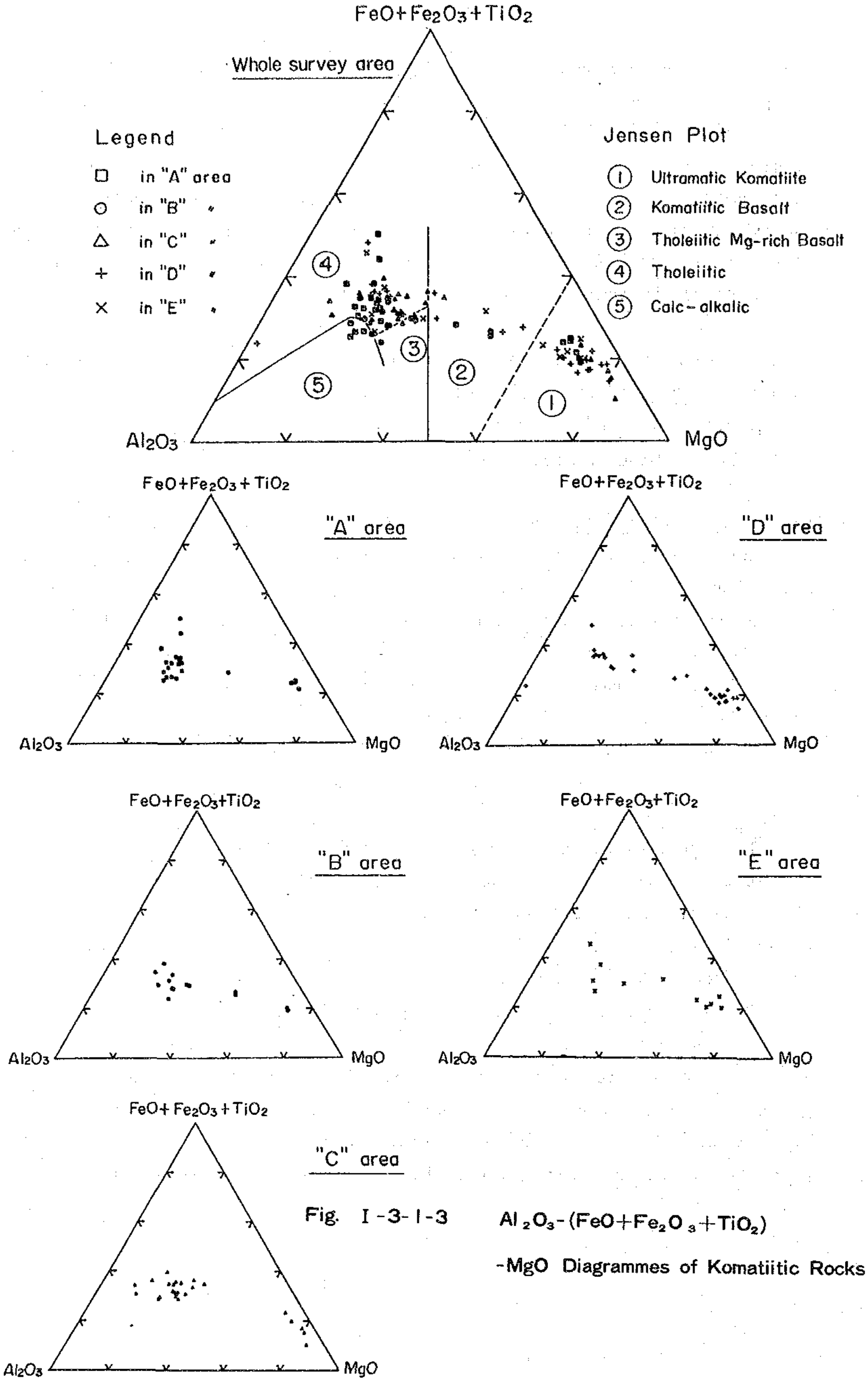


Fig. I-3-1-3 Al_2O_3-($FeO+Fe_2O_3+TiO_2$)-MgO Diagrammes of Komatiitic Rocks this area are intrusive, and nowhere was the pre-greenstone basement observed.

East-west striking bands of migmatite and injection gneiss are situated at the eastern end of the greenstone belt, and these are considered to be mixed zones of older granites, gneisses, greenstones, and younger reactivated granite intrusions.

Most of the pegmatites in this area are of the complex variety. The pegmatites mainly consist of large crystals of quartz, feldspar, muscovite, and lepidolite. Some of them have been mined for lithium, beryllium, tantalum, and tin.

Gabbro

A number of small size stocks and sill-like bodies of gabbro have intruded into the greenstones. Most of them show very coarse poikilitic texture or finer ophitic texture, but in some parts they show porphyroblastic texture. The rocks are usually slightly altered. It is thought that the gabbro intruded at the Upper Bulawayan age, but some of them are of the same activity as dolerite.

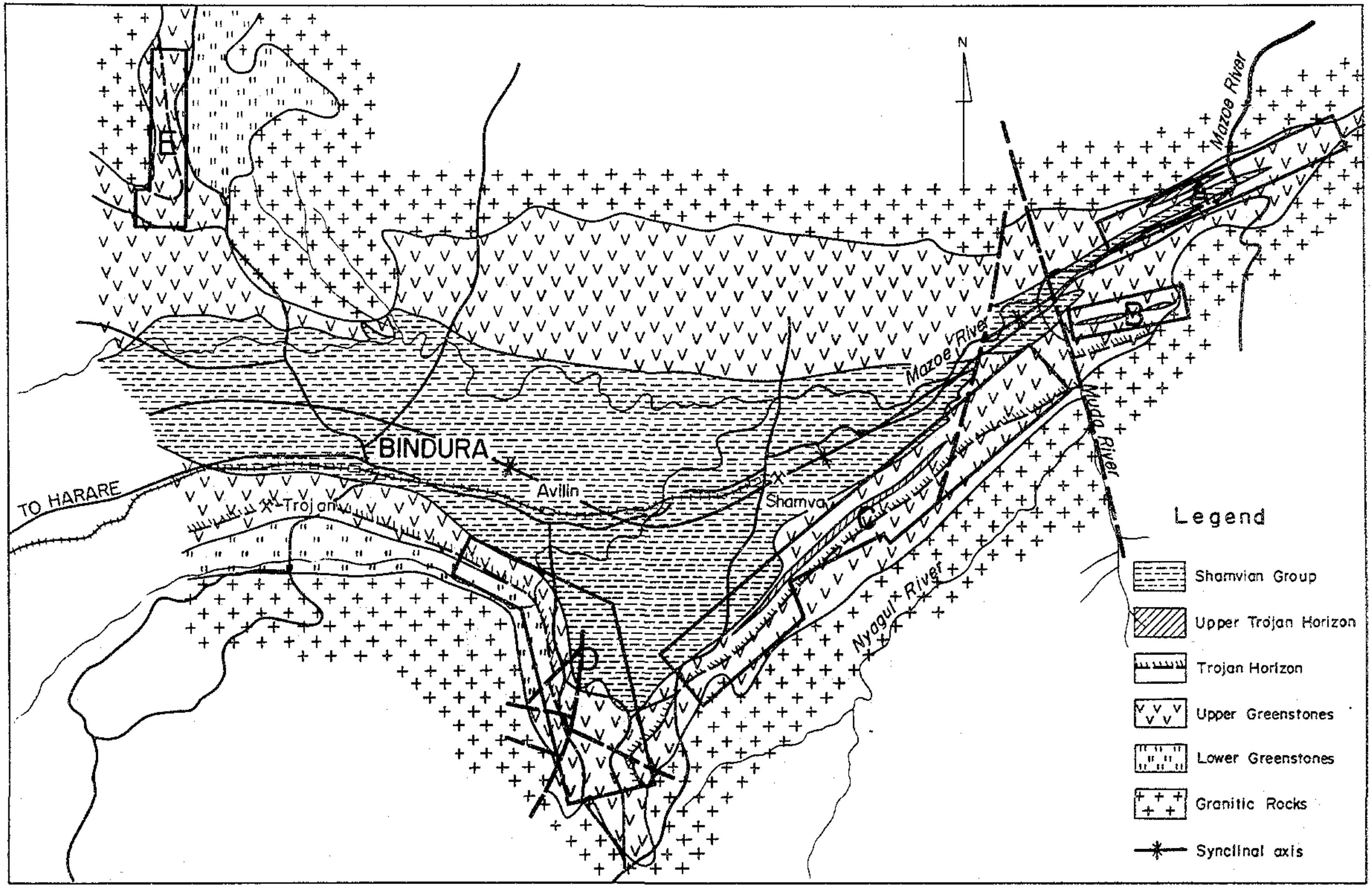
Dolerite

The dolerite is the youngest intrusive rock in the greenstone belt, and appears as a long dyke some of which are 100 km in length in this country. Three trends of the dykes are recognized; northeast-southwest, northwest-southeast, and north-south. Lithologically the dykes vary from quartz diorite to dolerite and gabbro, and some of them have been metamorposed into amphibolite facies.

3-2 Geological Structure

The general area covers the eastern part of the Mazoe-Shamva Greenstone Belt. The overall trend of rocks is east-west with a central synclinal axis in the central part of the belt, however, the southeastern boundary of the belt trends northeast to southwest, and the southwestern boundary trends northwest to southwest. The greenstone terrain is surrounded by large masses of granite-gneiss complex.

The greenstones are tightly folded along the synclinal axis, therefore the rock pile generally shows very steep dips. Folding was possibly



Railway and siding
Road
Survey Area

0 10 20km

Fig. I-3-2-1 Outline of Geological Structure of the General Area accompanied by granite and ultramafic intrusions and some mineralization.

The horizon hosting the Trojan ore deposits could be very important for future exploration activities, because of the reason mentioned in "3-5 Geological Setting of Mineral Occurrence". A postulated extention of the horizon in the area is shown in Fig. I-3-2-1.

3-3 Metamorphism

The whole greenstone belt has been subjected to a regional metamorphism. The Metamorphism is of a low pressure regional type, ranging green schist facies to amphibolite facies, judged from the existence of andalusite and cordierite as metamorphic minerals.

Ultramafic rocks have been commonly metamorphosed into sheared serpentinite and actinolite-tremolite schist.

It can be assumed that metamorphic temperature ranges between 400°C and 650°C, judged from common existence of tremolite and talc. The assumed temperature is not against the regional metamorphism facies.

Intrusion of granite rocks into the greenstone belt made contact metamorphic effect to the country rocks, and in some places greenstones have been metamorphosed into recrystallized amphibolite hornfels with some schistosity.

3-4 Mineral Occurrence

Three main types of mineralization occur in the general area; gold bearing quartz veins, nickel deposits associated with ultramafic rocks, and rare earth mineral-bearing pegmatites.

<u>Gold Occurrence</u>

o Shamva Mine (operated by Attica Mines Pvt. Ltd., Lonrho Group)

Location : Central part, East of Shamva

Geology : Metamorphosed pyritiferous tuffaceous sedimentary rocks of the Shamvaian

Ore Deposit : Ore channels are almost indistinguishable from the country rock, but are aligned principally along north-east and east-north-east directions parallel to shear or fracture directions dipping steeply to the north. Total strike length of the mineralized channels is about 1,200 m

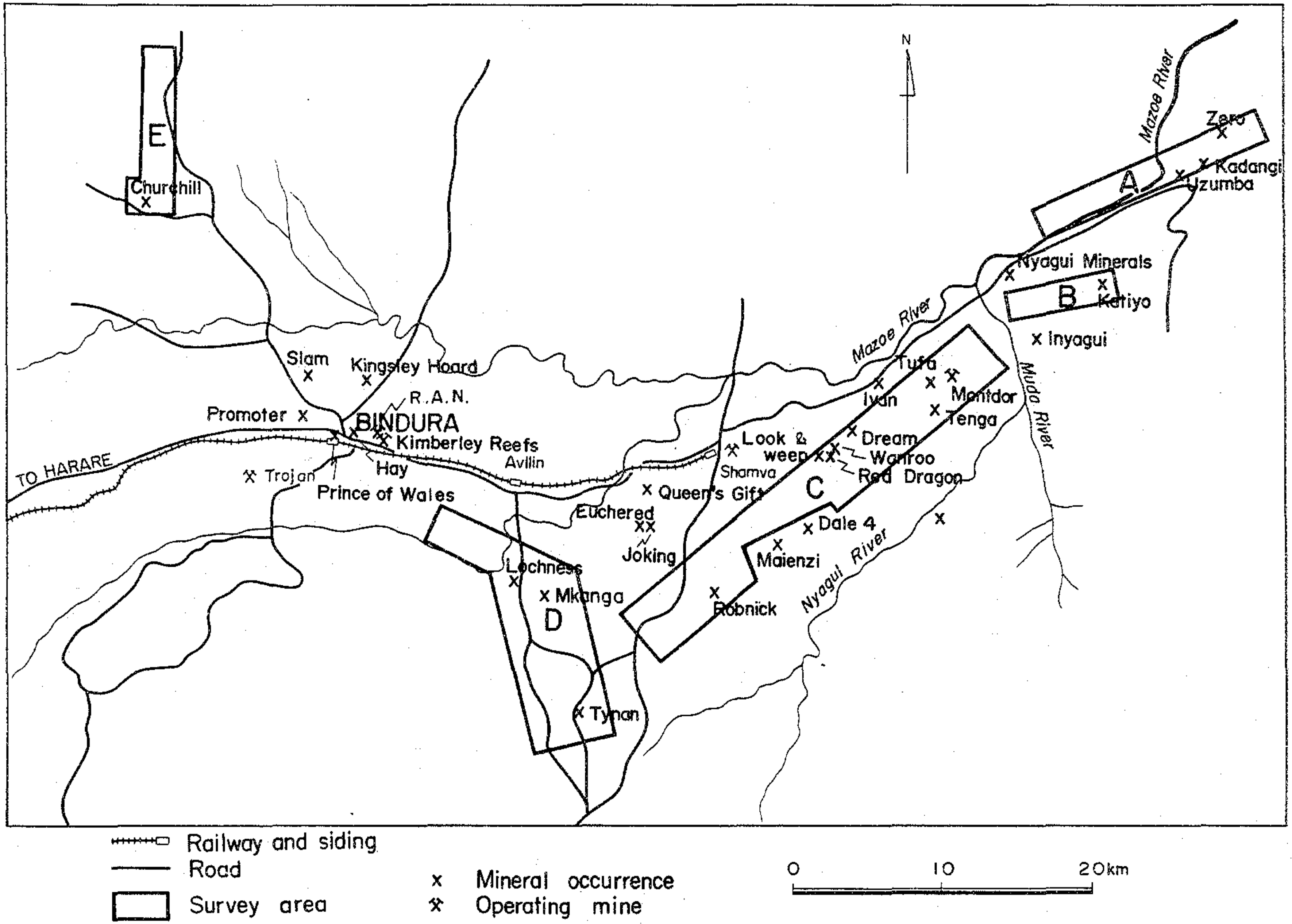


Fig. I-3-3-1 Mineral Occurrences in the General Area

Output : Started 1893. Total output to the end of 1965 was 46.447 kg of gold reflecting a recovery of 5.1 g/t. Presently annually producing about 45 kg Au.

o Gold mineralization zone around the Bindura Granite Stock (Kimberley Reef, R.A.N., kingsley Hoard, Prince of Wales, Slam, Promoter, Hay: Some operating)

Location : Central part. north of Bindura

Geology : Bindura Granite and surrounding sandstone of the Shamvaian. Closely associated with the granite intrusion

Ore Deposit : Three types of ores; quartz fissure veins, quartz veins with impregnation or replacement of wall rocks, impregnation deposits. Dominant strike of the reefs is east-west with a few trending north-south. Dips are get steep away from the granite

o Output : Not available

o Montdor Mine (operated by a private owner)

Location : Central part, Eastern part of Area C

Geology : Foliated greenstones of the Upper Bulawayan. Strike north-east, dip 50° - 70° north.

Ore Deposit : Gold occurs within laminated stringer zones and folded quartz veins, and is associated with much pyrite and pyrrhotite, occurring as fine disseminations, stringers, and large blebs.

Output : Started 1909. Operated intermittently. Total output of the end of 1965 was 2,745 kg of gold at an average recovery grade of 22.6 g/t. Almost exhausted.

o Red Dragon Mine

Location : Central part. Middle of Area C

Geology : Basaltic greenstone of the Upper Bulawayan. Some plagioclase, porphyry and banded ironstone

Ore Deposit : Four quartz reefs. Strike E-W, dip 30° - 55°N width 15 - 45 cm

Output : Started 1908. Operated intermittently. Total output at the end of 1965 was 183.5 kg of gold, reflecting a recovery of 8.8 g/t

o Churchill Mine

Location : Northwestern part. Southwestern portion of Area E

Geology : Basaltic greenstone of the Upper Bulawayan and intrusive micro-diorite

Ore Deposit : Quartz vein on the contact between greenstone and micro-diorite

Output : Not available, ceased the operation in 1982

o Ivan Claim

Location : Central part. Near the east boundary of Area C

Geology : The Upper Bulawayan

Ore Deposit : Quartz vein

Output : Since 1937 a total of 1.46 kg of gold at an average recovery grade of 4.2 g/t

o Inyagui Mine

Location : Eastern part. In the south of Area B

Geology : Recrystallized limestone in the Upper Bulawayan. Strike NNE-SSW, dep 60° - 65°NW

Ore Deposit : Mineralized shear zone in of the crystalline limestone band

Output : Started 1910 operated intermittently. Total output at the end of 1936 was 5.88 kg of gold reflecting a recovery of 14.9 g/t

o Kadangi Mine

Location : Eastern part. In the east of Area A

Geology : The Upper Bulawayan

Ore Deposit : Quartz vein

Output : Since 1925 until 1939 a total of 22 kg of gold at an average recovery grade of 9.7 g/t

Nickel Occurrence

o Trojan Mine (operated by Bindura Nickel Co.)

Location : Western part

Geology : The Upper Bulawayan. From base of sequence ; andesitic lava, banded ironstone, and serpentinized ultramafic lava. Iron formation is interlayered with the ore bearing serpentinites and the whole assemblage is inclined nearly vertically to the north. The rocks have suffered amphibolite grade metamorphism.

Ore Deposit : The deposits occur in the serpentinite as massive, near massive, and disseminated ores. The main sulphide minerals are pyrrhotite, pentlandite, and chalcopyrite. Minor amounts of pyrite are present. The NI : Cu ratio of all three types of ore averages 15:1. Two main, as well as several minor, ore bodies occur at Trojan, and contain a total reserve of some 13 million tons of ore with an average tenor of 0.68% Ni.

Output : Started 1961. Total output at the end of 1982 was about 13 million ton of ore

o Katiyo Claims

Location : Eastern part. In the east of Area B

Geology : Serpentinite and banded ironstone of the Upper Bulawayan

Ore Deposit : Pyrite and pyrrhotite mineralization in serpentinite

Output : no production

Pegmatite Occurrence

o Uzumba Claims

Location : Eastern part. Center of Area A

Geology : Granite stock intruded into the Upper Bulawayan

Ore Deposit : Pegmatite vein in the granite

Output : Beryl 0.25 t

o Zero Claims

Location : Eastern part. In the east of Area A.

Geology : Tremolite schist in the Upper Bulawayan.

Ore Deposit : Pegmatite vein

Output : Beryl 2.07 t

o Wanroo Mine

Location : Central part. Middle of Area C

Geology : Greenstones of the Upper Bulawayan

Ore Deposit : Lepidolite bearing pegmatite vein. 16 parallel veins within a belt of greenstone about 700 m wide. Strike SE-NW, dip 75° - 90° SW. Strike length up to 600 m. Width 0.3 - 5 m grade 1.15 kg/t microlite

Output : 1959 - 1962. Microlite 4.62 t. Average concentrate grade 9.48% Sn, 68.60% Ta_2O_5 + Nb_2O_5

o Look and Weep Claims

Location : Central part. Middle of Area C

Geology : Greenstones of the Upper Bulawayan

Ore Deposit : Pegmatite vein

Output : Until 1962 : tantalum concentrate, 0.52 t

o Chenjera Claims

Location : Southeastern part

Geology : Younger granite

Ore Deposit : Pegmatite vein

o Tafuna Hill area (Euchred, Joking, Queen's Gift, etc.)

Location : Central part

Geology : Greenstone of the Upper Bulawayan

Ore Deposit : A large number of lepidolite-bearing pegmatites, Strike N-S, dip 40° - 65°W. Strike length 30 - 400 m, width 20 - 150 cm

Output : Until 1962 Euchered clm. 0.95 t microlite
Jocking clm. 4.45 t microlite

o Robnik Claims

Location : South-central part. In the west of Area C

Geology : Greenstones of the Upper Bulawayan

Ore Deposit : Tin-bearing pegmatite vein o Maienzi Claims

Location : South-central part. Middle of Area C

Geology : Greenstones of the Upper Bulawayan

Ore Deposit : Tin-bearing pegmatite vein.

Strike E-W, dip 35° - 50°N, length 100 m, width 4 m, some visible cassiterite

o Dale 4 Claims

Location : South-central part. Middle of Area C

Geology : Greenstones of the Upper Bulawayan

Ore Deposit : Tin-bearing pegmatite vein.

3 reefs. Strike NW-SE. dip 30°E

o Nyagui Minerals Claims

Location : Eastern part. In the northeast of Area C

Geology : Greenstones of the Upper Bulawayan

Ore Deposit : Tin-bearing pegmatite vein

o Lochness Mine

Location : Central part. Middle of Area D

Geology : Serpentinite in the Upper Bulawayan

Ore Deposit : Tin-bearing pegmatite vein

o Mkanga Mine

Location : Central part. Middle of Area D

Geology : Serpentinite in the Upper Bulawayan

Ore Deposit : Tin-bearing pegmatite vein

The precedings are the mineral deposits and occurrences which were recorded in some papers and maps, but there are many other mine trenches found in the area. Almost all spots underlain by ironstones or gossans have been previously prospected by trenching or other ways, as well as quartz veins or pegmatite rich areas.

In other words, it can be said that surface prospecting in the area has been satisfactorily done by now.

3-5 Geological setting of mineral occurrences

Nickel sulphide deposits associated with ultramafic rocks

Two types of nickel sulphide deposits are well known in the world; one is high copper-nickel ratio type associated with tholeiitic mafic rocks (Sudbury, Noril'sk, etc.), the second is low copper-nickel ratio type associated with komatiitic ultramafic rocks (Kambalda, Thompson, Trojan, etc.). the latter is restricted in the age of 2,700 Ma to 2,800 Ma, late Archean age.

A schematic geological diagram of the Trojan area, where is one of the typical nickel sulphide mineralized areas associated with komatiitic ultramafic rocks, is shown in Fig. I-3-5-1.

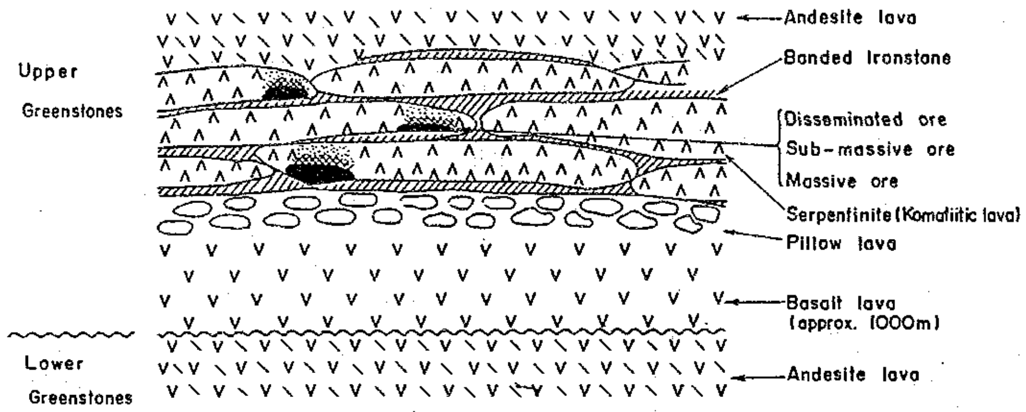


Fig. I-3-5-1 Schematic Geological Section of Trojan Mine Area

The basal part of the Upper Greenstones, host rock horizon of the Trojan ore deposits, is very important horizon because of existence of ore hosted komatiitic ultramafic lava flows. It is said that nickel ore deposits in Zimbabwe would be restricted in this horizon. (L. Haynes 1982). According to him ore genesis is of contamination of banded ironstone into magma, sulphide-silicate immiscibility, and gravitic segregation.

The rocks of this horizon are extensively distributed in Area D, specially serpentinite and banded ironstone increase their thickness significantly. But from Area D to the east, to Areas C, B and A, the distribution of these rocks gets poor.

In addition to above mentioned geological settings, it is appraised that the vicinity of big ore deposits has high potential for hidden new deposits, and to trace same horizon in vicinity of known deposits is relatively easier than in remote areas. Therefore Area D would be given high marks geologically for hidden ore potential.

It is a well known fact that ores associated with komatiitic ultramafic rocks have high nickel-copper ratio (15:1), and ores associated with tholeiitic rocks have low nickel-copper ratio (3:1). Furthermore, the two magma types are generally regarded as being part of the same magmatic event and therefore they can also be intimately mixed. (L. Haynes 1983). In Zimbabwe, several ore deposits associated with tholeiitic rocks are known, (Empress, Preserverance, Madziwa etc.), and this type of ore deposit in the world frequently contain certain amount platinoid minerals.

From the above mentioned points, it is worth while to think of the potential of whole ultramafic to mafic rocks including both komatiite and tholeiite rock series.

Gold and Pegmatite Deposits

All known gold and pegmatite deposits are assocaited with granitic activity, and situated in marginal areas of granitic bodies or surrounding greenstone areas. Geologic structural interpretation, specially of fissure pattern, is essential for the further exploration of such type of ore deposits.

PART Ⅱ.

SURVEY RESULTS

CHAPTER 1 AREA A

1-1 Geological Survey

The area is situated in the northeastern end of the Mazoe-Shamva Greenstone Belt, and is underlain by the Upper Bulawayan. The formation mainly consists of mafic lavas with interbedded lavas and beds of serpentinite, felsic pyroclastic rocks, and banded ironstone.

Parts of the mafic lava are komatiitic ultramafic rocks, which show spinifex texture in the field, but exact distribution of such komatiitic rocks is not clear. The serpentinite appears as small lenticular bodies concordantly with surrounding greenstones beds, therefore it is thought that the serpentinites are metamorphosed from ultramafic lavas.

The basal parts of the Shamvaian Group are locally exposed in the southern part of the area, and consist of arenaceous to lutaceous sediments.

The bedding of the rocks strikes east-north-east to west-south-west, and dips nearly vertically.

In the northwestern ridge and east end of the area, granite-gneiss complex bodies are exposed. Swarms of pegmatite dykes are intruded into those complex bodies, and parts of them have been mined for microlite. (Uzumba, Zero). Gold-bearing quartz veins are intruded in the eastern part of the area.

Small stocks of gabbroic intrusion are scattered in the area.

1-2 Geochemical Survey

As a result of the geochemical survey, local anomalies for Cu, Zn, Ni and Cr were detected over the area from the centre to the western part. The following anomalies were noticed: "B" zone (180 to 333 ppm) and very locally"A"zone (334 ppm and more) anomalies of anomalies Cu; A zone (351 ppm and more) and "B" zone (203 to 350 ppm) of Zn; "B" zone (622 to 1831 ppm) anomalies of Ni; and "B" zone (1118 to 3461 ppm) anomalies of Cr. These weak anomalies are thought to be related to serpentinites. As to Nb, weak anomalies ranging from 20 to 40 ppm are distributed near the

Note: "A" zone refers strong anomaly zone (GM+2), "B" zone refers modevocate anomaly zone (GM+ -2), "C" zone refers weak anomaly zone (GM+). Z_1 refers first principal component, Z_2 refers second principal component.

eastern end. As the distribution of these anomalies agrees with that of granites and pegmatites, the anomalies are thought to have resulted from these rocks.

1-3 Conclusion

The results of the surveys show that the distribution of ultramafic rocks is very limited, mineral occurrences recognized in the area are only small scale ones associated with pegmatites, and results of the geochemical survey are negative.

Therefore, as the conclusion, it can be said that the potential for economic ore deposits in the area is low.

CHAPTER 2 AREA B

2-1 Geological Survey

This area is underlain by the Upper Bulawayan. Most of the formation mainly consists of mafic lavas with interbedded thin layers of felsic-mafic pyroclastic rocks, serpentinite, and banded ironstone. Parts of mafic lavas are komatiitic ultramafic rocks, which show spinifex texture in the field. But the exact distribution of such komatiitic rocks is not clear. The serpentinite appears as small lenticular bodies concordantly with surrounding greenstone beds, so it is thought that original rocks of the serpentinite were ultramafic lavas. Bedding of the rocks strikes east-north-east to west-south-west, and dips nearly vertically.

In the eastern part of the area, a mining company undertook some exploration program, consisting of trenching and shaft sinking, to test sulphide mineralized zone in the contact between the serpentinite body and the banded ironstone layer. At present no mineralized rock can be seen on the surface.

In this area, small size lenticular bodies of gabbro are intruded into the greenstone belt, as well as pegmatite dykes, but no economically profitable pegmatite deposits exist.

2-2 Geochemical Survey

As a result of the geochemical survey, anomalies of Zn, Ni and Cr were detected in the central part. The following anomalies were noticed: "A" zone (351 ppm and more) and "B" zone (203 to 350 ppm) anomalies of Zn; "B" zone (624 to 1831 ppm) and very locally "A" zone (1832 ppm and more) anomalies of Ni; and "B" zone (1118 to 3461 ppm) anomalies of Cr. Near the eastern end, anomalies of Cu, Zn, Ni and Cr were detected: "B" zone (180 to 333 ppm) anomalies of Cu; "A" zone (351 ppm and more) and "B" zone (203 to 350 ppm) anomalies of Zn; "A" zone (1832 ppm and more) and "B" zone (624 to 1831 ppm) of Ni; and "B" zone (1118 to 3461 ppm) anomalies of Cr were noticed respectively. These anomalies have high scores of principal component analysis and their distribution agrees with that of serpentinites, but the scope of their distribution is local.

2-3 Conclusion

The results of the surveys show that the distribution of ultramafic rocks is limited, a mineral occurrence relating those rocks is of very small scale, past exploration activity showed negative results, and results of the geochemical survey are negative.

Therefore, as the conclusion, it can be said that the potential for economic ore deposits in the area is low.

CHAPTER 3 AREA C

3-1 Geological Survey

The area is underlain by the Upper Bulawayan. Most of the formation consists of mafic - ultramafic lavas with interbedded layers of felsic - mafic pyroclastic rocks, felsic lavas, limestone, banded ironstone, and serpentinite. In the center to west of the area, komatiitic lavas are abundant, and range in thickness up to 200 m. But exact distribution of the lavas is not clear. Small lenticular serpentinite bodies intermittently extend concordantly with surrounding mafic rocks.

Based on these occurrences, it can be said that the original rocks of the serpentinite are mainly ultramafic lavas. The limestone extend intermittently in the almost same horizon, so that can be marked as a key bed.

The greenstone beds strike northeast-southwest, and dip almost vertically.

Several micro-diorite, gabbro, and dolerite bodies are intruded in the greenstone belt, particularly north-south and northwest-southeast trending long dolerite dykes are intruded in the eastern and central parts of the area.

Several gold ore deposits (Montdor, Red Dragon, etc.) and pegmatite deposits (Wanroo, Look and Weep, Robnik, Maienzi, Dale 4, etc.) exist in the area, but only Montdor Mine is in operation.

3-2 Geochemical Survey

As a result of the geochemical survey, no anomalies were detected on these komatiite lavas. However, in the southwestern part, anomalies within the scope of "A" zone and "B" zone of four elements, Cu, Zn, Ni and Cr are overlappedly distributed over a wide area, showing the following values: "A" zone (334 ppm and more) and "B" zone (180 to 333 ppm) anomalies of Cu; "A" zone (351 ppm and more) and "B" zone (203 to 350 ppm) anomalies of Zn: "B" zone (624 to 1831 ppm) anomalies of Ni; and "B" zone (1182 to 3461 ppm) anomalies of Cr. Because serpentinites are distributed in these parts of the area, these anomalies need to be studied further as there are promising indications of nickel and copper deposits.

As to Nb, only weak anomalies ranging from 10 to 20 ppm are distributed. As to Au, anomalies ranging from 0.05 ppm to 0.3 ppm are extensively distributed in the northeastern part. In these anomalies, a small gold mine is in operation now, the anomalies, therefore, are thought to be related to the mineralization of gold.

For the area from the central part to the northeastern part, analysis for ten elements including Co, Sn and As were conducted. The results showed scarce traces of Sn, W and Ce. High content of Co, Be, Li, As and S, with little fluctuation, was generally the case. These high contents are thought to have been caused by high backgrounds.

3-3 Geophysical Survey

CSAMT Survey

Survey results were shown as apparent resistivity plans, apparent resistivity sectional views, resistivity structure plans, and resistivity structure sectional views using methods described in the phase II report. These results, in combination with the geological and geochemical exploration results from the first year survey, describe each area as follows:

The apparent resistivity plans show complicated resistivity distributions at shallower depths, but in the deeper part there is a long distribution of low resistivity zones (below 20 Ω-m) running NE to SW through the area to the edge. They extend to the deepest part, although their expansion is unclear. Additionally, low resistivity zones (below 10 Ω-m) of small to medium size were found near survey points C-82-9, C-86-6 and C-89-6.

The resistivity structure plans, show complicated distributions of large resistivity differences in the shallower part (125 m, 225 m depth). Low resistivity zones are distributed near points C-86-0 to C-81-0 at the southern border of the area. They extend from 125 m to 525 m deep. Zones near C-81-0 and C-89-6 go below 125 m. High resistivity zones are distributed near points C-81-3, C-83-3, C-86-3, C-88-3, C-84-9 and C-90-9. Those near survey points C-86-3 and C-88-3 are deeply extended cylindrical shapes.

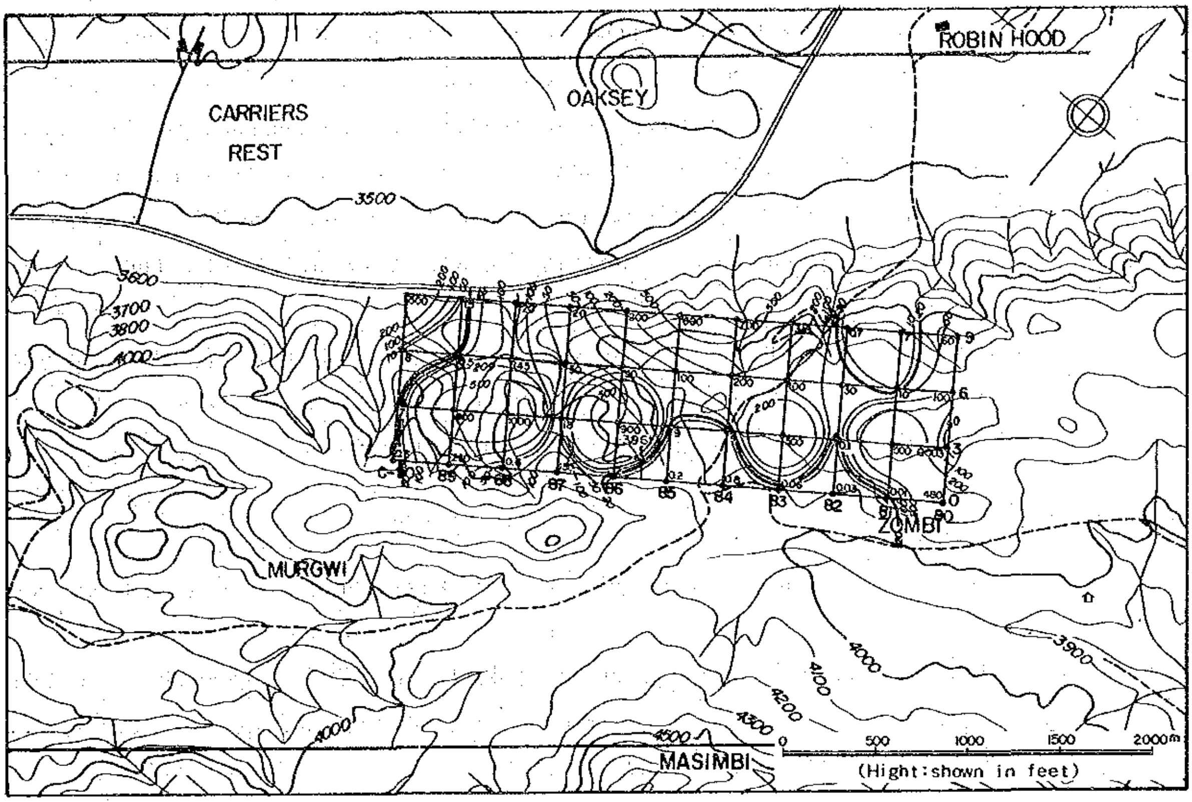


Fig. Ⅱ-3-3-1 (a) Plan of Resistivity Structure (Area C, 125m) unit: Ω-m

A representative level, below 125m from the serface

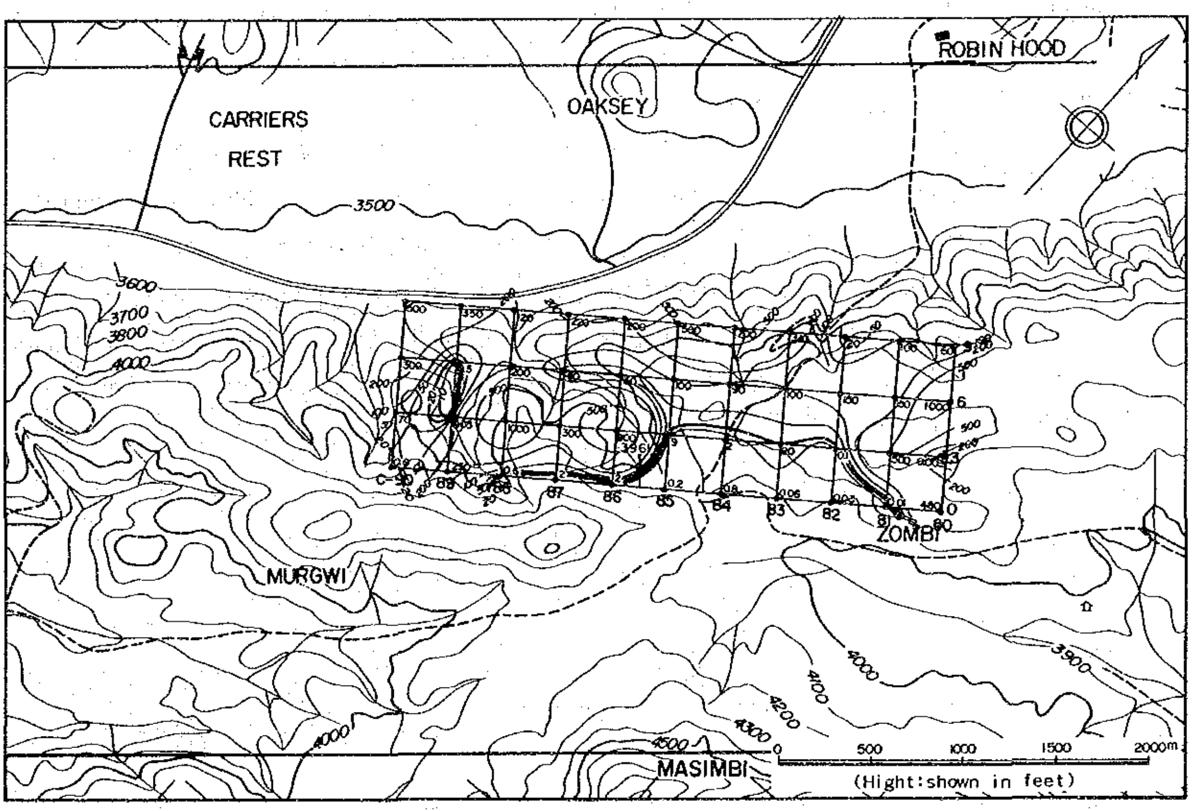


Fig. Ⅱ-3-3-1 (b) Plan of Resistivity Structure (Area C, 325m) unit: Ω-m

A representative level, below 325m from the serface

The low resistivity zones from survey points C-86-0 to C-81-0, near the southern border of the area, did not coincide with geochemical anomalies but there is a possibility of a serpentine extension in the deeper part at survey point C-81-3. A mineralized zone is thought to exist here. The low resistivity zone, near survey point C-89-6, relates to mafic lava and the geochemical anomaly is slightly offset to the eastern side.

Although the low resistivity zone around point C-81-9 was included in the high resistivity zone simulation analysis, it consists of mafic pyroclastic rock and no geochemical anomaly was noticed.

3-4 Conclusion

The results of the geological, geochemical, and geophysical surveys are as follows.

The low resistivity zone around C-81-0 to C-86-0 (in the southern rim of the area) which was detected by the CSAMT survey, is deep, but located in an unfavourable geological setting for nickel sulphide ore deposits. Rocks in the area are andesite, chert, and banded ironstone.

The Trojan ore horizon, which contains serpentine intrusive bodies, extends to about 600m to 800m north of the low resistivity zone. A geochemical anomaly covers the extension zone of the Trojan ore horizon, but does not cover the low resistivity zone.

The low resistivity zones around C-82-9 and C-89-6 are located near a serpentine body in the Trojan ore horizon extension, and are associated with a geochemical anomaly. But, their size and depth are poor.

Therefore, as the conclusion, it can be said that there is some potential for economic ore deposits in the southwestern part of the area, and it is hoped to conduct further detail geophysical survey around there to examine the potential.

CHAPTER 4 AREA D

4-1 Geological Survey

The area is underlain by the Lower and Upper Bulawayan. The Lower Bulawayan occupies the northwestern part of the area, along with the edge of the granite batholith, extending northwest to southeast. The formation consists of felsic pyroclastic rocks and sandstone. The Upper Bulawayan occupies almost all of the remaining area, and consists of serpentinite, mafic lavas, banded ironstone, chert, felsic pyroclastic rocks, and sandstone. The serpentinite is mostly extensively distributed in the area reaching a thickness of 1,000 m in the central part, and 400 m - 600 m in the southern part. Specially in the southern part, more than one layers are distributed together with thick layers of banded ironstone. Under the microscope, it can be recognized that the original rocks of the main part of the serpentinite are wehrlite, lherzolite, harzburgite, and dunite. But from the occurrences, it may be said that at least some parts are ultramafic lavas.

A margin of a granitic batholith, which is extensively distributed to the south, is exposed in the south end of the area. Small intrusive bodies of gabbro and pegmatite are intruded into the greenstone belt.

The area is situated in the southern expanded zone of the Mazoe-Shamva Greenstone Belt, therefore its geological structure is very complicated. The area is divided into three blocks by faults. The South Block is characterized by a west convex structure, and the sequence is from east to west, base to top. The central block shows north open concave structure, and the sequence is from outer rim to center (north). The north block shows simple northwest-southeast extending structure.

Some of pegmatite dykes in the central part (Lochness, Mranga) have been mined for rare earth metals and tin, but operations were very small scale. In the southern part of the area, several mining companies have conducted exploration programmes in Tynan claims in the past several years and put several drill holes. Sulphide mineralized zones were intersected in several holes.

4-2 Geochemical Survey

As a result of the geochemical survey, widespread and overlapped high anomalies of Zn, Ni and Cr were detected in the southeastern part. "A" zone (351 ppm and ore) and "B" zone (203 to 350 ppm) anomalies of Zn, "A" zone (1832 ppm and more) and "B" zone (624 to 1831 ppm) anomalies of Ni and "B" zone (1118 to 3461 ppm) anomalies of Cr, were noticed. In this part of the area, serpentinites have characteristically distributed matching with that of the anomalies, this part is regarded as a promising zone for nickel ore deposits.

Also from the central part to the northern part, widespread and overlapped high anomalies of Cu, Zn, Ni and Cr were detected. The following anomalies were noticed: "A" zone (334 ppm and more) and "B" zone (180 to 333 ppm) anomalies of Cu; "A" zone (351 ppm and more) and "B" zone (203 to 350 ppm) anomalies of Zn; "B" zone (624 to 1831 ppm) anomalies of Ni; and "B" zone (1118 to 3461 ppm) anomaly of Cr. Also in this part of the area, as serpentinites are widespreadly distriubted, and as their distribution matches with that of the anomalies, therefore this part of the area is regarded as a promising zone which may embrace nickel and copper ore deposits. As to Nb, high anomalies ranging from 50 to 150 ppm were detected near the southeastern end of the area. These high anomalies are on banded ironstones or serpentinites and near granites, therefore, they are thought to be related to granites, but further investigation is required.

For the central part, analysis for the ten elements including Co, Sn and As were conducted out. Although scatteredly, high anomalies of Sn ranging from 28 to 39 ppm were detected, also scatteredly, high anomalies of Co ranging from 30 to 100 ppm were detected, and as to Li, Be and Co, high anomalies each from 49 to 68 ppm, from 5.6 to 7.7 ppm and from 92 to 177 ppm respectively were detected in accordance with the distribution of pegmatites. As to the pegmatite deposits, the possibility of downward extension must be investigated.

4-3 Geophysical Survey

CSAMT Survey

Survey results were shown as apparent resistivity plans, apparent resistivity sectional views, resistivity structure plans, and resistivity structure sectional views using methods described in the Phase II report. These results, in combination with the geological and geochemical exploration results from the first year survey, describe each area as follows:

(1) Area D-1

The apparent resistivity plans and sectional views, show complicated resistivity distribution in the shallower part, but, in the deeper part, low resistivity zones and high resistivity zones are clearly distinguishble. At 256 Hz, a zone that shows slightly-low resistivity values (below 100 Ω-m) is distributed along a NNW line in the eastern part of the area. Expansion and contraction is repeated at several places, and low resistivity spots (below 20Ω-m) are found near survey points D-30-9, D-34-9, D-37-6 and D-41-6. They also tend to occur in deeper parts. High resistivity zones are found in the western and eastern parts of the area and, in the south, from line D-29 southward, higher resistivity occurs more generally.

Low resistivity zones (below 20 Ω-m) are scattered mostly in the NNW near survey points D-30-9, D-38-6 to D-33-6, D-39-12 and D-41-6 from shallow to deeper parts of the resistivity structure plans.

Resistivity structure, sectional views show a low resistivity value of 5.5 Ω-m between 100 m and 270 m depths at survey point D-30-12. Notable low resistivity values of 0.2 to 40 Ω-m at points D-37-6 to D-37-15 to depths of 400 m were also found.

Western and southern parts generally show high resistivity. A low resistivity zone, around point D-30-9, is in the geochemical anomaly area, found in the first year survey, where serpentine is distributed.

These results suggest the existence of mineralized zones in serpentinite rocks from shallow to deep parts. Serpentinite, pegmatite, mafic lava and pyroclastic rock, felsitic pyroclastic rock and felsitic sandstone are distributed in the low resistivity zones near survey points D-38-6 to D-33-6, which shows good agreement with the geochemical anomaly around point C-38-6. Mineralized zones in serpentinite in deeper parts are suggested by these results.

Serpentinite is distributed in the low resistivity zones near points D-39-12 and D-41-6, which compares with the weak anomaly in the geochemical exploration.

(2) Area D-2

Shallow parts of the apparent resistivity plans and sectional views show complicated resistivity distributions, but low resistivity zones and high resistivity zones are clearly distinguishable in the deeper part. At 16 Hz, a single low resistivity zone, which shows 200 Ω-m or less, is found in the NE direction with an extension range of 200 m, near survey points D-4-6 to D-8-18. The central part has a low resistivity (below 20 Ω-m) running in a NEE direction, with an extension range of about 600 m, from points D-7-12 to D-8-18.

High resistivity zones exist in the western, southern and northern parts of the area, and the deep part shows notably high resistivity values except in the above-mentioned low resistivity zone.

A low resistivity zone in the resistivity structure plans, exists around point D-3-12 and extends deeply. An anomalous zone, around the survey point D-7-15 occurs in the deeper part and shows an eastwards extending tendency. Western and northern parts generally show high resistivity.

Survey point D-7-12, in the resistivity structure sectional views, shows a low resistivity value of 10 Ω-m below 50 m. The deep part at survey point D-4-6 to 9, shows low resistivity values of 10 to 35 Ω-m.

The low resistivity zone around D-3-12 suggests banded ironstone, chert, felsitic sandstone, etc., but no geochemical anomaly was noticed.

Low resistivity around survey point D-7-15, is believed to be caused by the effect of clay-rich layers, etc. in the shallow alluvial layer, but deeper down, mineralized zones are expected in the serpentine rocks on the western side.

(3) Area D-3

Relatively low resistance values (100 Ω-m or less) are noticed from the apparent resistivity plans and sectional views, from the center to the southern part of the area at shallow depths. Low resistivity zones (below 20 Ω-m) at survey points D-3-33, D-3-45, and D-6-42 in the south-

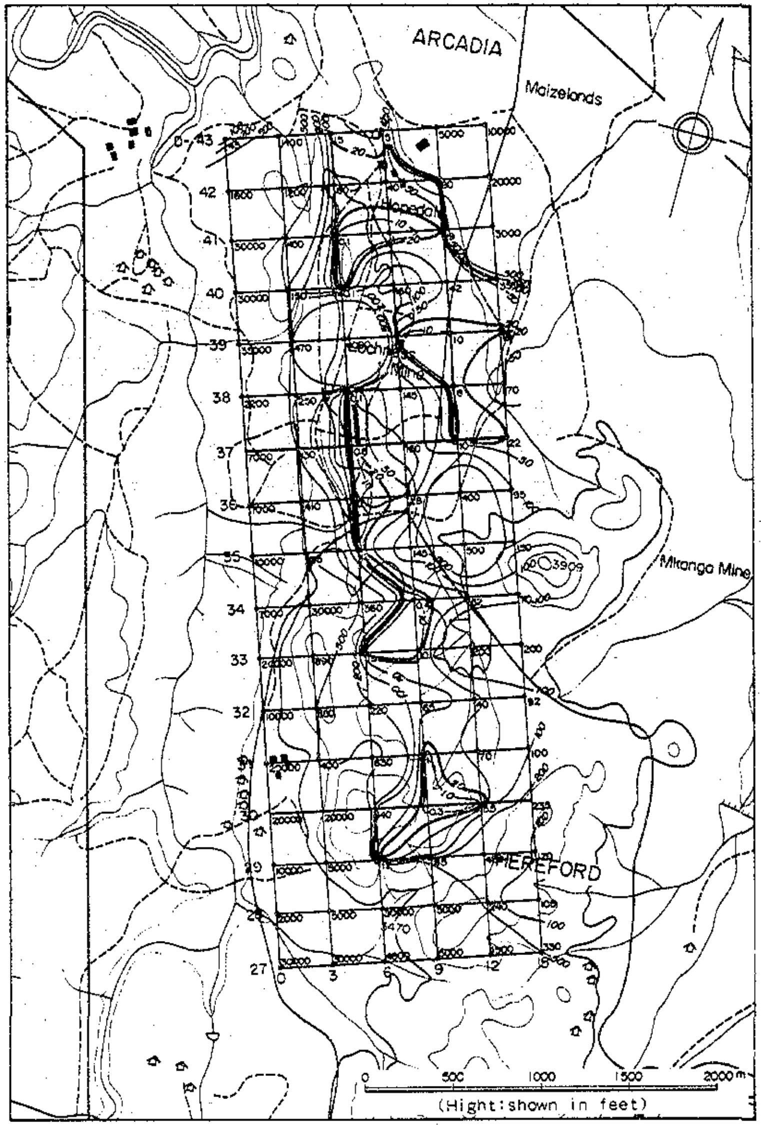


Fig. Ⅱ-4-3-1 (a) Plan of Resistivity Structure (Area D-1, 125m)

unit: Ω-m

A representative level, below 125m from the serface

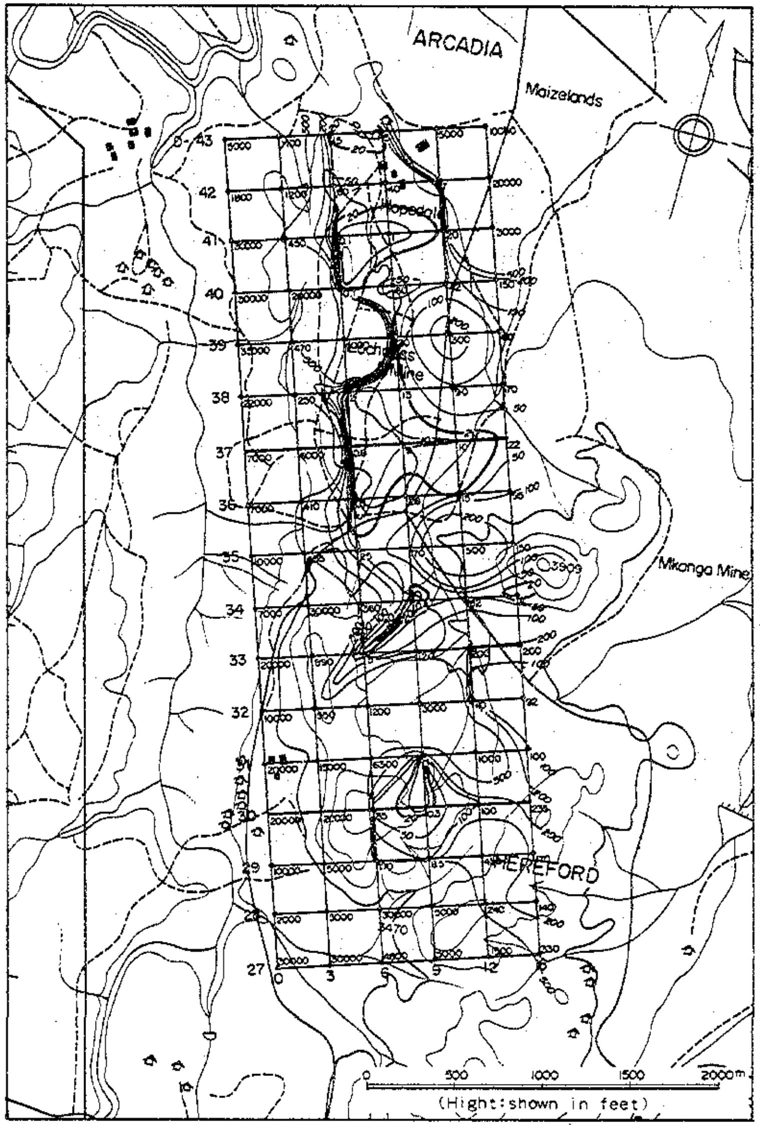


Fig. Ⅱ-4-3-1 (b) Plan of Resistivity Structure (Area D-1, 325m)

unit: Ω-m

A representative level, below 325m from the serface

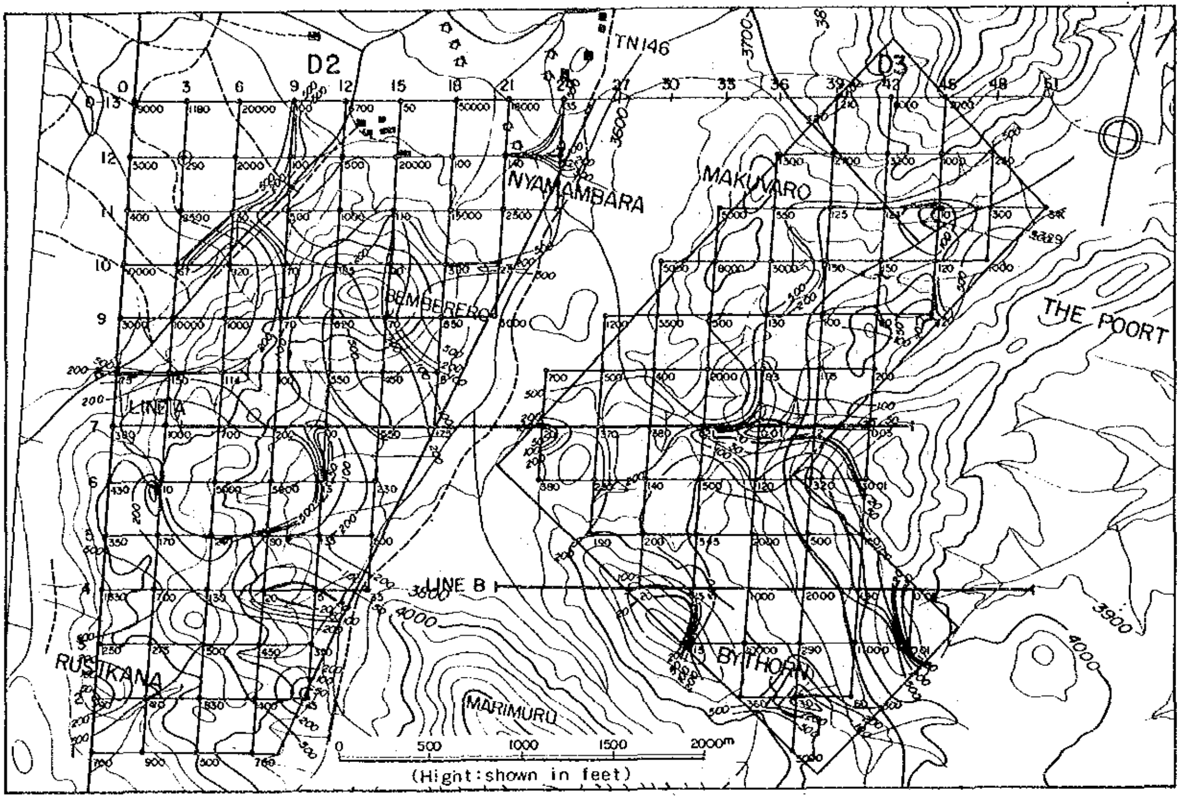


Fig. Ⅱ-4-3-1 (c) Plan of Resistivity Structure (Area D-2, D-3, 125m) unit:Ω-m

A representative level, below 125m from the serface

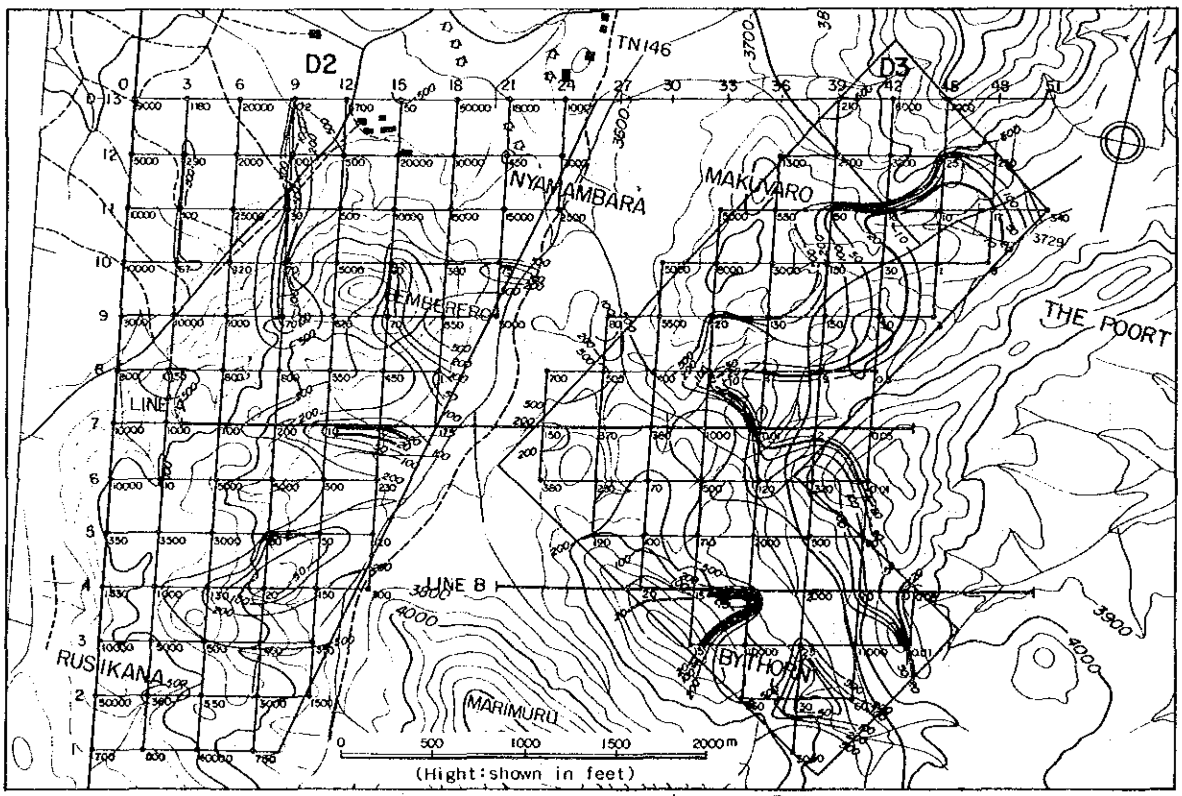


Fig. Ⅱ-4-3-1 (d) Plan of Resistivity Structure (Area D-2, D-3, 325m) unit:Ω-m

A representative level, below 325m from the serface

ern part of the area, are scattered around a high resistivity zone (above 500Ω-m) near survey point D-4-39. Low resistivity zones (below 20Ω-m) are noticed near survey points D-9-45, D-7-36 to 42 and D-3-33 in the deeper eastern part of the area. They show notable low resistivity values (below 10Ω-m) in the central parts.

High resistivity zones are distributed near the above-mentioned point D-4-39 and in the northern part.

Low resistivity zones near point D-3-33 and around points D-7-36 to D-7-12 are noticed, from the resistivity structure plans, in the shallow parts. In the deeper part, low resistivity zones occur extensively in the neighborhood of point D-10-48. A low resistivity zone is also noticed near point D-4-45 at the southeastern end of the area. Northern and north-western parts generally show high resistivity.

The area from survey point D-7-33 to D-7-42, in the resistivity structure sectional views, shows low resistivity values (below 10Ω-m) to depth of 200 m. Point D-4-42 shows a resistivity value as low as 0.3 m near a depth of 200 m. The low resistivity zone near point D-9-45 has been explored in the past. It almost agrees with the Tynan nickel mineralization zone in serpentine which intruded into sedimentary rocks, banded ironstones, komatiitic basalt and komatiitic pyroclastic rocks. A geochemical anomaly is also noticed. The low resistivity zone near points D-7-36 to D-7-42 is associated with the distribution of banded iron- stone. It is connected with the previous low resistivity zone, and the existence of deep mineralized zones is expected. A low resistivity zone, near point D-3-33 is associated with the distribution of banded ironstone and komatiitic basalt. It agrees with a small scale geochemical anomaly as does a low resistivity zone near point D-4-45, where banded ironstone occurs.

SIP Survey

General tendencies (apparent resistivity, PFE, phase differences, etc.) for survey lines A to D, based on the results obtained from the above analysis, and the anomalous zones found in this survey are described in the discussion section.

(1) Survey Line A (D-7-4 - D-7-44)

The apparent resistivity of this survey line suggests the existence of low resistivity zones (below 10Ω-m) under survey points 8 to 10 (n = 2 - 5), under survey point 31 and eastward (n = 2 - 5). Under survey points 34 to 37, a very low resistivity value of about 1 Ω-m was found.

From survey point 9 westward, under survey points 11 to 20 (n = 2 - 5) and under survey points 23 to 29 (n = 1 - 5), high resistivity zones (above 100Ω-m) are thought to exist.

High PFE values of 5% or more were noticed at the low resistivity zones of the above-mentioned three places. Additionally, a negative coupling phenomenon was observed from the spectral characteristics of phase difference which seems to reflect the contrasting high resistivity underground structure. This anomalous zone is discussed later as the first priority anomalous zone. Negative coupling for 3 point decouple phase differences was predominant, and decoupling by this technique is thought to be difficult, so it was omitted from this report. Low PFE values (2% or less) were noticed at the high resistivity zones mentioned above and the spectrum characteristics of phase differences are shown by a straight line with a gradient of almost 45° with frequency increase. This is the usual electromagnetic coupling phenomenon, occurring when IP effects scarcely exist.

In the eastward inclined zone, under survey point 23.5 (n = 3), and the westward inclined zone, under survey point 29.5 (n = 1), spectrum characteristics in the several Hz or less frequency band, show a tendency to constancy or slightly rightward-decrease with frequency increase. This anomalous zone is discussed as the second priority anomalous zone later (Fig. II-4-3-2 (a), (b)).

(2) Survey Line B (D-4-22 - D-4-52)

The apparent resistivity of this survey line shows low values (n = 3-5) over its whole length and suggests the existence of low resistivity zones (below 10Ω-m) especially under survey points 30 to 32 (n = 1 - 5), under survey points 35 to 38 and under survey point 42 eastward (n = 3 - 5).

High PFE values (5% or more) were found at the low resistivity zones of the above-mentioned, three places.

The spectrum characteristics of phase difference show a tendency to constancy, or slightly rightward-decrease, with frequency increase at survey point 32 and westward (n = 1 - 2), under survey points 39 to 41 (n = 1 - 3) and at survey point 44 and eastward (n = 1 - 2). A negative coupling phenomenon was observed over almost the entire area except at the above three places. The former anomalous zone is graded as the second priority anomalous zone and the latter, the first priority anomalous zone. Both are discussed later (Fig. II-4-3-2 (c), (d)).

(3) Survey Line C (D-37-0 - D-37-15)

The apparent resistivity of this survey line suggests the existence of low resistivity zones (below 10Ω-m) under survey points 4 to 7 (n = 2 - 5).

High resistivity zones (above 100Ω-m) are supposed to exist west of survey point 5 (n = 1 - 3) and east of survey point 7 (n = 1 - 3). High PFE values (above 5%) were noticed at the low resistivity zones mentioned above and their spectral phase difference characteristics show negative coupling phenomena. This anomalous zone is discussed later as the first priority anomalous zone.

Spectral characteristics of phase difference at the above-mentioned high resistivity zones, show a gradient of almost 45° with frequency increase, which represents normal electromagnetic coupling phenomenon, when IP effects scarcely exist. Phase difference spectrum characteristics in the low frequency band, at the eastward inclined zone under survey point 6.5 (n = 1 - 4), show a tendency to constancy, or slightly rightward decrease, with frequency increase. This anomalous zone is discussed later as the second priority anomalous zone (Fig. II-4-3-2 (e), (f)).

(4) Survey Line D (D-30-0 - D-30-15)

The apparent resistivity of this survey line suggests the existence of low resistivity zones (below 10Ω-m) under survey points 7 to 10 (n = 1 - 2) and shows very low resistivity values (below 1Ω-m) especially at n = 2 - 3.

High PFE values (above 10%) were noticed at the above-mentioned low resistivity zones. Negative coupling phenomena were noticed from the phase difference spectrum characteristics. This anomalous zone is discussed later as the first priority anomalous zone.

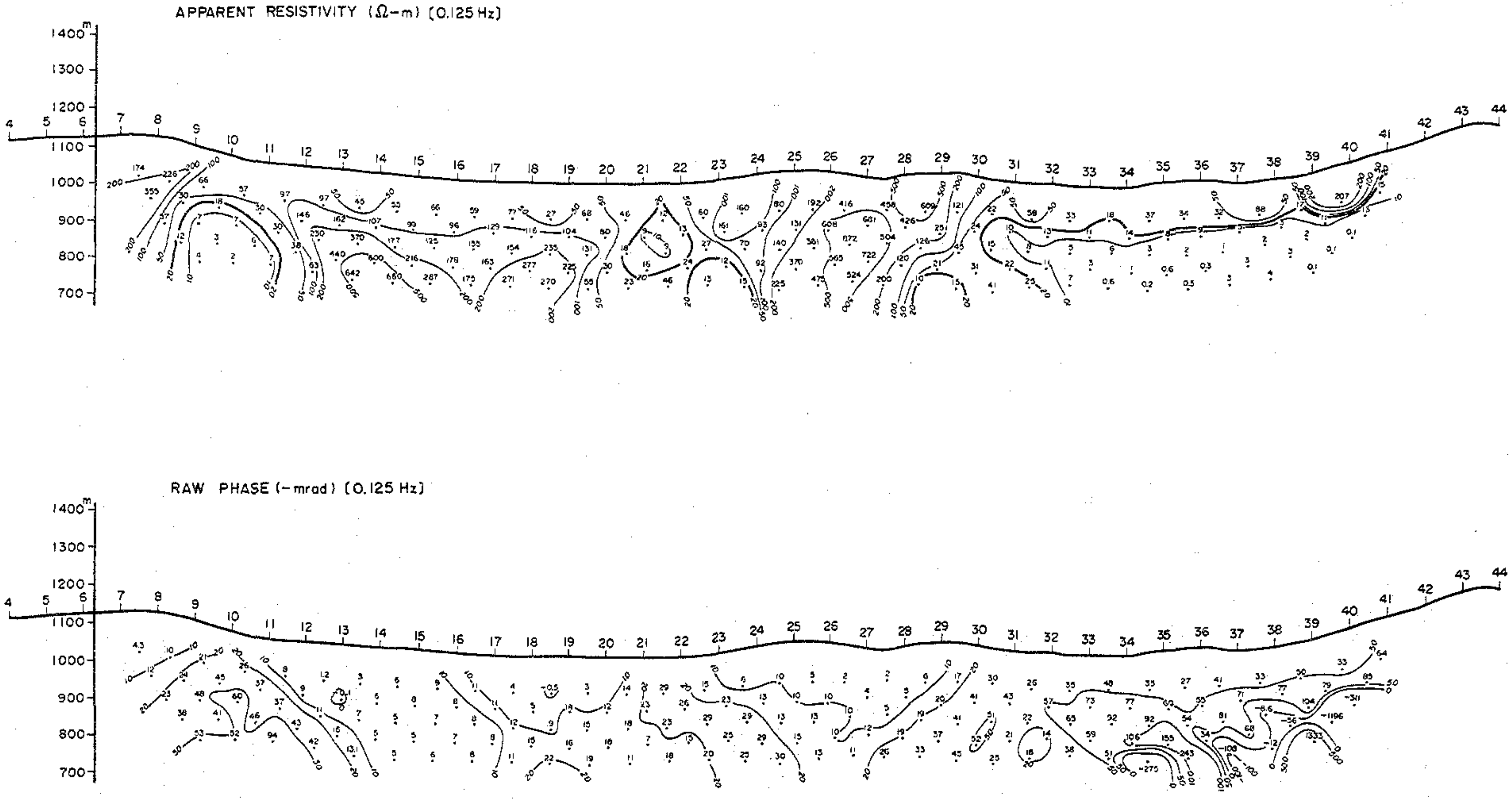


Fig. II-4-3-2(a) Spectral IP Pseudo-Section of Line A (I)

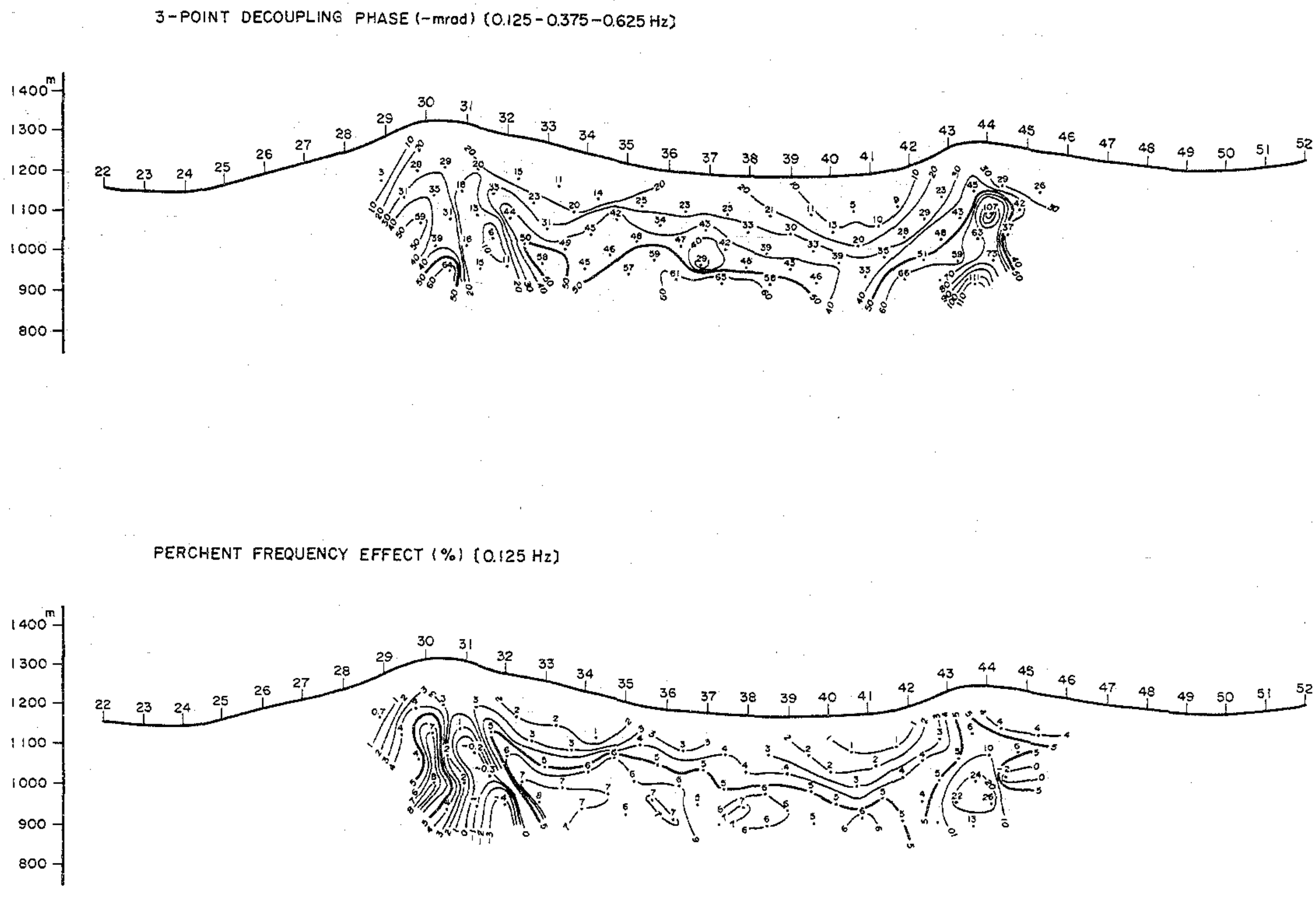


Fig. Ⅱ-4-3-2(d) Spectral IP Pseudo-Section of Line B (2)

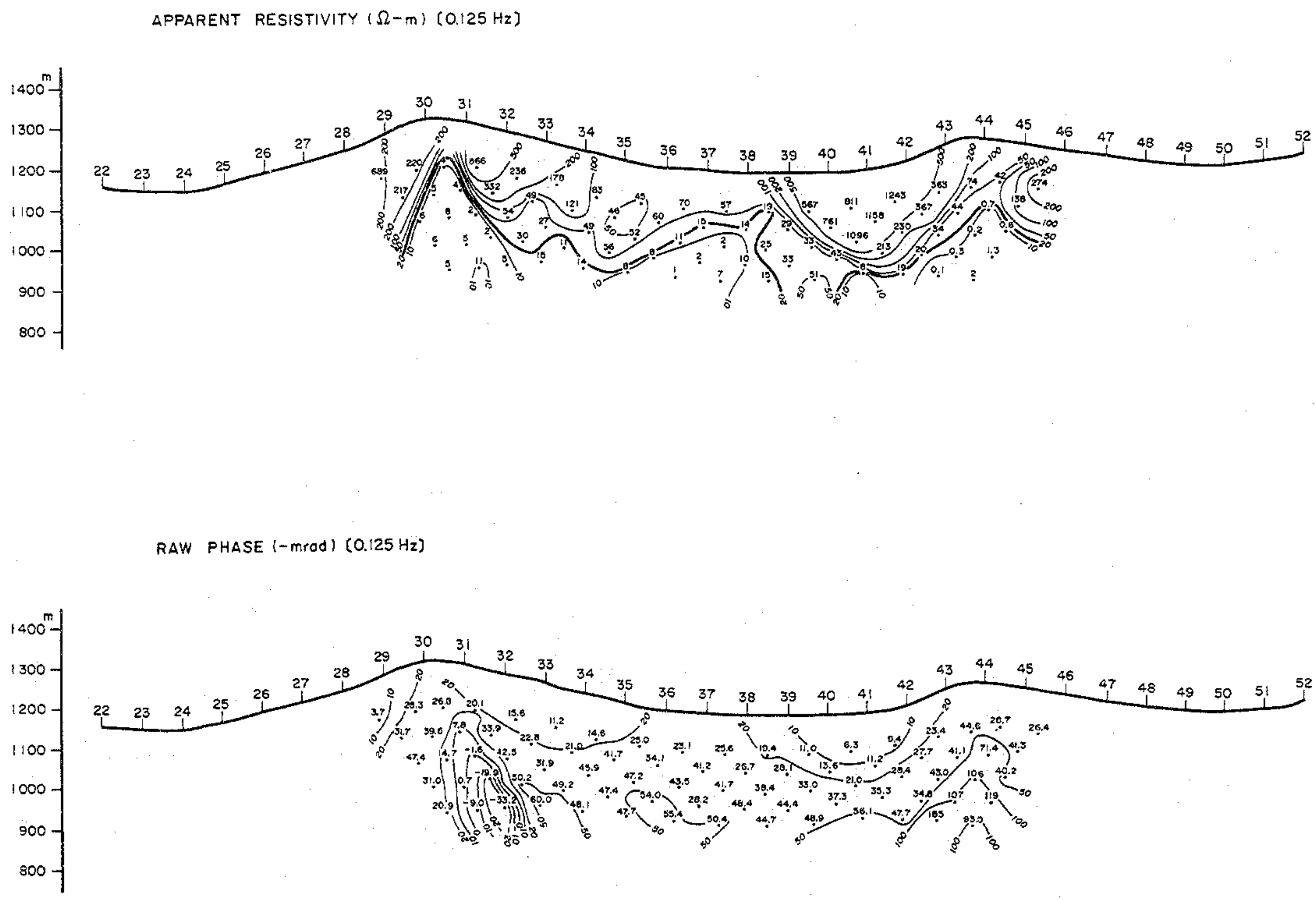


Fig. II-4-3-2(c) Spectral IP Pseudo-Section of Line B (1)

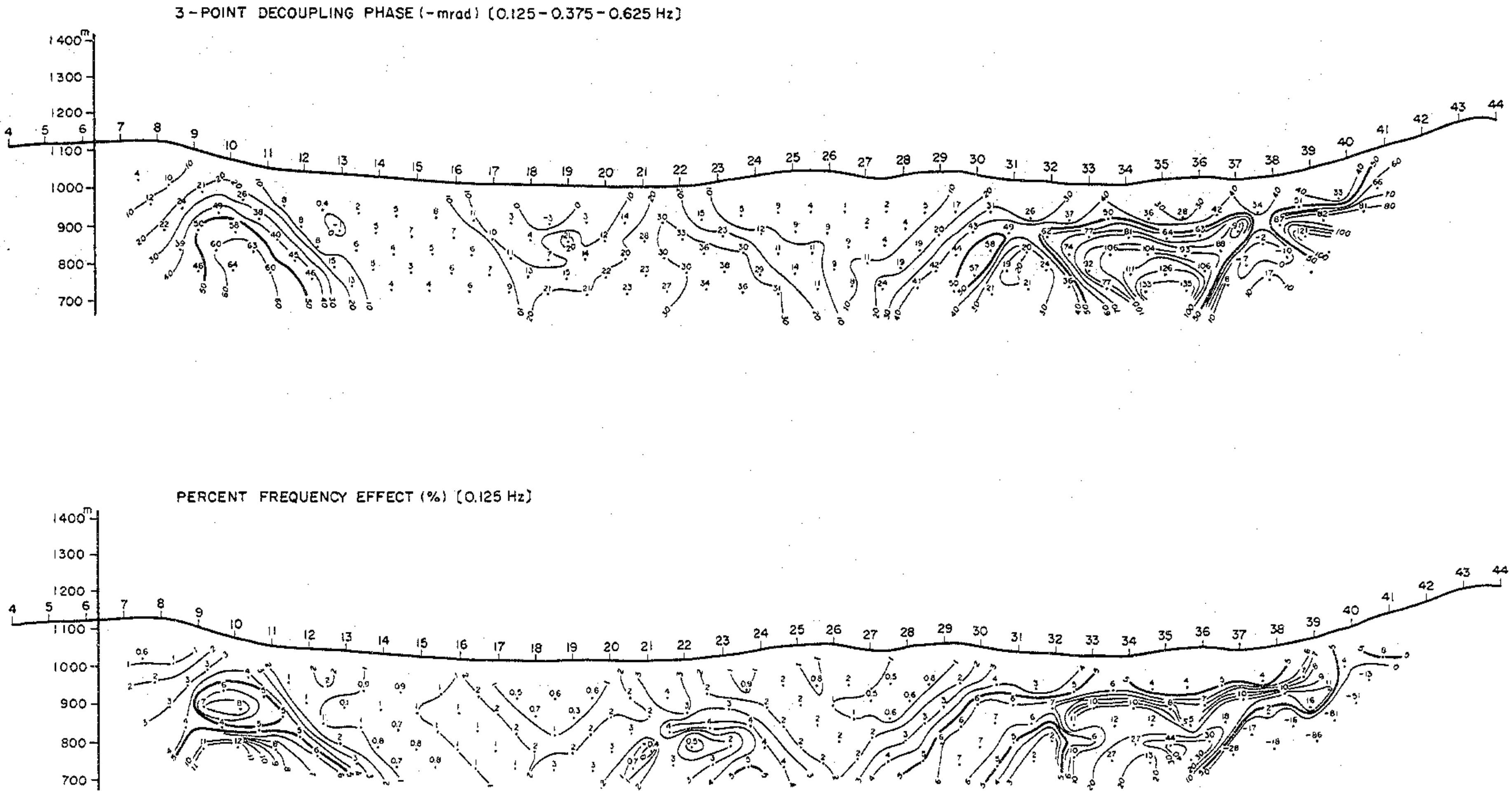


Fig. II-4-3-2(b) Spectral IP Pseudo-Section of Line A (2)

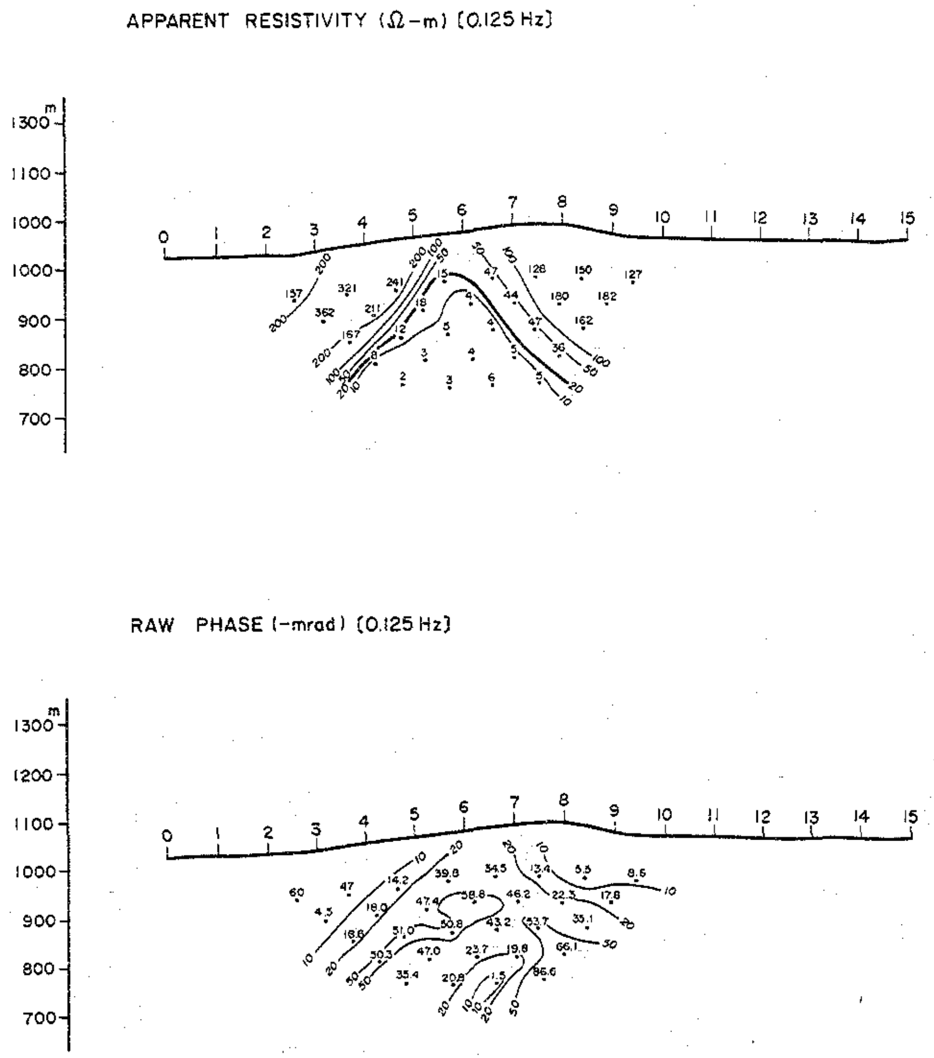


Fig. Ⅱ-4-3-2(g) Spectral IP Pseudo-Section of Line D (1)

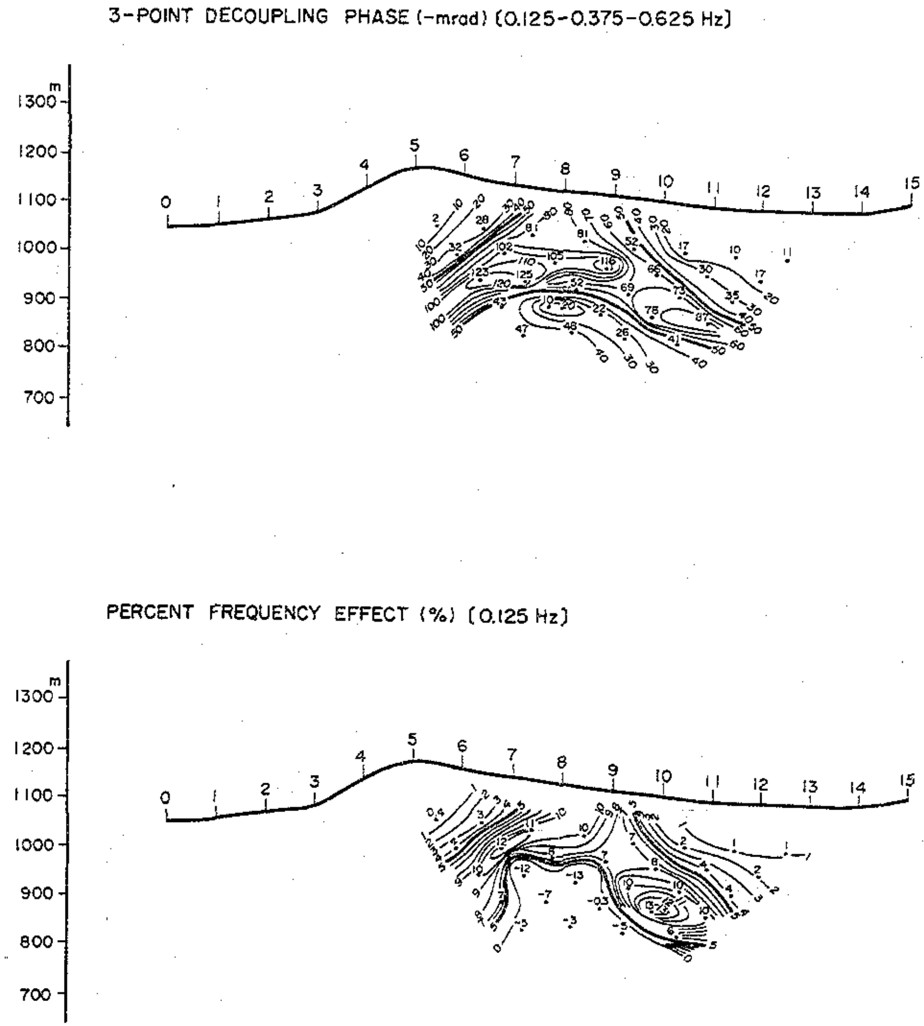


Fig. Ⅱ-4-3-2(h) Spectral IP Pseudo-Section of Line D (2)

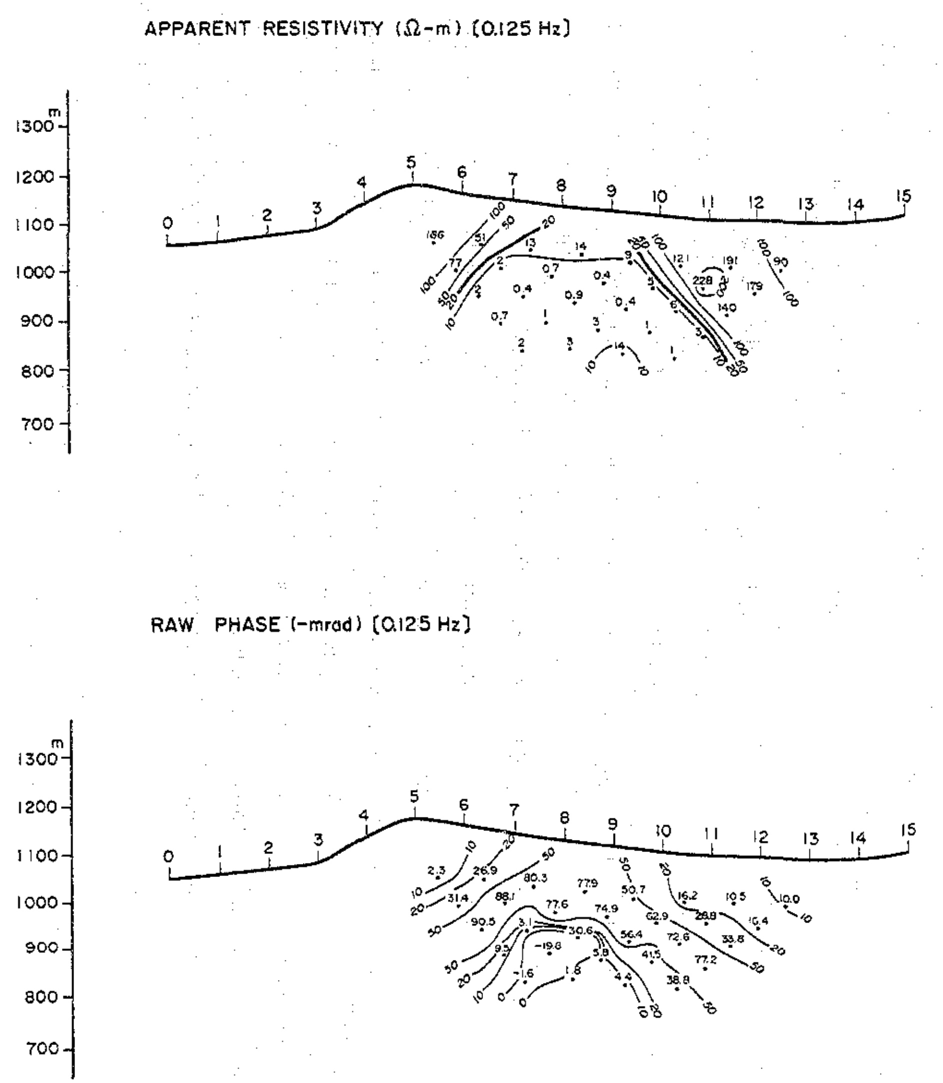


Fig. II-4-3-2(e) Spectral IP Pseudo-Section of Line C (1)

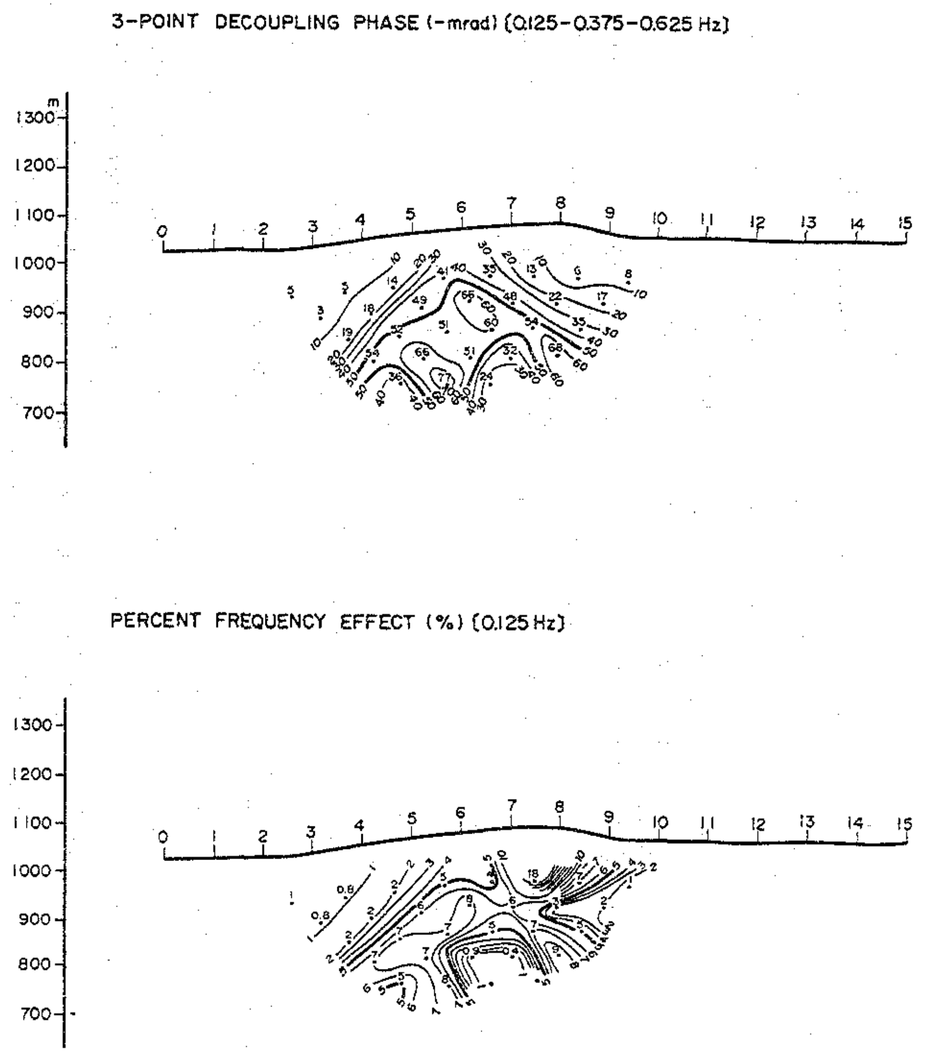


Fig. II-4-3-2(f) Spectral IP Pseudo-Section of Line C (2)

West of survey point 6 (n = 1 - 2) and east of survey point 11 (n = 1 - 2), high resistivity zones (above 100 Ω-m) are thought to exist. Phase difference spectrum characteristics show normal electro-magnetic coupling phenomenon, occurring when IP effects scarcely exist.

The phase difference spectrum characteristics in the low frequency band at the eastward inclined zone under survey point 10.5 (n = 1 - 3), show a tendency to constancy, or slightly rightward-decrease, with frequency increase. This anomalous zone is discussed later as the second priority anomalous zone (Fig. II-4-3-2 (g), (h)).

Discussion

Two categolies of anomalous zones with strong IP effect were found by the SIP survey.

Features of each anomalous zone are described as follows:

(1) First Priority Anomalous Zone

The negative coupling phenomenon is predominant in this anomalous zone, which usually reflects non-uniformity of resistivity structure. it is a phenomenon which particularly appears when a low resistivity zone exists locally in a high resistivity zone, which agrees with the area survey results.

East of survey point 31 on survey line A, the negative coupling phenomenon is noticed over a wide range, and under survey point 21.5 a /\ -shaped characteristic is found.

On survey line B, negative coupling is found over almost the entire region, except parts west of survey point 32 (n = 1 - 2), under survey points 39 to 41 (n = 1 - 3) and east of survey point 44 (n = 1 - 2).

The above-mentioned anomalous zones found on survey lines A and B are thought to be caused by the same rocks of very high conductivity because of the similarity of spectral characteristics.

Negative coupling is noticed under survey point 5.5 (n = 1 - 5) on survey line C and under survey point 8 (n = 1 - 5) on survey line D. The negative coupling is thought to result from the same rocks of very high conductivity because the /\ -shaped characteristic is found in both places and their spectral characteristics are similar.

(2) *Second Priority Anomalous Zone*

This anomalous zone is characterized by a tendency to constancy, or slight rightward-falling phase difference spectrum characteristics, with frequency increase, in the frequency band below several Hz. Spectrum characteristics like this usually have high IP effects. On survey line A, this second priority anomalous zone is noticed in the eastward inclined zone under survey point 23.5 (n = 3) and in the westward inclined zone under survey point 29.5 (n = 1). On survey line B, it is noticed west of survey point 32 (n = 1 - 2), under survey points 39 to 41 (n = 1 - 3) and east of survey point 44 (n = 1 - 2).

Both the above anomalous zones are situated on the periphery of the first priority anomalous zone, and are thought to result from rocks which are changing to the first priority anomalous zone's types.

Also, on survey lines C and D, this second priority anomalous zone is noticed on the periphery of anomalous zone A detected on each survey line.

Geological setting relating to these anomalous zones and their apparent resistivity values are described below:

Survey line A

The apparent resistivity distribution shows notable low resistivity zones (below 10Ω-m) under survey points 8 to 10, 21 to 22 and under survey point 31 and eastward.

Low resistivity under survey points 8 to 10 agrees with the distribution of serpentinite and banded ironstone.

There is a possibility of mineralized zones in this area because the Trojan ore deposit is situated on the boundary of the two layers. The part under survey points 31 to 42 is associated with banded ironstone.

Survey line B

Low resistivity zones (below 10Ω-m) are found under survey point 30 to 32, 35 to 38 and under survey point 42 and eastward. Low resistivity under survey points 3 to 32 and the part under survey points 35 to 38 is associated with banded ironstone. The part under the east of survey point 42 agrees with the banded ironstone-sedimentary rock boundary.

Survey line C

The apparent resistivity distribution shows a notable low resistivity zone (below 10Ω-m) under survey points 4 to 7. Mineralized zones in serpentinite or mineralized zones caused by the intrusion of pegmatite are suspected.

Survey line D

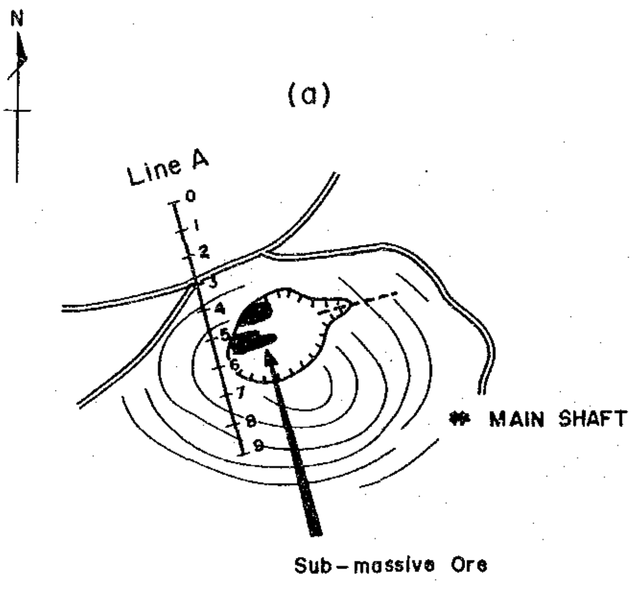
The apparent resistivity distribution shows a notable low resistivity zone (below 10Ω-m) under survey points 7 to 10. Mineralized zones in serpentinite or mineralized zones caused by the intrusion of pegmatite are suspected.

(Reference Data)

A SIP test survey was conducted on the Trojan deposits to get reference data. The test result of the survey line "A" is shown in Fig. II-4-3-4 (a), (b), and II-4-3-5.

From the spectral charactors of the phase difference, negative coupling phenomena reflecting geological structures which have clear resistivity contrast, were detected. This kind anomaly was named as First Class Anomaly as mentioned. These anomalies found in the test area are supposed to be caused by very conductive rocks, and shows the effect of the Trojan deposits.

The test result gave us a good guide line for analysis of the SIP survey results in the survey areas.



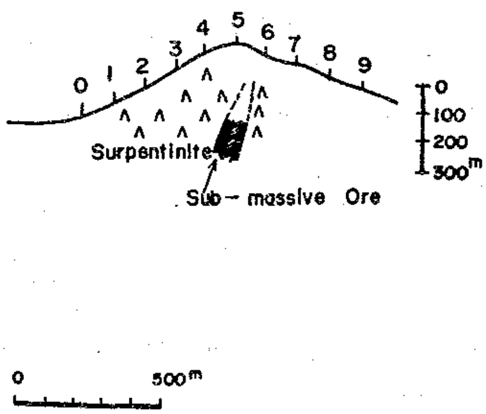
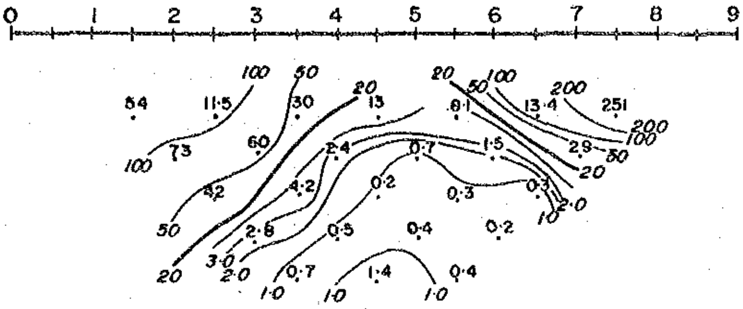


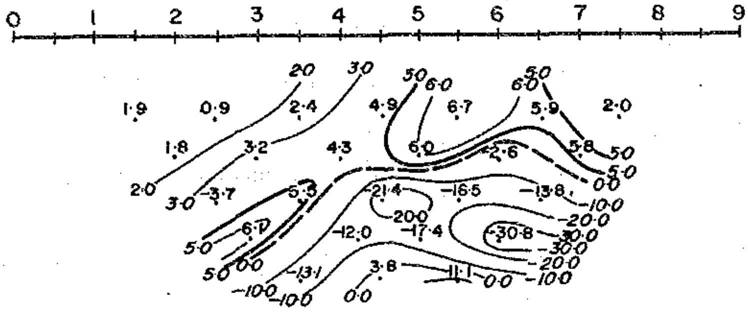
Fig. II-4-3-4(a) Location of SIP Survey Line A (Trojan Mine)

Fig. II-4-3-4(b) Section of Line A

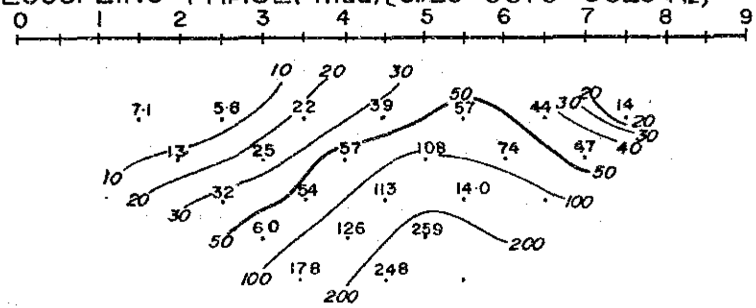
APPARENT RESISTIVITY (Ω − m) (0.125 Hz)



PERCENT FREQUENCY EFFECT (%) (0.125 Hz)



3-POINT DECOUPLING PHASE(-mrad) (0.125-0.375-0.625 Hz)



PHASE SPECTRUM

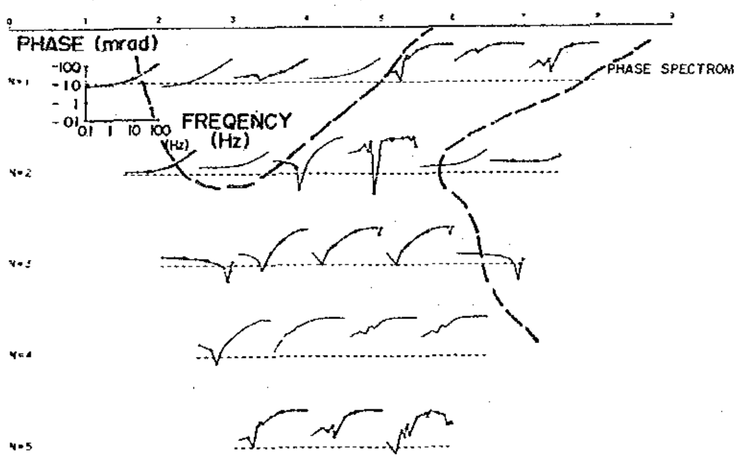


Fig. Ⅱ-4-3-5 Spectral IP Pseudo-Section Line A (Trojan Mine)

Results of Measuring IP Properties

The IP properties of 22 ore samples collected in the survey area were measured. Representative samples of the ores distributed in the survey area were selected, including the same ores with different degrees of alteration, to provide as many types of samples as possible. Samples were collected evenly from all the D-1, D-2, D-3, and C areas, and measured results are shown in Table II-4-3-1.

The ores show low resistivity and high IP effect. Serpentines, tuffs, and banded ironstones show relatively low resistivity but moderate IP effect. The phase difference of the ores is very high (about 800 m rad peak) but the resistivity ranges from 59 Ω-m at 0.125 Hz to 45 Ω-m at 88 Hz.

These properties of the ore samples are clearly different from those of other rocks.

Table II-4-3-1 IP Properties of Ore and Rock Samples

No.	Sample No.	Resistivity 0.125Hz(Ω-m)	Raw Phase 0.125Hz(-mrad)	3ptDecoupled (-mrad)	P.F.E. (%)	Rock name	Sample Locality
1	1	792	3.08	-0.43	1.04	Banded Ironstone, cherty part	D-3
2	2	1111	15.0	15.7	1.84	Banded Ironstone, iron-rich part	D-3
3	3	1531	11.1	10.5	1.54	Banded Ironstone, hard cherty part	D-3
4	5	3028	11.0	11.1	1.45	Serpentinite, strong	D-3
5	9	1214	6.95	4.48	1.35	Serpentinite, weak	D-3
6	10	17011	14.0	12.70	2.07	Pyroxene Andesite,(komatiite ?)	D-3
7	12	2768	7.53	6.79	1.14	Dolerite	D-3
8	13	2571	11.33	9.02	1.91	Chert,(sandstone ?)	D-3
9	14	2078	10.1	9.73	1.43	Granite	D-3
10	15	8989	10.1	8.95	1.59	Gabbro	D-3
11	16	4072	5.13	4.37	0.86	Andesite	D-3
12	18	1707	9.52	8.78	1.39	Andesite, weak serpentinized	D-2
13	19	3671	3.74	3.66	0.61	Pegmatitic Granite	D-2
14	20	611	13.35	16.0	1.25	Serpentinite	D-1
15	27	498	5.77	2.91	1.34	Acidic tuff	D-1
16	28	173	3.11	-3.01	1.58	Serpentinite	D-1
17	21	9864	3.70	3.12	0.61	Basalt	C
18	22	8691	7.13	5.75	1.06	Dolerite	C
19	23	8642	5.68	5.14	0.84	Porphyrite	C
20	24	21760	4.30	3.74	0.66	Basalt, weak serpentinized	C
21	30	14040	4.41	4.40	0.63	Komatiite	C
22	31	59	54.01	457.7	138.4	Ni-Cu Ore	Trojan

The summary results of the geological, geochemical, and geophysical surveys are as follows.

Area D-1

The low resistivity zones around D-41-6, D-39-12, D-38-6, D-33-6, and D-30-9, which were detected by the CSAMT survey, are located on a serpentine body in the extension zone of the Trojan ore horizon in the north-south central part of the area. Their depth extension is also good. Among them, D-41-6 and D-38-6 coincide with the distribution of pegmatite dykes. This is an inconsistent phenomenon, because, generally, pegmatites show high geophysical resistivity. It might indicate that these pegmatite dykes are small scale, with poor depth extension.

The zones of D-41-6, D-39-12, and D-33-6 are not coincident with any geochemical anomaly, but the zones of D-38-6 and D-30-9 are coincident with strong geochemical anomalies. The latter two zones extend to depth, and their scales are extensive. Therefore, the potential for expected sulphide ore deposits associated with serpentines is high, and further geophysical survey, SIP, was recommended for them.

The IP anomalies around D-36-4 to D-36-8 and D-30-6 to D-30-11, found in SIP survey lines "C" and "D" are deep-sited and strong. They are expected to be caused by nickel sulphides associated with serpentines. It is therefore recommended that a drilling program be conducted to examine the existence of mineralized zones.

Area D-2

The low resistivity zones around D-3-12 and D-8-18, which were detected by the CSAMT survey, are on the eastern side of a serpentine body in the extension of the Trojan ore horizon, the local rocks are banded ironstones. The zones extend to depth, but are not coincident with any geochemical anomaly. In spite of this evidence, the D-8-18 zone was covered by a SIP survey line in relation to the low resistivity zones detected by the CSAMT survey in Area D-3.

The IP anomaly around D-7-10, which was found in the SIP survey line "A", is a deep-sited one, located near a serpentine body. It is expected to be caused by nickel sulphides associated with serpentines, and it is recommended that a drilling program be conducted to examine the existence of mineralized zones, despite the lack of an associated geochemical anomaly.

Area D-3

The low resistivity zones around D-4-33, D-7-36 to D-7-42, and D-9-39 to D-9-42, which were detected by the CSAMT survey, are on a serpentine body surrounding banded ironstones, in the extension of the Trojan ore horizon. A geochemical anomaly is coincident with this serpentine body, and closely associated with the low resistivity zones. Depth extension of the zones is good.

Among them, the zone D-10-39 to D-9-42 is well known as the Tynan Occurrence. Extensive exploration programs have been conducted by companies several times, including drilling programs. Therefore, this zone was eliminated from the SIP survey target. The rest are in a favourable geological setting and coincident with geochemical anomalies. Further SIP survey was therefore recommended for them.

The IP anomaly around D-7-35, which was found in the SIP survey line "A", is strong, deep-sited, and is located in the southwestern extension, about 600m, of the Tynan Occurrence in the eastern rim of the serpentine body. This strongly suggests that the anomaly is caused by nickel sulphides associated with the serpentine. It is therefore recommended that a drilling program be conducted to examine the existence of mineralized zones.

The IP anomaly around D-4-44, which was found in the SIP survey line "B", deviates from the serpentine body and geochemical anomalies. Rocks around here are banded ironstones and cherty sediments. But because this good IP anomaly exists in association with a low resistivity zone, it is wise not to ignore it. A drilling program to examine the existence of mineralized zones is recommended here too.

The IP anomaly around D-4-30, which was found in the SIP survey line "B", is on the serpentine body, coincident with a good geochemical anomaly, and is in the deep extension of the D-4-44 zone. It is expected to be caused by nickel sulphides associated with serpentines, and it is recommended that a drilling program be conducted to examine the existence of mineralized zones.

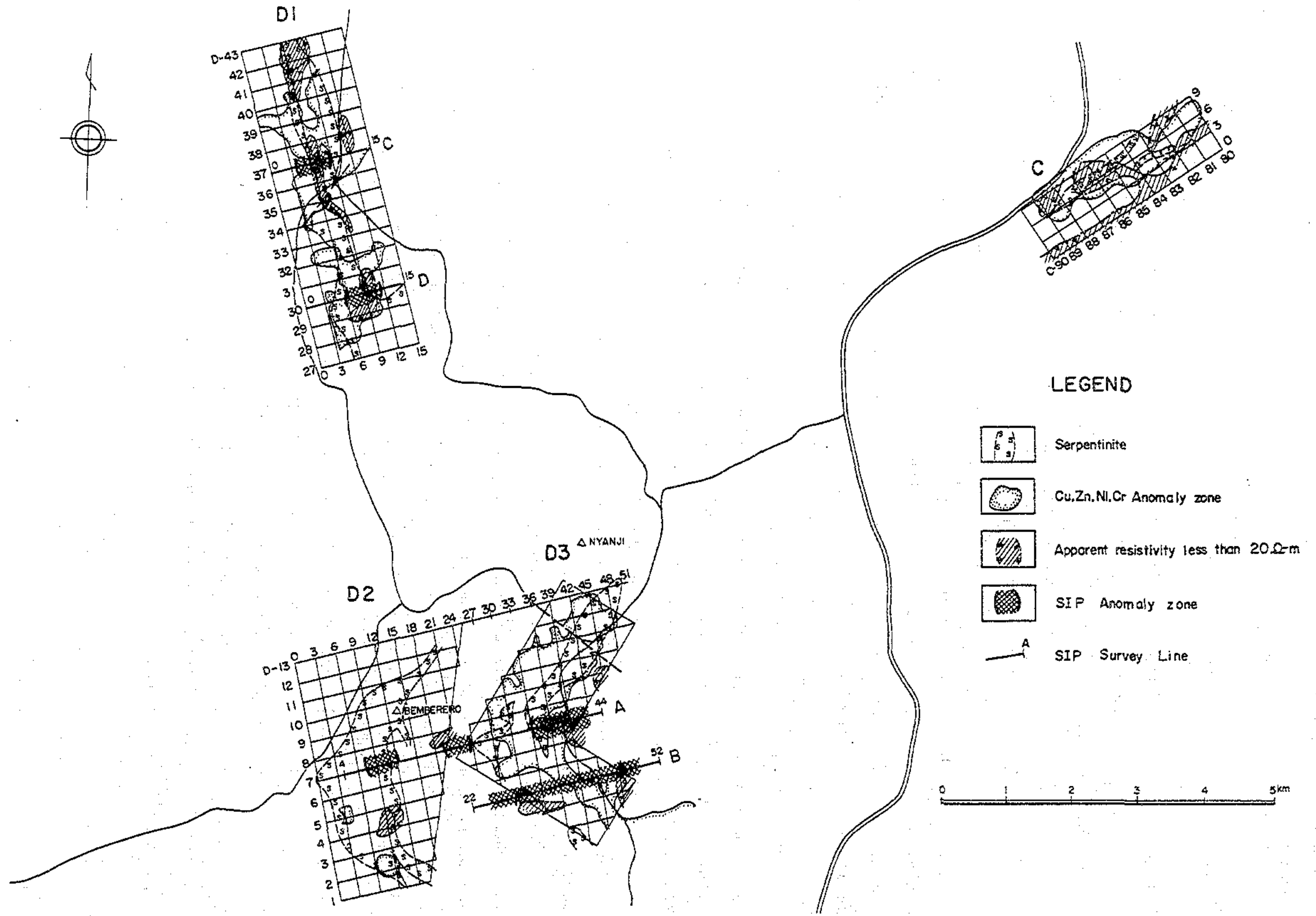


Fig. II-4-3-3 Compilation Map of CSAMT, SIP Rgesults, Geology, & Geochemistry

4-4 Drilling Survey

Selection of the Drilling Targets

In the third and final year's programme for the Shamva Project, based on the whole results of the geological, geochemical and geophysical surveys conducted in the previous two years, a drilling programme was planned to examine potential mineral occurrences in the most promising anomalous targets.

The following points were considered as important elements for the selection of drilling targets.

(1) Favourable geological setting similar to that of the Trojan nickel ore deposits.

(2) Good geochemical anomaly in Ni, Cr, Cu, and Zn.

(3) Low resistivity anomaly in CSAMT survey, and IP anomaly in SIP survey.

Although the above mentioned elements were basic ones, some targets were selected because of their favourable geological setting, despite lack of geochemical or geophysical anomalies.

Summary of the anomalies in the selected drilling targets is shown in Table II-4-1-1.

Table II-4-4-1 Summary of Anomalies in Drilling Taregets

Hole No.	Geology	Geochem.	CSAMT	SIP	Others
MJZ-1	Edge of serpentine	None	Low resistivity	-	North of Loch-ness pegmatite
MJZ-2	Edge of serpentine	Yes	Low resistivity	Medium	South of Loch-ness pegmatite
MJZ-3	Edge of serpentine	Yes	Low resistivity	Medium	
MJZ-4	Edge of serpentine	None	High resistivity	-	
MJZ-5	Edge of serpentine	None	Low resistivity	Medium	
MJZ-6	Edge of serpentine	None	Low resistivity	-	
MJZ-7	Edge of serpentine	Yes	Low resistivity	Strong	Southwest of Tynan nickel occurrence
MJZ-8	Banded ironstone	Nearby	Low resistivity	Medium	

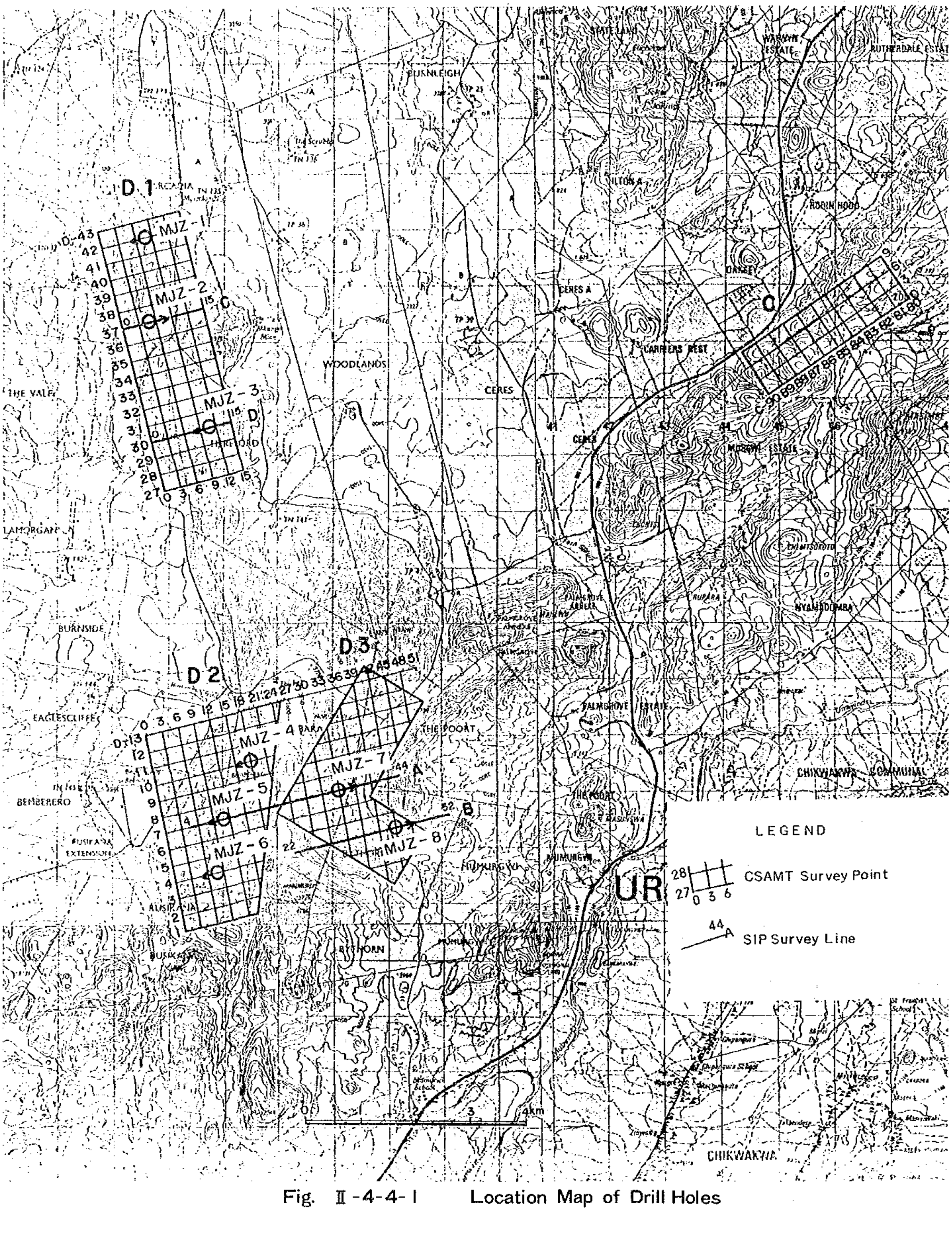


Fig. Ⅱ-4-4-1 Location Map of Drill Holes

Table Ⅱ-4-4-2 Summary of Drilling Programme

	Azimuth	Dip	Depth(m)	Period
MJZ-1	255°	-60°	200.05	7.10.1985 ∿ 29.10.1985
MJZ-2	75°	-60°	201.00	19. 9.1985 ∿ 17.10.1985
MJZ-3	255°	-60°	200.03	4. 9.1985 ∿ 28. 9.1985
MJZ-4	255°	-60°	200.00	2. 9.1985 ∿ 8.10.1985
MJZ-5	255°	-60°	200.09	14. 8.1985 ∿ 20. 9.1985
MJZ-6	255°	-60°	200.03	9. 8.1985 ∿ 31. 8.1985
MJZ-7	75°	-60°	250.00	4. 7.1985 ∿ 3. 9.1985
MJZ-8	75°	-60°	200.00	5. 7.1985 ∿ 9. 8.1985
			1,651.20	

Outline of Geology for Each Hole and Correlation with Geophysics

MJZ-1

The rocks of the hole are green schist, talc schist, biotite schist, and muscovite schist, except a section of banded ironstone from 9.65 meter to 11.00 meter. Within them, especially in the shallow parts of the hole, lenticular pebbles of granitic rocks are enclosed in the biotite schists. These are probably products of compaction by reactivation of the granites and gneiss.

In the deeper parts of the hole, the rocks are injected by pegmatitic material consisting of chlorite, epidote, quartz, feldspar, etc.

As the hole is located near the granite-gneiss terrain, the rocks of the hole were affected by compaction and pneumatolytic reaction.

The hole is situated in an area of shallow low resistivity (30 -m) in the CSAMT survey, and no SIP survey was conducted. The rocks in the shallow part of the hole such as banded ironstone and water holding zones such as shears in the surrounding area presumably caused such low resistivity.

MJZ-2

The rocks of the hole are biotite-quartz schist enclosing granitic pebbles down to 41.00 meter, then pebble-free types of the same rocks down to 52.60 meter, then ultramafic volcanics (hornblendite) down to 77.40 meter, then quartz schist down to 109.50 meter, then pebbly biotite schist down to 195.00 meter, and finally pebble-free biotite schist down to the bottom at 201.00 meter. Pegmatite injections are recognized between 133.00 meter and 195.00 meter, and some pyrrhotite occurs within this zone.

The hole is situated in an area of low resistivity (Approx. 30 -m) in the CSAMT and SIP surveys, and of a clearly defined IP anomaly in the SIP survey. No good indication explaining those anomalies was recognized in this hole. It is presumed that the anomaly is seated in a deeper part around there.

MJZ-3

The rocks of the hole are serpentine down to 53.20 meter, this rock containing 0.70 meter and 1.40 meter thick talc schist inclusions and a

0.10 meter thin asbestos layer, then alternation of ultramafic volcanics and thin sandstone-chert layers down to 86.50 meter, then serpentine down to 150.30 meter with intercalations of 3.50 meter of pegmatite, 2.30 meter of banded ironstone, 0.90 meter of graphitic schist assaying Cu 0.14%, and 0.17 meter of massive pyrrhotite with minor chalcopyrite assaying Cu 0.38%, Ni 0.56%, and Co 0.08%. After 150.30 meter, ultramafic volcanics occurs to the bottom at 200.03 meter, and contain three 0.20 meter to 0.55 meter-thick andesite dykes and a 0.30 meter-thick tuffaceois layer.

The hole is situated in an area of low resistivity (several -m) in the CSAMT survey combined with similar resistivity and a significant IP anomaly in the SIP survey. However no obvious interpretation of these anomalies was recognized in the hole. The reason for it seems that the size of the expected mineralized zone judged from the anomalies is too small to locate by a drill hole.

The geology of the hole is very favourable for nickel sulphide ore deposits associated with ultramafic rocks. In addition some small but distinct copper-nickel occurrences are recognized in the hole. Consequently it is considered that the area around this hole is one of the highest potential areas for economic ore deposits.

MJZ-4

The rocks of the hole are quartz-biotite schist down to 77.90 meter, then ultramafic volcanics - intrusives down to 150.00 meter, then serpentine down to the bottom at 200.00 meter. No mineralized zone is found in the hole.

The hole is situated in an area of high resistivity (several hundred to 1,000Ω-m) in the CSAMT survey where no SIP survey was conducted. The geology of the core satisfactory explains the high resistivity.

MJZ-5

The rocks of the hole are andesitic pyroclastics down to 47.20 meter, then argillaceous rocks down to 109.90 meter, then banded ironstone down to 116.10 meter, then serpentine down to the bottom at 200.09 meter.

The hole is situated in an area of low resistivity (approx. 10

Ω-m) in the CSAMT survey combined with similar resistivity and a low level (10% REF) small scale IP anomaly in the SIP survey. These anomalies are interpreted as probably due to a 30 meter-thick banded ironstone containing disseminated to semi-massive pyrrhotite, a pegmatite dyke containing some probably remobilized pyrrhotite, and widespread minor amounts of disseminated pyrrhotite in the argillaceous rocks and pyroclastics.

MJZ-6

Except dolerite intersected from 181.10 meter to the end of the hole at 200.03 meter, almost entire hole was drilled through predominantly argillaceous rocks, graphitic schist and banded ironstone.

Pyrrhotite layers up to several millimeters thick are interbeded in the graphitic schist forming a banded texture, but may also form disseminated, pod like, stockwork, and semi-massive textures. Several tens centimeters thick pyrrhotite layers and lenses are alternatively interbeded in the banded ironstones where in some sections they form disseminated, veinlet, and network textures. As the pyrrhotite quite often cuts across original sedimentary textures of the rocks, it is suggested that these minerals were removed from their original chemically precipitated positions during the period of metamorphism.

Such mineralized zones are seen from 51.40 meter to 181.10 meter, a length of 130.00 meters. Within this section, a 2.50 meter quartz vein containing some pyrrhotite and a 3.50 meter pegmatite are included.

The significant assay values of these mineralized sections are as follows.

From	To	
84.50 m	84.90 m	Cu 0.19%, Ni 0.18%, Co 0.04%
70.25 m	71.75 m	Au 0.3 g/t
104.30 m	105.80 m	Au 0.2 g/t
108.85 m	109.90 m	Au 0.2 g/t
133.80 m	135.70 m	Au 0.3 g/t
159.00 m	161.33 m	Au 0.2 g/t

This type of sulphide mineralization in Archaen greenstone belts in

Zimbabwe contains gold in some places and, though low grade, may be large in scale. Some deposits are in operation as gold mines. The low assay values reported from this hole are, however, of no economic interest.

The hole is situated in an area of low resistivity (approx. 10Ω-m) in the CSAMT survey where no SIP survey was conducted. The large amounts of sulphide minerals in the hole certainly account for the resistivity anomaly.

MJZ-7

The rocks of the hole are andesitic pyroclastics down to 35.00 meter, then predominantly serpentine down to the bottom at 250.00 meter. Mafic volcanics are intercalated between 197.10 meter and 227.40 meter.

Very strong shear zones were intersected in the hole from surface to a depth of 120 meter, those parallel to the foliation of the serpentine causing many drilling problems.

Drilling intersected disseminated to semi-massive pyrrhotite zones in the serpentine. Sulphide ratios to the waste are 20% to 30%, and in most parts inclusions of graphitic argillaceous rocks are contained.

Assay results of this mineralized zone show Cu 80-640 ppm, Ni 160-630 ppm, Co 50-100 ppm.

The hole is situated in an area of low resistivity (20Ω-m) in the CSAMT survey and very low resistivity (several Ω-m) combined with a deep seated large scale significant IP anomaly showing a double pattern in the SIP survey. However no mineral occurrence was seen at the depth expected from the anomaly. The reason may be that the hole was not deep enough to reach the expected mineralized zone: our experiences is that IP anomalies quite often appear above actual mineral occurrences. Judging from the scale and quality of the anomaly, it is still expected that deeper seated mineralized zones occur in the vicinity of the hole. Above mentioned 15 meters mineralized zone is too shallow to be detected by geophysical surveys using a wide spacing of electrodes.

Judging from such favourable geological setting similar to that of the Tynan occurrence and those sulphides occurrences in the hole, areas between the hole and the Tynan occurrence can be evaluated as one of the highest potential areas for economic ore deposits.

MJZ-8

The rocks of the hole are gneiss down to 30.90 meter, then andesitic pyroclastics down to 57.00 meter, then quartz-biotite schist down to 139.40 meter, then finally gneiss down to the bottom at 200.00 meter. Thin pegmatite dykes (0.40 to 0.80 meter) intruded around the depth of 100 meter. The gneiss underlies in the shallow part of the hole than expected from the surface geology, therefore the slope angle of its surface would be very gentle.

No mineral occurrence was fouind in the hole.

The hole is situated in an area of high resistivity in the shallow part and low resistivity (several Ω-m) in the deeper part in the CSAMT survey, and same range resistivity and weak small scale IP anomaly in the SIP survey. But no evidence to explain these anomalies is recognized. The reason for it is probably that near surface weak mineral occurrences around the electrodes of the SIP survey affected to the results relating to the electrode arrangement.

Outline of Mineralized zones

As described in the previous section, some sulphide mineral occurrences were found in four holes among eight holes drilled in this programme. Summary of the mineral occurrences in the each drill hole is as follows.

Table II-4-3-1 Mineral Occurrences in Drill Holes

Hole No.	Sulphides associated with Ultramafic rocks	Sulphides associated with Banded ironstone	Sulphides associated with Graphitic rocks
MJZ-3	0.17m msv Po with some Cp, 0.20 m semi-msv Po	2.30m semi-msv Po	0.90m semi-msv Po
MJZ-5		19.15m semi-msv Po	
MJZ-6		62.05m diss - semi-msv Po	41.90m diss - semi-msv Po
MJZ-7	15.00m diss - semi-msv Po		

Hole No.	Minerals associated with Pegmatite	Quartz vein
MJZ-3	3.50m	
MJZ-5	16.95m minor Po	0.50m minor Po
MJZ-6	3.75m	2.40m minor Po

Note
Po: Pyrrhotite
Cp: Chalcopyrite

Samples for analysis were basically prepared for every 1.50 meter section of the mineralized sections, and were assayed elements of Cu, Ni, and Co for sulphides, Nb, Ta, and Sn for mineral occurrences associated with pegmatite, and Au for every two samples. Results of the assay are shown in the supplemental table, and some significant values selected from the table are as follows.

Hole No.	Section m	Cu %	Ni %	CO %	Au g/t
MJZ-3	91.60 - 91.77	0.379	0.560	0.081	
	146.80 - 147.70	0.139	0.065	0.021	
MJZ-6	70.25 - 71.75				0.3
	84.50 - 84.90	0.187	0.178	0.037	
	104.30 - 105.80				0.2
	108.85 - 109.90				0.2
	133.80 - 135.70				0.3
	159.00 - 161.33				0.2

Of these the first shows some economical values, but the section is only 0.17 meters. Nevertheless this is a mineral occurrence in serpentine, a favourable host rock for Trojan type nickel mineralization, and it is suggested that a very high potential for economic ore deposits exists in the area around the hole.

4-5 Conclusion

The distribution of ultramafic rocks and banded ironstone is very extensive. Furthermore, as this area is situated in the extension zone of the Trojan ore horizon, it is suggested that the geological setting is very favourable for hosting further such ore deposits. Results of the geochemical and geophysical surveys showed many significant anomalies. In four out of eight boreholes drilled on the basis of these results, pyrrhotite was intersected.

The occurrences in the holes MJZ-3 and MJZ-7 are especially significant, their geological settings being very favourable for hosting ore deposits.

Therefore, it is concluded that this area has the highest potential for economic ore deposits, and is the most attractive one for further exploration activities.

CHAPTER 5 AREA E

5-1 Geological Survey

The Area is underlain by the Lower and Upper Bulawayans. The Lower Bulawayan occupies very small area in the central east part of the area, and consists of quartzite and sandstone. The Upper Bulawayan occupies major part of the area, and consists of serpentinite and mafic lavas with interbedded thin layers of banded ironstone. The serpentinite is distributed in the central to northen part of the area, and is 200 m - 1,000 m in thickness. But serpentinization is generally weak. Under the microscope, original rocks of some serpentinites are identified as dunite, lherzolite, and wehrlite, but some others presumably seemed to be komatiitic ultramafic lava.

In the central west part of the area, an edge of a big granitic complex body is exposed. In the southern part of the area, small stocks of gabbro and microdiorite intrude in the greenstones.

The rock pile strikes north to south in the northern part of the area, but east to west in the southern part of the area. The shape of the geological structure is open to the north, and the dip of the rocks is generally very steep, almost vertical.

A small operation of gold was worked in the Churchill mine in the southern part of the area until several years ago when the gold price was high. But it has ceased operation now. The ore seems to be hosted in the contact zone between a microdiorite stock and mafic rocks.

5-2 Geochemical Survey

As a result of the geochemical survey, anomalies of Ni and Cr were detected in accordance with the distribution of serpentinites. For Ni, anomalies in "B" zone (624 to 1831 ppm) and those in "A" zone (1832 ppm and more), which are scattered in the same area as that of the former, were noticed, and for Cr, anomalies in "B" zone (1118 to 3461 ppm) were noticed. However, the anomalies of Cu and Zn were not found. The anomalies of Ni and Cr are thought to have caused by bed rocks and higher anomalies of Ni are scattered in patches. As to Au, weak anomalies are scattered all over the area. A small gold mine exists near the southwestern end, the anomalies are though to be related to its mineralization.

5-3 Conclusion

The results of the surveys show that the distribution of ultramafic rocks is large, but the results of the geochemical survey are negative, just showing background values for those rocks.

Therefore, as the conclusion, it can be said that the potential for economic ore deposits in the area is low.

PART Ⅲ.

CONCLUSIONS AND FUTURE OUTLOOK

CHAPTER 1 CONCLUSION

The Shamva project, consisting of geological and geochemical surveys in 1983, a geophysical survey in 1984 and a drilling survey in 1985, were completed with acceptable results.

This project followed a stepped process from an early geological stage to the final drilling stage, and the results of each year's programme were satisfactory. In paticular the pyrrhotite occurrences found in four out the eight holes drilled in the final year's programme establish the success of the various survey methods used.

Even though these mineral occurrences did not show any economic grade and scale, the results should lead to future exploration activities in the area.

Conclusion for each survey area are as follows.

Area A

The distribution of ultramafic rocks of the type hosting Trojan-type nickel sulphide ore deposits is very limited and results of the geochemical survey did not show any significant response.

It is considered, therefore, that this area has low potential for economic ore deposits.

Area B

Like Area A, the distribution of ultramafic rocks in this area is very limited, and results of the geochemical survey did not show any significant response.

This area is consequently considered also to have low potential for economic ore deposits.

Area C

The distribution of ultramafic rocks associated with some geochemical anomalies is moderatly extensive, and results of the geophysical survey over these rocks showed deep-seated low resistivity anomalies.

It is assessed that this area has some potential for economic ore deposits but is not very attractive for further exploration activity.

Area D

The distribution of ultramafic rocks and banded ironstone is very extensive. Furthermore, as this are is situated in the extension zone of the Trojan ore horizon, it is suggested that the geological setting is very favourable for hosting further such ore deposits. Results of the geochemical and geophysical surveys showed many significant anomalies. In four out of eight boreholes drilled on the basis of these results, pyrrhotite was intersected.

The occurrences in the holes MJZ-3 and MJZ-7 are especially significant, their geological settings being very favourable for hosting ore deposits.

Therefore, it is concluded that this area has the highest potential for economic ore deposits, and is the most attractive one for further exploration activities.

Area E

The distribution of ultramafic rocks in this area is extensive, but results of the geochemical survey failed to show any significant response.

This area is judged to have low potential for economic ore deposits.

CHAPTER 2 FUTURE OUTLOOK

Based on the conclusions described in Chapter 1, it is hoped that further exploration programmes consisting of detailed surface geophysical measurements along additional survey lines, possible borehole geophysical logging, and a drilling programme based on results of those surveys, will be conducted in the localities of MJZ-3 and MJZ-7 at a stage in the future when the mineral demand situation allows it.

REFERENCES

REFERENCES (Phase I)

1) ARNDT, N., and BROOKS, C.
1980: Komatiite; Geology, v. 8, p. 155-156.

2) BESWICK, A.E.
1981: Some geochemical aspects of alteration, and genetic relation in komatiitic suites; Komatiite, p. 283-308.

3) BROOKS, C., and HART, S.R.
1974: On the significance of Komatiite; Geology, v. 2, p. 107-110.

4) CHIMIMBA, L.R.
1982: The geology and mineralization at Trojan Nickel Mine, Zimbabwe; "Nickel Sulphide Field Comference III".

5) CLUTTEN, J.M., HOSTER, R.P., and MARTIN, A.
1981: Nickel mineralization in Zimbabwe; IGCP Project 161.

6) DUKE, C.W.
1980: The Wanroo microlite mine, Shamva district; Anuals, Geol. Survey of Zimbabwe.

7) HAYNES, L.
1980: The distribution of archaean nickel mineralization in Zimbabwe and the development of new exploration concept; Inst. Min. Research, Univ. of Zimbabwe, Report No. C279.

8) METAL MINING AGENCY of JAPAN
1980: Overseas mining information, v. 10, No.5, p. 34-36 (in Japanese)

9) METAL MINING AGENCY of JAPAN
1981: Information of overseas mining state investigation (Republic of Zimbabwe), p. 3-25 (in Japanese).

10) METAL MINING AGENCY of JAPAN
1981: Overseas mining information, v. 11, No.4, p. 22-26 (in Japanese).

11) METAL MINING AGENCY of JAPAN
1982: Overseas mining information, v. 11, No.10, p.34-45 (in Japanese)

12) METAL MINING AGENCY of JAPAN
1983: Information of Overseas mining state investigation I (Africa Area), p. 52-65 (in Japanese).

13) MIYASHIRO, A.
1979: Geoscience 16, World geology; Iwanamishoten, p. 61-98 (in Japanese).

14) NAKAMURA, S.
1981: Introduction multivariate analysis with examples; Nikkankogyo Co., p. 211.

15) NALDRETT, A.J., and CABRI L.J.
1976: Ultramafic and related mafic rocks: Their classification and genessis with special reference to the concentration of nickel sulphides and platinum-group element; Econ. Geol., v. 71, p. 1131-1158.

16) NISBET, E.G., BICKIE, M.J., MARTIN, A., ORPEN, J.L., and WILSON, J.F.
1981: Komatiite in Zimbabwe; Komatiite, p. 97-104.

17) ROSE, A.W., HAWKES, H.E. and WEBB, J.S.
1979: Geochemistry in mineral exploration, Second Edition; Academic Press.

18) STIDOLPH, P.A.
1977: The geology of the country around Shamva; Rhodesia geol. Sur. Bull., No.78.

19) STAMATELOPOULOU, K., FRANCIS, D., and LUDDEN, J.
1983: The petrogenesis of the Lac Guyer komatiites and Basalts and nature of the komatiite-komatiitic basalt compositional gap; contributions to mineralogy and petrology 84, p. 6-14.

20) STAGMAN, J.G.
1978: An outline of the geology of Rhodesia; Rhodesia geol. Sur., Bull. No.80.

21) TYNDALE-BISCOE, R.
1933: The geology of the central part of the Mazoe valley gold belt, Rhodesia Geol. Sur. Bull., 22.

REFERENCES (Phase II)

1) CHARLES, M. and SWIFT, JR
1971: Theoretical magnetotelluric and turam response from two-dimensional inhomogeneities; Geophysics, v. 36, p. 38-52.

2) GOLDSTEIN, M.A.
1971: Magnetotelluric experiments employing an artifical dipole source; Ph. D. thesis, University of Toronto.

3) GOLDSTEIN, M.A. and STRANGWAY, D.W.
1975: Audio frequency magnetotellurics with a grounded electric dipole source; Geophysics, v. 40, p. 669-683.

4) METAL MINING AGENCY of JAPAN
1979: Report of Mineral Resources Exploration Technology (1979, Development of Deep Electrical Exploration Technique).

5) METAL MINING AGENCY of JAPAN
1980: Report of Mineral Resources Exploration Technology (1980, Development of Deep Electrical Exploration Technique).

6) METAL MINING AGENCY of JAPAN
1981: Report of Mineral Resources Exploration Technology (1981, Development of Deep Electrical Exploration Technique).

7) METAL MINING AGENCY of JAPAN
1982: Report of Mineral Resources Exploration Technology (1982, Development of Deep Electrical Exploration Technique).

8) METAL MINING AGENCY of JAPAN
1983: Report of Mineral Resources Exploration Technology (1983, Development of Deep Electrical Exploration Technique).

9) NABETANI, S. and RANKIN, D.
1969: An inverse method of magnetotelluric analysis for a multi-layered earth; Geophysics, v. 34, p. 75-86.

10) NELSON, P.H.
1977: Induced polarization effects from grounded structures; Geophysics, v. 42, p. 1241-1253.

11) PELTON, W.H., WARD, S.H., HALLOF, P.G., SILL, W.R. and NELSOO, P.H.
1978: Mineral discrimination and removal of inductive coupling with multifrequency IP; Geophysics, v. 43, p. 588-609.

12) STRDNGWAY, D.W., SWIFT, C.M. and HOLMER, R.C.
1973: The application of audio-frequency magnetotellurics (AMT) to mineral exploration; Geophysics, v. 38, p. 1159-1175.

13) SUMNER, J.S.
1976: Principles of induced polarization for geophysical exploration; Elsevier Scientific Publishing, Amsterdan.

14) SANDBERG, S.K. and HOHMANN, G.W.
1982: Controlled-source audiomagnetotellurics in geothermal exploration; Geophysics, v. 47, p. 100-116.

15) VAN VOORIS, C.D., NELSON, P.H. and DRAKE, T.L.
1973: Complex resistivity spectra of porphyry copper mineralization; Geophysics, v. 38, p. 49-60.

16) WYNN, J.C. and ZONGE, K.L.
1975: EM coupling, its intrinsic value, its removal and the cultural coupling problem; Geophysics, v. 40, p. 831-850.

17) YOKOKAWA, K., TSUJIMOTO, T., ENDO, Y.
1982: Example of Coupling phenomenan for spectral IP survey; Butsuri-Tanko, v. 35, p. 251-261.

18) YOSHIKAWA, H., YOKOYAMA, T., YOKOKAWA, K., HOSOI, Y.
1980: Spectral IP method; Butsuri-Tanko, v. 33, p. 287-293.

19) ZONGE, K.L. and WYNN, J.C.
1975: Recent advances and applications in complex resistivity measurements; Geophysics, v. 40, p. 851-864.

20) ZONGE ENGINEERING & RESEARCH ORGANIZATION, INC.
1982: Interpretation Guide for CSAMT Data.