REPORT ON THE MINERAL EXPLORATION OF KABUNDA AREA, THE REPUBLIC OF ZAMBIA

PHASE I

DECEMBER 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

The Government of Japan, in response to the request extended by the Government of the Republic of Zambia, agreed to conduct a metallic mineral exploration survey in Karenda area, and commissioned its implementation to the Japan International Cooperation Agency.

The agency, taking into consideration the importance of the technical nature of this survey, sought the cooperation of the Metal Mining Agency of Japan in order to accomplish the contempleted task.

The Government of the Republic of Zambia appointed the Mineral Exploration Department of Zambia Industrial and Mining Corporation Limited to execute the survey as counterpart to the Japan team. The survey is being carried out jointly by experts of both Governments.

The initial phase of the collaboration survey consists of geological, geochemical, and geophysical survey for metallic mineral exploration.

This report submitted hereby summarizes the results of the initial phase of the survey, and it will also form a portion of the final report that will be prepared with regard to the result to be obtained by the survey.

We wish to take this opportunity to express our gratitude to all sides concerned in the execution of the survey.

February, 1985

Keisuke Arita

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President,
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SUMMARY

During the course of this work, geological, geochemical and geophysical survey was conducted for a total area of 600km^2 with the objective of clarifying the occurrences of silver, copper, lead and zinc deposits of the Karenda area. Three promising areas were delineated.

The geology of the surveyed area consists of carbonates and argillaceous-arenaceous metasediments of the Kundelungu series of the Precambrian Katangan system, they are intruded by syenite, quartz porphyry and prophyrite. Also alluvial sediments are present.

The geologic structure is largely controlled by dominant E-W and N-S fault systems. The area is structurally divided into the Eastern Block to the east of the N-S fault, the Northern Block to the west of the N-S fault and north of the E-W fault and the Southern Block which lies to the west of the N-S fault and south of the E-W fault. The geologic units of the Eastern Block strikes in N-S direction and are often folded. Those of the Northern Block has monoclinic structure with 30° - 40° S dip and E-W strike. The formations of the Southern Block have a general N-S strike, but are disturbed by the intrusion of igneous bodies.

Brecciated structure is often found in the carbonate zone of the Northern Block. These bodies show circular to oval form at the surface and the size ranges from 10m to several hundred meters in diameter. The individual brecciated fractured zones are independent and are not aligned with any particular lineaments, but on the whole they are distributed harmoniously to the E-W geologic structure and the weak zone perpendicular to it.

Mineralization is observed mainly in the weak zones of the northern part of the surveyed area such as the brecciated fractured zones of the carbonate rock and the fissures of the argil-

laceous-arenaceous metasediments and syenites. The ore deposits are pipes, lenses and veins.

The major ore minerals are chalcocite, chalcopyrite, tennantite, pyrite and willemite. The outcrops consist mainly of iron and copper oxides.

The mineralized zones in the brecciated fractured belt of the carbonate rocks/in north occur harmoniously with the E-W trending geologic structure and at the intersections of the E-W and N-S trending weak lineations. The mineralized zones which occur along the weak lines such as the fissures in the south are not arranged in any particular directions, but show local occurrences.

As for the relation between geochemical anomalies and mineralization, two out of six geochemical anomalies in the southern part are shown to be related to known mineralization. These are the Pb-Zn anomalies in the vicinity of Kamiyobo Cu mineralization and its western extension. Sable Antelope Cu deposit and Bob Zinc Zn ore body are very close to each other and the relationship is similar to the above, where Pb-Zn body was discovered near a Cu outcrop.

Re-analysis of the geochemical data of the MINDECO/NORANDA work in the carbonate area in the north also show the distribution of the anomalies to be harmonious with the E-W structure and concentrated at the intersections of the geologically weak E-W and N-S lineations. Also a new Zn anomaly zone similar to the Bob Zinc body was found to the east of the Zn body. This anomaly was evaluated to have a very high possibility of ore deposit occurrence after carefully studying all available information including the results of the drilling conducted by MINDECO/NORANDA in 1957 and 1964.

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The geophysical anomalies are interpreted as reflecting the geological structure which affects the genesis of ore deposits rather than the ore deposit itself. Notable geophysical anomalies were obtained in the weak zone along Blue Jacket - Sable Antelope - Bob Zinc, in the vicinity of Crystal Jacket - Kakuyo, and near the Wonder Rocks mineralization.

PART I INTRODUCTION

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Chapter 1 Outline of the Survey

1-1 The Objective and Planning of the Survey

The Government of the Republic of Zambia issued in 1979, the "Third Five-Year Plan for National Development" and embarked on a policy of rectifying its economic structure heavily dependent on copper. As a part of this policy the Government is making strong efforts for exploration and exploitation of mineral resources other than copper. Under these circumstances, the Zambian Government, in December 1982, requested the Japanese Government to cooperate in resources development. The Japanese Government, in response to the above request, sent a Project-Finding Mission in February 1984 and a Preliminary Survey mission in May 1984 and consulted with the Zambia Industrial and Mining Corporation Limited. It was agreed by both Governments that Karenda area would be surveyed.

The survey was conducted with the objective of understanding the nature of metal concentration in the Karenda area of the Republic of Zambia by clarifying the detailed geology.

1-2 Surveyed Area

The area bounded by lines joining the following points was surveyed. The dimensions of the area are approximately 20km in E-W and 30km in N-S direction, 600km^2.

Latitude	Longitude
14°32'S	26°45'E
14°32'S	26°57'E
14°47'S	26°57'E
14°47'S	26°45'E

The area is located within the 1426 D_2 and 1426 D_4 sheets of the 1:50,000 scale topographic maps of Zambia. (Published by Directorate of Over Seas Survey; 1961).

Geophysical survey was conducted for 75 km^2 in A Zone and 4 km^2 in B Zone in the northern part of the surveyed area (Figs. i, ii).

1-3 Survey Methods and Amount of Work

1-3-1 Geological Survey

Geological survey was conducted in the known mineralized zones, along the road and along traverse lines with 1-2km interval. Topographic maps of 1:50,000 (Published by Directorate of Over Seas Survey; 1961) was enlarged to 1:25,000 scale for the field work and the results were compiled to a 1:50,000 scale geological map. The length of the total surveyed route was 315km.

The number of collected samples totaled 20 for rock microscopy, 12 for ore microscopy, 12 for X-ray analysis, and 30 for chemical assay for Ag, Cu, Pb and Zn (Ap. 1~5).

1-3-2 Geochemical Survey

Together with geological survey, soil samples were collected at 500m intervals for geochemical investigation. These samples were divided into two parts and retained as material for analysis by Japan and Zambia (MINEX). The number of samples amounted to 500 and they were analysed for the indicator elements; Ag, Cu, Pb and Zn (Ap. 6).

1-3-3 Geophysical Survey

CSAMT was applied for zones with Cu, Zn geochemical anomalies within the zone of concentrated mineral showings

in the northern part of the surveyed area. The total area of this work is 75km^2 in Zone A and 4km^2 in Zone B. The traverse interval was 400m, the same as that of geochemical survey and the measurement interval was 300m in geochemical anomaly area and 600m in other parts. Intermediate measurements were made where anomalies were observed during the survey. The number of measurements amounted to 301 in Zone A and 16 in Zone B with a total of 317 points.

1-4 Organization and Duration of the Survey

The survey was carried out during the period from 1 August 1984 to 10 February 1985. The field work and the organization of the field team were as follows.

1-4-1 Duration of the Field Work

(1) Geological and Geochemical Surveys

From 9 September 1984

To 15 November 1984

(2) Geophysical Survey

From 19 August 1984

To 15 November 1984

1-4-2 Survey Team

(1) Control, Chief Geologist and Geochemist
Hiroyuki FUJIOKA (Nikko Exploration and Development Co.,Ltd)

Chief Geophysicist
Harunobu SUMIDA (ditto)

Geology and Geochemistry
Tetsuo SATO (")

Geophysics

Toshiaki FUJIMOTO (Nikko Exploration and Development Co.,Ltd.)
Saburo TACHIKAWA (ditto)

Planning and Coordination

Ken NAKAYAMA (Metal Mining Agency of Japan)
Tadaaki EZAWA (ditto)

(2) Zambian

Control, Chief Geologist

Dr. Satya N. PUNUKOLLU (MINEX)

Coordinator, Chief Chemist

Dr. L. Borsch (ditto)

Coordinator, Exploration Supervisor

A.S. Sliwa (")

Coordinator, Exploration Supervisor

G. R. Rao (")

Field Leader, Geology, Geochemistry)

Elias Mbumba (")

Field Leader, Geophysics

Simasiku Simasiku (")

Geology, Geochemistry

Jesto Banda (")

Geophysics

William Lupupulala (")
Isaac Mwanza (")

MINEX : Mineral Exploration Department of Zambia
Industrial and Mining Corporation Limited.

Chapter 2. Surveyed Area

2-1 Geography

Topography: The general area from the capital city of Lusaka is relatively flat plateau with altitude ranging from 1,100m to 1,300m. Small hills are scattered in the area with relative height of 50-200m.

Climate : The climate of the general area including Lusaka is classified as savanna climate and has dry (May - October) and wet seasons (November - April). The dry season has cold (May - August) and hot (September - October) periods. During the cold period the temperature reaches 21°C in the day, but drops to 4°C at night in July. October is the hottest time, but the temperature rarely exceeds 35°C. Average precipitation is 810-1020 mm/year.

Vegetation: The general area including Lusaka consists of savanna vegetation with small trees and tall grasses. There are varying ratio of cultivated areas.

Access: Mumbwa is located 153 km WNW of Lusaka and can be reached in two hours by a car on a paved two-lane road. The southeast corner of the surveyed area is 25km NNW from Mumbwa and the access is an unpaved road. The MINEX camp at the north-east part of the area is 25km further north along the above road and the travel time is about one hour by car from Mumbwa. The roads accessible to vehicles are very sparse in the area. There are two main roads in the area, one branches off from the southeast corner and extends northward along the eastern border of the area to Kaindu (Kaindu Road) and the other runs along the western border from the southern end of the area to Kasempa (Lubungu Pontoon Road). There are several roads which branch out from these two main roads and they are accessible only to four-wheel drive vehicles. Although at slow speeds, the whole area will become accessible to four-wheel drive

vehicles after clearing some trees and bushes.

Population: Several to over a dozen houses of the Karenda Village are gathered here and there in the area. The total population is less than 1,000. Mumbwa is the city closest to the area. This is the second largest city of the Central Province and facilities such as bank, police, hospital, hotel, shops including supermarkets, electric power, running water and television reception are available.

Industry: The key industry of Zambia is mining, but the government is also laying emphasis on agriculture in recent years. Indian corn and cotton are raised in various parts in the vicinity of the surveyed area, and there is a National Service Farm. These are the main industry of the area and others include production of charcoal for fuel, hunting and fishing.

2-2 Previous Work

The area has been known as the "Big Concession", and geological survey and prospecting have been conducted since fairly old times. The first mining right was granted in 1895, and at that time the mineralized zones of Sable Antelope, Silver King, Crystal Jacket and others were already known. The production of Sable Antelope and Silver King began in 1906 and continued until 1923. During this period a small production (Cu 18t) was made from Crystal Jacket (1918) and the mineralized zones of Maurice Gifford, True Blue, Kakuyo and Blue Jacket were prospected.

The production from Big Concession is shown in the following table.

Copper and Silver Production From the Big Concession

(after Brandt (1955) and Bishopp (1932))

Year	Copper (tons)	Silver (kg)
1911 ~ 12	2,646	—
1914	43	85.8
1915	192	354.4
1916	187	273.7
1917	130	136.8
1918	108	71.5
1919	204	273.2
1920	117	202.4
1921	206	300.1
1922	182	248.9
1923	139	223.2
1925	10	—
Total	4,164	2,169.9
Grand Total	4,230	2,170

Although the figures conflict with the above table, there is a report that Cu 2,681t were produced from Sable Antelope and Silver King until 1913, and that Cu 1,523t and Ag 2,170kg were produced during 1914 to 1923 mainly from Silver King and also from Sable Antelope and Crystal Jacket (Murray-Hughes: 1923).

Ore has not been shipped from this area since 1924, but the stored ores of Sable Antelope has been handled in 1952 and 1955~56. Also exploration was carried out for the whole area excluding the above seven mineralized zones in 1925. In 1930, nine mineralized zones including the above seven and Colonel and North Star were prospected (Reeve:1963).

The results of geological and mineralogical investigations have been reported since 1929, but comprehensive geological survey was first conducted in 1952-55 (Brandt:1955). The mineralized zones of Kamiyobo, Bob Zinc, Wonder Rocks, Sugar

Loaf and Lou Lou were already known at that time, and some form of exploration was carried out for the zones observed at the surface.

Prospecting has been conducted in this area intermittently since then. During 1955~1964, geological survey, pitting, trenching, geochemical prospecting, geophysical prospecting (resistivity, EM) and drilling, 17 holes in Bob Zinc, 4 in Wonder Rocks and 2 in Lou Lou were carried out by Minerals Search for Africa (Pty)(Rio Tinto Zinc). "The Geology and Mineral Resources of Northern Rhodesia" and "The Geology of the Big Concession" were published by the Geological Survey in 1963 and 1971 respectively. During 1971-1973, the United Nations drilled 7 holes in Lou Lou, 3 in Sugar Loaf and 4 in Sable Antelope. In 1975, geological and geophysical (Turum and IP methods) prospecting was made for Bob Zinc and Wonder Rocks by Broken Hill Division of NCCM. In 1977, MINDECO/NORANDA conducted geological survey (160.6km^2) and geochemical survey (160.6 km^2, 6,128 samples) in the carbonate area in the north. They also carried out pitting and trenching in Bob Zinc, Wonder Rocks and Blue Jacket, and also shallow drilling (85 holes, total 2,014.4 m) in Bob Zinc and Wonder Rocks. At present, MINEX of ZIMCO is conducting detailed geological survey at Sable Antelope, detailed geological survey, geochemical survey, trenching and pitting at Lou Lou and Sugar Loaf for phosphorus.

2-3 General Geology and Ore Deposits of the Surveyed Area

As mentioned earlier, the geology and resources of Zambia were published in 1963 and those of the vicinity of the surveyed area in 1971 from the Geological Survey as geologic maps and explanatory texts. The geology and mineral resources of the area in the districts of Kabwe - Karenda mineralized zones are compiled from the above publication and the most recent edition of the geologic map of Zambia (1981) as follows (Fig. I-1).

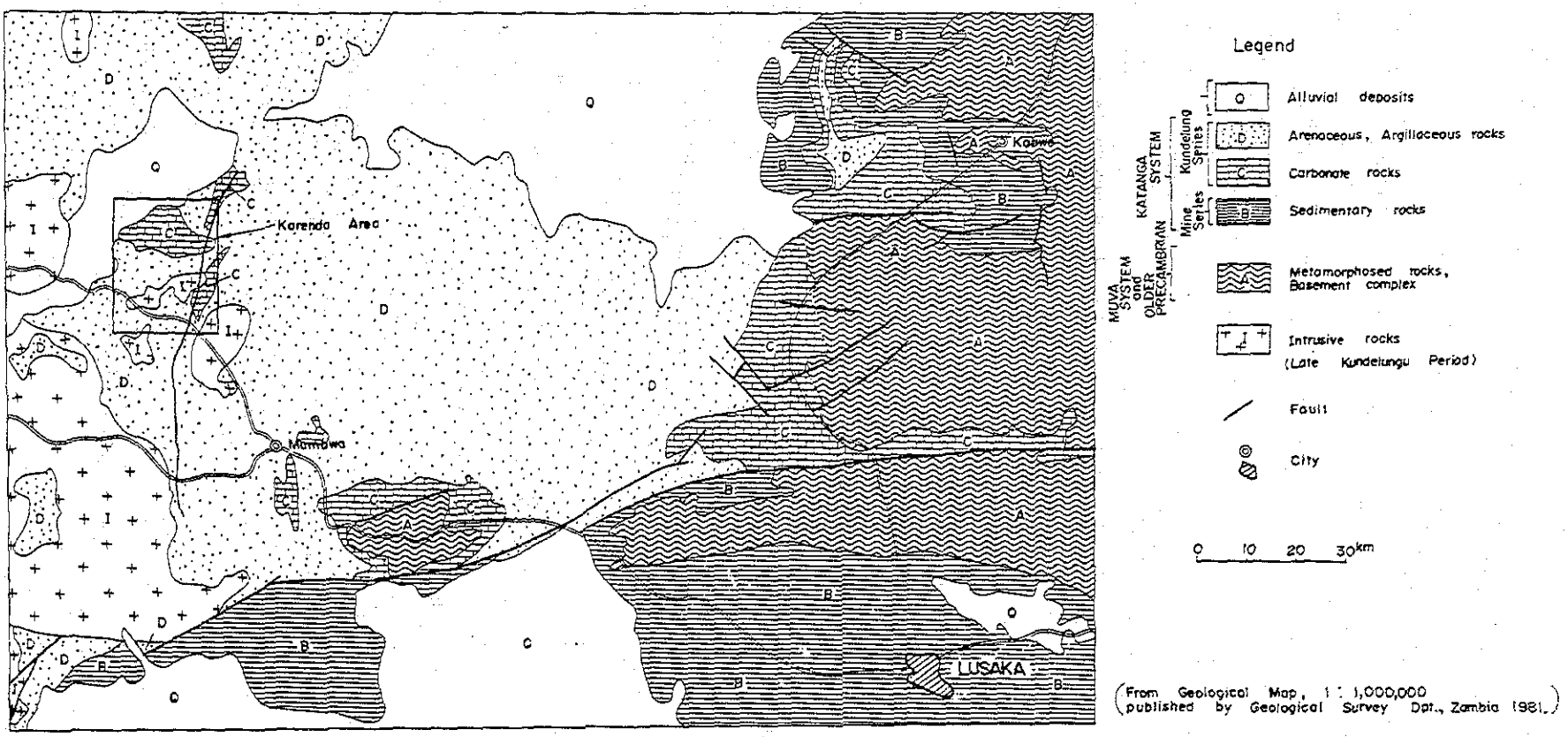

Fig. 1 - 1 Generalized Geological Map of the Area between Karenda and Kabwe

The basement rocks of the area are developed to the east of the Kabwe - Lusaka Road and to the south of the Lusaka - Mumba Road. The basement is divided into the lower basement rocks which consist mainly of granite gneiss and granite-hybrid rock, and the upper basement rocks consisting mainly of metamorphosed argillaceous-arenaceous rock, quartzite, matacarbonates and meta-volcanics.

The Precambrian Katangan system which overlies the basement unconformably is widely developed in the central part of the surveyed area. This system is composed of the Mine series and Kundelungu series in the ascending order. The Mine series occurs surrounding the basement rocks and continues further north to the Copper Belt area. The series of the area consists mainly of quartzite, arkosic sandstone, shale, dolomite and conglomerate and it is stratigraphically lower than the country rocks of the Copper Belt. The rocks of the Kundelungu series are carbonates and argillaceous-arenaceous sediments. The carbonates are distributed intermittently in the Kabwe - Mumba - Karenda zone. The argillaceous-arenaceous rocks overlie the carbonates conformably throughout the area.

Hook Granite intrudes the above rocks and is developed widely to the west. Also syenites which are the satellite bodies of the above granite occur in the Karenda area.

Alluvial deposits are developed in the northern and southern part of the surveyed area. Kundelungu series is developed to the north and the basement is distributed to the south of the surveyed area.

Kabwe (former Broken Hill) deposit is the only worked deposit in this area. The geology near the deposit consists of massive carbonates, bedded carbonates, metasediments in the ascending order. The ores occur replacing a part of the brecciated fractured zone within the massive carbonates and the major ore minerals are sphalerite and galena with significant amount of copper minerals, mainly chalcopyrite. Also

willemite and zinc phosphates are present.

Since the Kabwe deposit is similar to Sable Antelope in Karenda as mentioned above, the zone Kabwe - Karenda has been noted as a target zone for lead-zinc exploration for many years.

PART II GEOLOGICAL SURVEY

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Chapter 1 Geology

1-1 General Outline

The geology of the surveyed area consists of carbonates, argillaceous - arenaceous metasediments intruded by syenites, quartz porphyry and porphyrite, and alluvial sediments. According to the geologic map published by the Geological Survey in 1971 and 1981, the carbonates and the argillaceous-arenaceous metasediments are correlated to the lower - middle part of the Kundelungu series of the Katangan system. The igneous bodies are satellites of the Hook Granite and is believed to be the product of the activity of the late Kundelungu period. The above correlation will be used in this report.

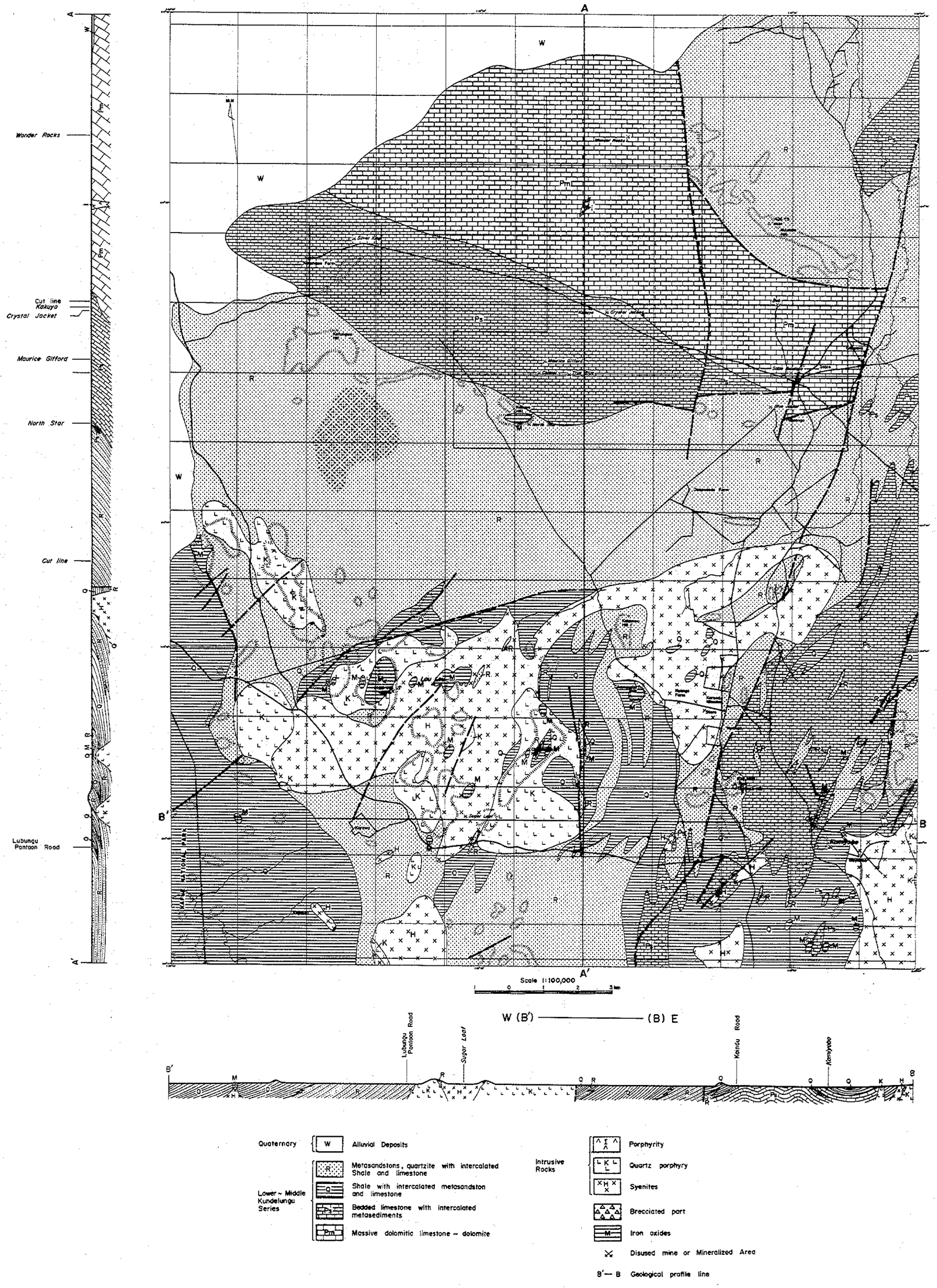
1-2 Stratigraphy

The geological map of the surveyed area is laid out in Fig. II-1 and the stratigraphy and the igneous activity in Fig. II-2.

1-2-1 Carbonates

The carbonate rocks of the area are divided into the lower massive dolomite, dolomitic limestone and the upper bedded limestone. The lower massive dolomite is widely distributed in the Sables Antelope to Wonder Rocks in the northern part of the surveyed area. The upper bedded limestone is distributed conformably with the lower carbonates in the Silver King to Crystal Jacket in the northern part and intermittently with north-south trend in the eastern part of the surveyed area.

The lower massive dolomite and dolomitic limestone occur together and there are no clear boundaries. They both show white, grey, pale red colour and are medium to coarse-grained. Also recrystallization is often observed. The rocks in the mineralized zone are partly brecciated and is sideritic, yellow-



Quaternary
- W — Alluvial Deposits

Lower ~ Middle Kundelungu Series
- R — Metasandstons, quartzite with intercalated Shale and limestone
- Q — Shale with intercalated metasandston and limestone
- Ps — Bedded limestone with intercalated metasediments
- Pm — Massive dolomitic limestone ~ dolomite

Intrusive Rocks
- Porphyrity
- Quartz porphyry
- Syenites
- Brecciated part
- M — Iron oxides
- Disused mine or Mineralized Area
- B'— B Geological profile line

Fig. II - 1 Geological Map of the Surveyed Area

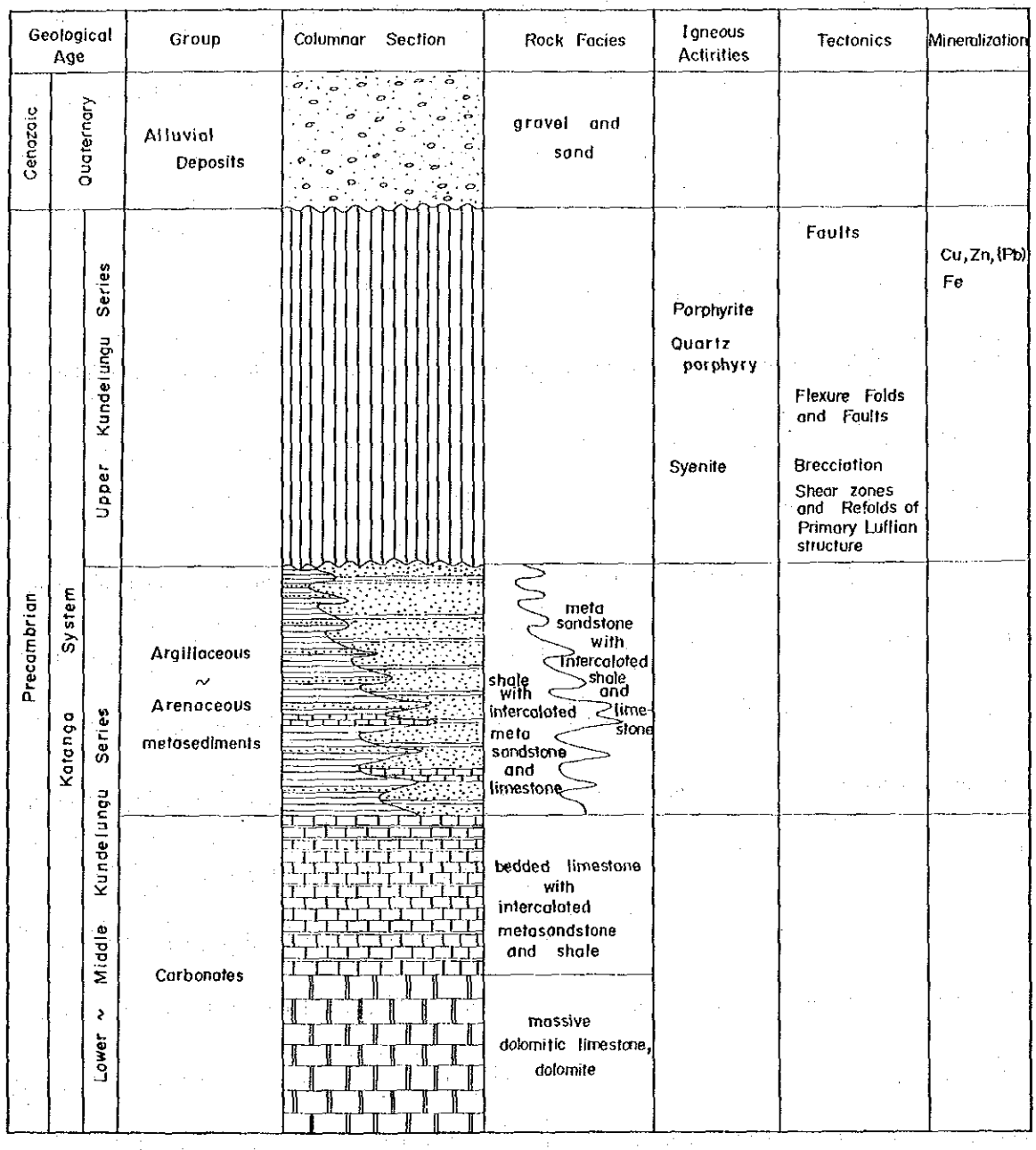


Fig. II－2 Generalized Geological Column of Surrveyed Area

ish and hardened by silicification.

Mosaic aggregate of calcite and dolomite with smaller amount of quartz, sericite, iron minerals and clay minerals are observed microscopically.

Metasandstone and shale of several millimeters thick are often intercalated in the upper bedded limestone. Limestone is grey to dark grey and fine-grained. Metasandstone and shale are reddish brown and they are either calcareous or siliceous. The metasandstone is fine-grained. The weathered surfaces of the bedded limestone show seaweed-like and banded-texture, but the fresh surfaces are homogeneous and patterns or textures are not seen. The patterns on the weathered surfaces do not have any trend, bedding or otherwise.

The bedded limestones are partly brecciated, sideritic, yellow and hardened.

Aside from calcite dolomite and small amount of quartz, mica and iron minerals are observed microscopically in the limestone. Quartz, calcite, and sometimes dolomite, muscovite, feldspars and sericite are observed in the metasandstone.

1-2-2 Argillaceous-Arenaceous Metasediments

These rocks overlie the bedded limestone conformably and are distributed widely in the surveyed area except the northwestern part. Argillaceous metasediments are predominant in the north while both occur in similar amounts in the south. The two rock units occur as alternations and also interfinger with each other in various areas. The argillaceous metasediments in the north contain more intercalations of arenaceous metasediments than in the south.

The major constituents of the argillaceous metasediments are weakly metamorphosed sandstone and quartzite with thin intercalations of limestone in the lower parts. The metamorphosed sandstone is generally yellowish brown to reddish brown and is fine to medium-grained. Microscopically, it consists mainly of well-sorted quartz grains with small amount of potassium feldspar, iron minerals, clay minerals and occasionally tourmaline and zircon.

The arenaceous metasediments are composed mainly of shale, weakly metamorphosed mudstone and siltstone with thin intercalation of weakly metamorphosed sandstone. The shale is mostly brown to yellow and sometimes reddish brown or grey. Sericite, quartz and iron minerals are observed microscopically

1-3 Intrusive Rock

The intrusive rocks of the surveyed area are syenites, quartz porphyry and porphyrite.

1-3-1 Syenites

Syenites occur intruding the bedded limestone and argillaceous-arenaceous metasediments in the southern part of the surveyed area. They occur as relatively large bodies and are strongly weathered. The detailed lithologic variation is not clear, but it varies considerably such as syenite, syenite porphyry, quartz syenite porphyry, quartz diorite, diorite and monzonite. Also the colour varies considerably from leucocratic, pale red-red, grey to green-dark green. They are generally medium to fine-grained and are rarely coarse. The texture is most often subhedral granular, but is porphyritic in the marginal zones.

Orthoclase, plagioclase, biotite, amphibole, pyroxene and smaller amount of sphene, epidote, scapolite, apatite, and magnetite are observed microscopically. Orthoclase is platy, plagioclase is albite-andesine and is euhedral with zonal structure.

1-3-2 Quartz Porphyry

Quartz porphyry occurs intruding the bedded limestones, argillaceous-arenaceous metasediments and syenites. It has characteristic reddish brown to greyish brown colour and contain 5-7mm euhedral phenocryst of quartz and feldspar. The boundary between the intruded host rock is relatively clear. In the marginal parts of the bodies, anhedral granular texture is sometimes observed. Microscopically it shows porphyritic texture and quartz, microcline, orthoclase and plagioclass are observed.

1-3-3 Porphyrite

There is only one occurrence of porphyrite observed in this surveyed area to the south of Wonder Rocks. There, porphyrite intrudes massive dolomite as small dykes of 1-2m wide. The rock is green to dark green, compact and hard with microcrystals of plagioclase.

1-4 Geologic Structure

The geologic structure of the area is controlled by major faults of E-W and N-S systems and is divided into three major blocks. E-W faults are cut by N-S faults. The area is divided into eastern 1/3 (Eastern Block) and western 2/3, by the N-S fault in the eastern part and the western part is further divided into the northern side (Northern Block) and the southern side (Southern Block) by the E-W fault cutting across the central part of the area.

The geologic units of the Eastern Block have N-S strike, and are often folded with 50°~60° E or W dip. Those of the Northern Block have E-W strike with monoclinic 30°~40° S dip. The bedding of the rock of the Southern Block is not very clear, because of the weathering and the intrusion of igneous bodies, but it is inferred from the distribution of the beds that they have N-S trend and dip westward. The syenites of the Southern Block is cut by a large fault at the border to the Northern Block, but generally they are interpreted to have intruded along this fault.

Aside from the above major faults, there are small faults with various trends in each block. Of these minor faults, relatively larger ones occur in the Northern Block and they trend in N-S and E-W directions. The N-S faults are developed along the mineralized zones of Blue Jacket, Sable Antelope, Bob Zinc and also to the east of the Crystal Jacket and Wonder Rocks mineralized zones. The E-W faults are transected by the above N-S faults and form the boundary of bedded limestone and argillaceous metasediments.

Folding is developed in the Eastern Block, but the details are not clear because the exposure is poor and most of the folds are of small scale. From the distribution of the units, it is inferred that they generally have axes parallel to the N-S major fault and form an anticlinorium with the bedded limestone as the core.

Brecciated structures occur frequently in the Northern Block. The mineralized zones in the carbonate area are all developed in these brecciated zones. The planar distribution of these brecciated zones are circular to oval with smaller breccias in the central and larger breccias in the marginal parts. The largest brecciated zone is at Sable Antelope with 300m(+) × 500m(+) and the small ones occur at Maurice Gifford, Colonel, True Blue with dimensions in the order of 10-20m.

Aside from these zones, there are brecciated structures of limestone and metamorphosed sandstone extending 2~3km to the south of Silver King in the argillaceous metasediment area. In this zone, the size of the limestones and metamorphosed sandstones are similar, but the ratio of their abundance varies. Here, mineralization and alteration are not observed.

Chapter 2. Economic Geology

2-1 Outline

Mineralization found in the surveyed area are silver, copper, (lead), zinc, iron and phosphorous, but in the present survey, work was done mainly on silver, copper, lead and zinc deposits. Mineral showings were found in the following 14 localities.

Geological Block	Name of the Mineralized Area	Components	Mineralized Place
Northern B.	Sable Antelope	Ag, Cu, Zn	Brecciated Part in Massive Carbonates
〃	Bob Zinc	Ag, Zn	〃
〃	Wonder Rocks	Ag, Cu, Zn, Fe	〃
〃	Silver King	Ag, Cu, Fe	Brecciated Part in Bedded Carbonates
〃	Crystal Jacket	Ag, Cu	〃
〃	Kakuyo	Ag, Cu	〃
〃	Maurice Gifford	Ag, Cu	〃
〃	Colonel	Ag, Cu	〃
〃	True Blue	Ag, Cu	〃
〃	Blue Jacket	Ag, Cu	Fracture in Metasandstone
〃	North Star	Ag, Cu	〃
Eastern B.	Kamiyobo	Ag, Cu, Fe	Fracture in Shale
Southern B.	Sugar Loaf	Ag, Cu, Fe, P	Fracture in Syenites
	Lou Lou	Ag, Cu, Fe, P	〃

Of these showings, Sable Antelope, Silver King and Crystal Jacket were worked. Prospecting including drilling were conducted at Bob Zinc, Wonder Rocks, Sugar Loaf and Lou Lou. Geological prospecting including pitting, trenching and other work is carried out for other showings. Most of these mining and prospecting, however, were done many year back and the presently available data are not sufficient for clarifying the details of mineralization. The general occurrence of silver, copper, (lead), zinc mineralizations are in brecciated fractured zones and fissures of massive carbonates, bedded carbonates, arenaceous metasediments, argillaceous metasediments and syenites. Also alteration associated with the mineralizations is silicification.

The outcrops mainly consist of iron oxides and copper oxides. The ore minerals of the old mines are sulfides such as chalcocite, bornite, chalcopyrite, tennantite, and pyrite. Willemite is also found in drill cores.

2-2 Description of Deposits

2-2-1 Sable Antelope Deposit

This deposit is located at the northeastern part of the surveyed area. It has been developed since 1906. The ore from various deposits of the Big Concession were processed at this mine until 1925 and thus the production grade and the last year of shipment of this deposit is not clear. But since most of the total copper production of 4,300t from the concession is from Sable Antelope and Silver King deposits, if we assume the grade of the crude ore to be 10% Cu, the recovery rate 60% and the specific gravity to be 3, the crude ore produced from the two mines would be around 200,000t. Thus the size of each deposit is inferred to be a small, in the order of 100,000t.

The description of Sable Antelope ore bodies vary considerably by authors, but they are summarized as follows.

The major ore body extended about 75m with maximum width of 15m at the surface. It was 90m deep, but the size decreased rapidly below 30m. For example at 45m depth, the dimensions were in the order of 6m × 4.5m. There was a very high-grade massive part in the ore body.

The deposit occured in brecciated Mg-limestone and dolomitic limestone. It was small massive sulfide lens surrounded by stockwork and disseminated zone. The trend of the lens was northeastward strike and southeastward dip. The 1972 report, however, mentions E-W trend of mineralization with 60m length and 2.40 ~ 4.50m width as a result of trenching. The shoot of the ore body is variously described as low angle SW, steep (70°) NE and vertical.

The major ore minerals of the main ore body are chalcopyrite, bornite and chalcocite and those of the smaller bodies are large amount of tennantite with small amount of bornite. The analyses of ores and concentrates are listed below.

Data of the Analyses in Sable Antelope Mine

Samples	Components									Remanks
Typical orc (%)	Cu	FeO	CaO	MnO	S	Insolubles				Marray-Hughes and Fitch (1929)
	17.71	21.07	6.36	6.36	9.12	4.22				
Ore Concentrate (ppm)	Cu	Pb	Zn	Co	Ni	Mn	As	Ge	Ag	Sharp (1957) and Berning (1958) Spectrogrographic Analysis
	Mc	600	1,000	800	300	3,000	Mc	200	200	
	Mc = Major constituent V, Cd, Au, Te, Zr, Pt, Ce and Os were not detected The presence of Sb and Bi are noted									
Selected ore from Dump	Ag	Cu	Zn	As	Bi	Ni + Co				
	42 g/t	11.9%	0.08%	1.40 %	0.07 %	0.04 %				

Four holes were drilled in the zone from the vicinity of the ore bodies southeastward in 1970 by the United Nations. The geologic columnar description of the drilling results is laid out below and significant mineralization is not observed.

UN Drill Data in Sable Antelope Mine

Drill No.	Depth (m)	Rock and Mineralization
UN 12	0.00 ~ 54.00 +	Marble No mineralization
UN 13	0.00 ~ 12.00	Mineralized marble Average Cu <1%, Max Cu 181 %
	12.00 ~ ?	Mineralization decreases sharply.
UN 14 (-60°, MN 275°)	0.00 ~ 28.65	Fine grained grey marble with dark brown siderite, and ankerite.
	28.65 ~ 43.00	Fine grained grey marble with small veins of siderite, ankerite and hematite.
	43.00 ~ 76.20	Grey - white marble with vugs in filled by calcite, siderite and hematite.
UN 15	0.00 ~ 5.00	Red soil
	5.00 ~ 30.00	Fine grained grey - white marble with small veins of specularite.
	30.00 ~ 50.30	Fine grained grey marble with thin chalcopyrite veins.

During the course of this survey, we were not able to enter the adits and exposure was poor. Thus we were only able to observe the mineralization near the main shaft and in parts of the trenches. There are old workings at 60 ~ 70m south of the main shaft. We were not able to enter these old workings, but we observed from the outside green parts which probably are malachite. High grade material was very rare in the dump, and ores found there are extremely small. It was thus not possible to clarify the details of mineralization and the observed facts are as follows.

The mineralization near the main shaft is strong in the cementation zone of the brecciated dolomite and dolomitic limestone. It sometimes extends to the brecciated zone, but the mineralization is weak with dissemination of chalcocite, malachite, azurite, chalcopyrite and pyrite. Trenching is done on both sides of the main shaft for a total length of 22m. At the edge of the trenches, strong and weak mineralized zones are observed and there are barren silicified brecciated dolomite and dolomitic limestone outside the trench. Thus the direction of the trench is inferred to approximate the general strike of mineralization (Fig. II-3).

There are trenches about 20m long on both sides of the above inferred direction of mineralization. The direction of the trenches is similar that of the mineralization. The distance between the trenches is about 100m and the width of the trenches is maximum 10m and minimum 2m. There are no exposures in these trenches. The direction of the green part (malachite) in the shaft is interpreted to be the direction of the dip of the mineralized zone. These facts point to a mineralized zone with N60°W strike, 80-90°S dip, 100 m length and 2-10m width. The intensity of mineralization probably differs considerably specially, but the grades are; strongly mineralized zone, Ag 22g/t, Cu 25.90%, weakly mineralized zone, Ag 5g/t, Cu 3.50% and Pb, Zn contents were very minor in both zones (Ap. 2). The high-grade ore collected from the dump contained Ag 108g/t, Cu 24.10%, and Ag 99g/t, Cu 23.25%, low-grade material from the dump contained Ag 19g/t, Cu 2.50% with very minor content of Pb and Zn (Ag content of these materials is higher than those of the outcrops and these may have been transported from Silver King).

The old working located 60~70m south of the main shaft is lens-shaped with dimensions of 13m in N-S and 6m in E-W directions. It was not possible to collect samples from the old working, but the high-grade ore from the dump consisted mainly of chalcocite, tennantite, bornite and malachite. It

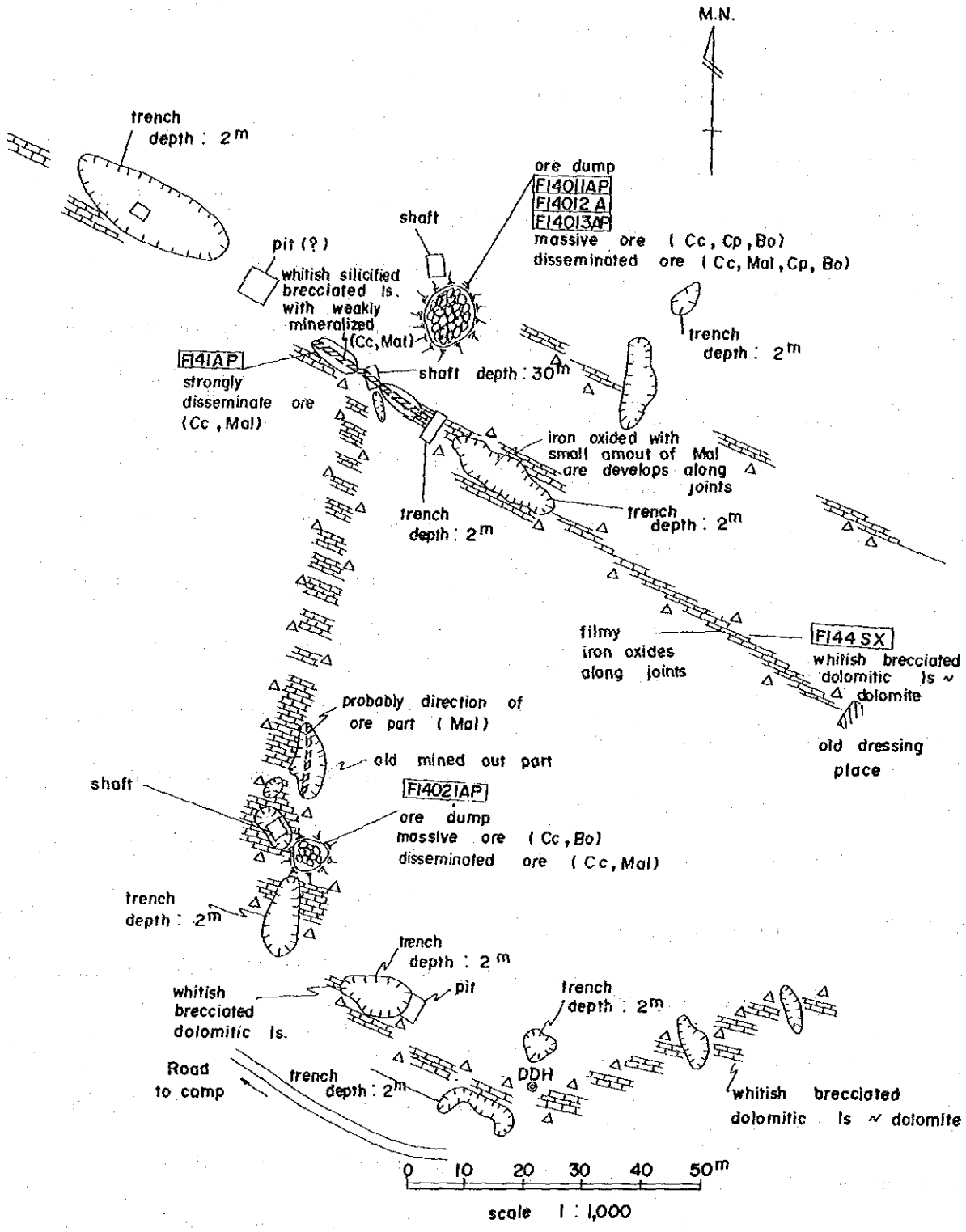


Fig. II-3 Geological Sketch of the Sable Antelope Disused Mine

contained Ag 37g/t, Cu 19.45%, Zn 1.42% and very minor amount of Pb. Zinc minerals were not observed microscopically. The ore was rich in tennantite and bornite and considering the data below, it is possible that Zn was contained in these minerals.

Spectrographic Analyses of Tennantite and Bornite in Sable Antelope Mine (Berning, 1958)

	Cu	Pb	Zn	V	Co	As	Sb	Ge	Ag
Tennantite	Mc	nd	Mc	nd	1,000	Mc	Present	nd	20
Bornite	Mc	nd	2,000	nd	100	10,000	nd	nd	200

Mc = Major constituent, nd = not detected, unit : ppm

The results of microscopic study is laid out in Ap. 3, the ore minerals observed are, tennantite, bornite, chalcopyrite, chalcocite, pyrite and copper oxide minerals. These minerals occur scattered irregularly in lump-vein-dissemination form among the gangue minerals. Tennantite (coarse-grained) and bornite lumps often contain chalcopyrite (grain size < 0.4mm) scattered in small lump, grain, veinlet and lattice form. Chalcocite occurs near the chalcopyrite inclusions. Pyrite (grain size < 0.2mm) occurs in small amounts mainly associated with tennantite and chalcopyrite. Small amounts of copper oxide occur mainly near chalcocite.

2-2-2 Bob Zinc Mineralized Zone

This mineralized zone occurs approximately 2km north of Sable Antelope deposit. Percussion drilling for water well in 1957 detected mineralization and it was followed by five diamond drilling which confirmed the deposit. Subsequently in 1964, 12 diamond drilling was conducted in order to confirmed the geochemical anomalies and the extent of the deposit. The result of the drilling is shown in Table II-1.

Table II－1 The Results Obtained from Boreholes in Bob Zinc Prospect

Bore hole	Inclination	From To (m)	Width (m)	Ag (g/t)	Zn (%)	Remarks	
						Year	Final Length
Water Hole	Vertical	9.1 ～ 54.9	45.8	103	12.47		
B 1	Vertical	6.1 ～ 71.0	64.9	373	10.23	1957	106.7
B 2	－50°	109 ～ 111 166 ～ 168	－	－	Trace	〃	178.6
B 3	－50°	－	－	－	－	〃	127.1
B 4	－50°	0.0 ～ 115.2	115.2	177	15.70	〃	182.9
B 5	Vertical	－	－	－	－	〃	91.4
BL 1	－50°	20.7 ～ 32.3	11.6	43	15.66	1964	35.4
BL 2	－50°	22.6 ～ 42.1 42.1 ～ 46.9 46.9 ～ 48.0	19.5 4.8 1.1	17 29 } 17	13.66 3.80 } 8.80	〃	55.8
BL 3	－50°	46.0 ～ 56.1 56.1 ～ 75.0 75.0 ～ 78.0	10.1 18.9 3.0	36 } 29	1.27 } 0.99	〃	83.8
BL 4	－65°	38.1 ～ 53.0 53.0 ～ 98.5	14.9 45.5	39 } 35	11.35 } 9.02	〃	103.6
BL 5	－60°	52.1 ～ 57.9 57.9 ～ 78.6 78.6 ～ 96.2	5.8 20.7 17.6	45 } 35	1.36 } 0.78	〃	103.6
BL 6	Vertical	－	－	－	－	〃	78.6
BL 7	－60°	33.1 ～ 34.1	1.0	6	＜0.5	〃	92.0
BL 8	－60°	9.4 ～ 71.0	61.6	8	＜0.5	〃	79.9
BL 9	－60°	23.8 ～104.9	81.1	5	＜0.5	〃	107.3
BL 10	－40°	13.1 ～ 96.9	83.8	3	＜0.5	〃	132.0
BL 11	－50°	13.7 ～ 82.9	69.2	2	＜0.5	〃	88.4
BL 12	Vertical	－	－	－	－	〃	16.2

A total of eight bore holes, six in high-grade parts and two in low-grade parts, penetrated the ore body and it is calculated as 109m in strike direction, 12m average width, 106m depth, 305,000t reserve with Ag 164g/t, Zn 11.6%. The ore shoot is measured to be 100,000t reserve with Ag 96g/t and Zn 22.77%.

According to a survey report of 1958, the country rock is brecciated sideritic carbonate and willemite mineralization was observed for 8m in manganese containing soil in trench. The result of spectrographic analysis of ore from drilling core is listed below.

Spectrographic Analysis of the Bob Zinc Ore

	Zn	Pb	Cu	Ag	V	Co	Ni	Gc	Bi	Mc = Major constituent nd = not detected unit : %
Bob ore	Mc	0.10	0.01	0.02	nd	nd	nd	nd	nd	

During the course of this survey, the location of the mineralized zone was inferred from the water well and the trench, but no outcrops could be located. In the trench, one exposure of white, massive silicified dolomitic limestone was found, but there is no trace of mineralization. Completely barren massive dolomitic limestone is distributed to the west of the mineralized zone, but no outcrop is found to the west.

Therefore, the mineralization was studied from drilling data only. The result is shown in Figs. II-4,5,6. The body is inferred to be a vein with; strike approximately E-W, dip 70°-80°S, length on surface 70~80m, length at -50m 80~100m, width 10-20m, shooting ESE. At 80m depth the body takes a pipe-like form of approximately 30m in diameter.
The distribution of high anomaly zone extracted from the results of shallow percussion drilling and geochemical prospecting carried out by MINDECO/NORANDA agrees well with the known Bob Zinc vein. It also confirms the results of the prospecting carried out at the eastern extention of the strike direction of the Bob Zinc vein, namely the diamond drilling at BL 6, 7,

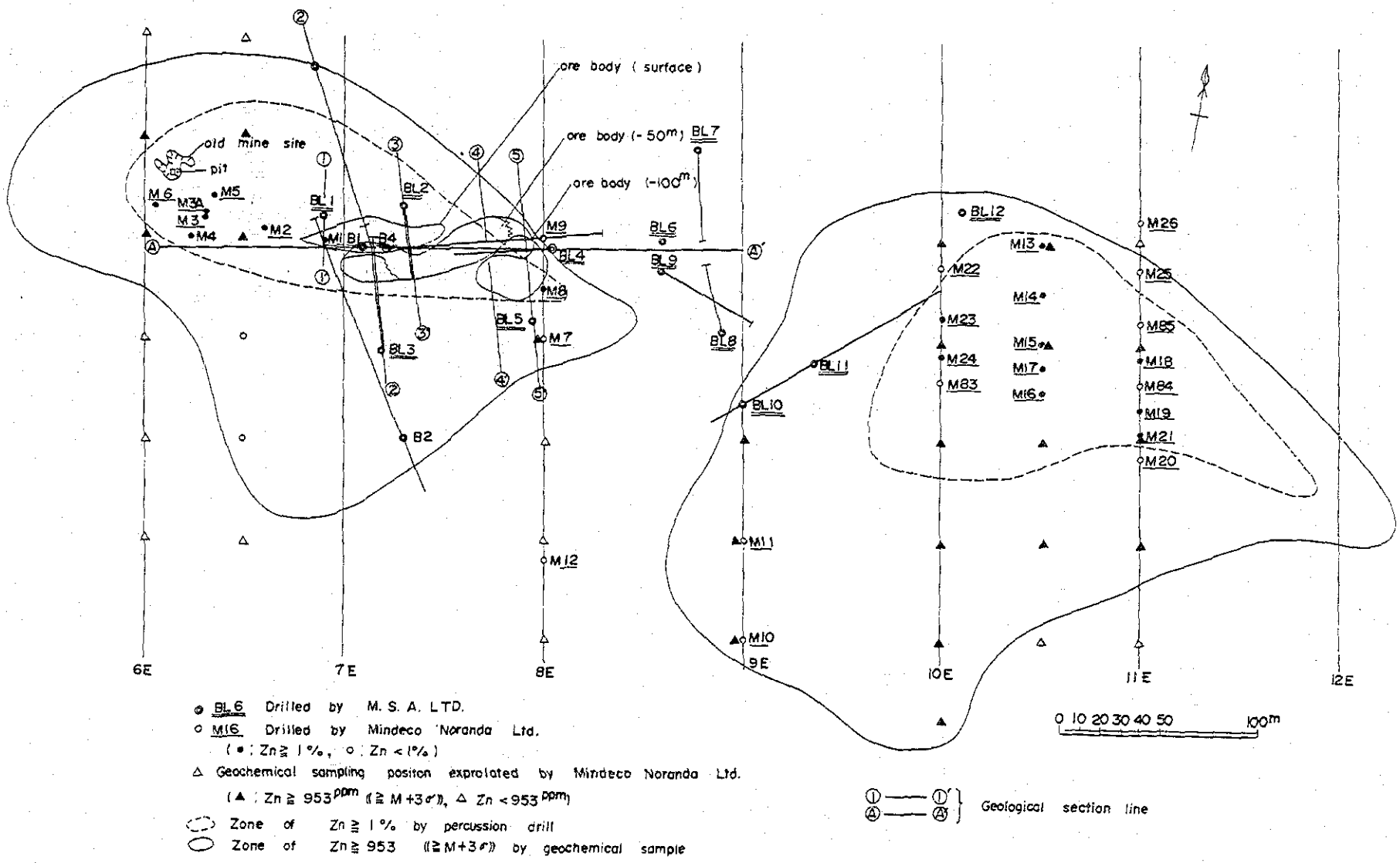


Fig. II-4 Map of the Bob Zinc Mineralized Area

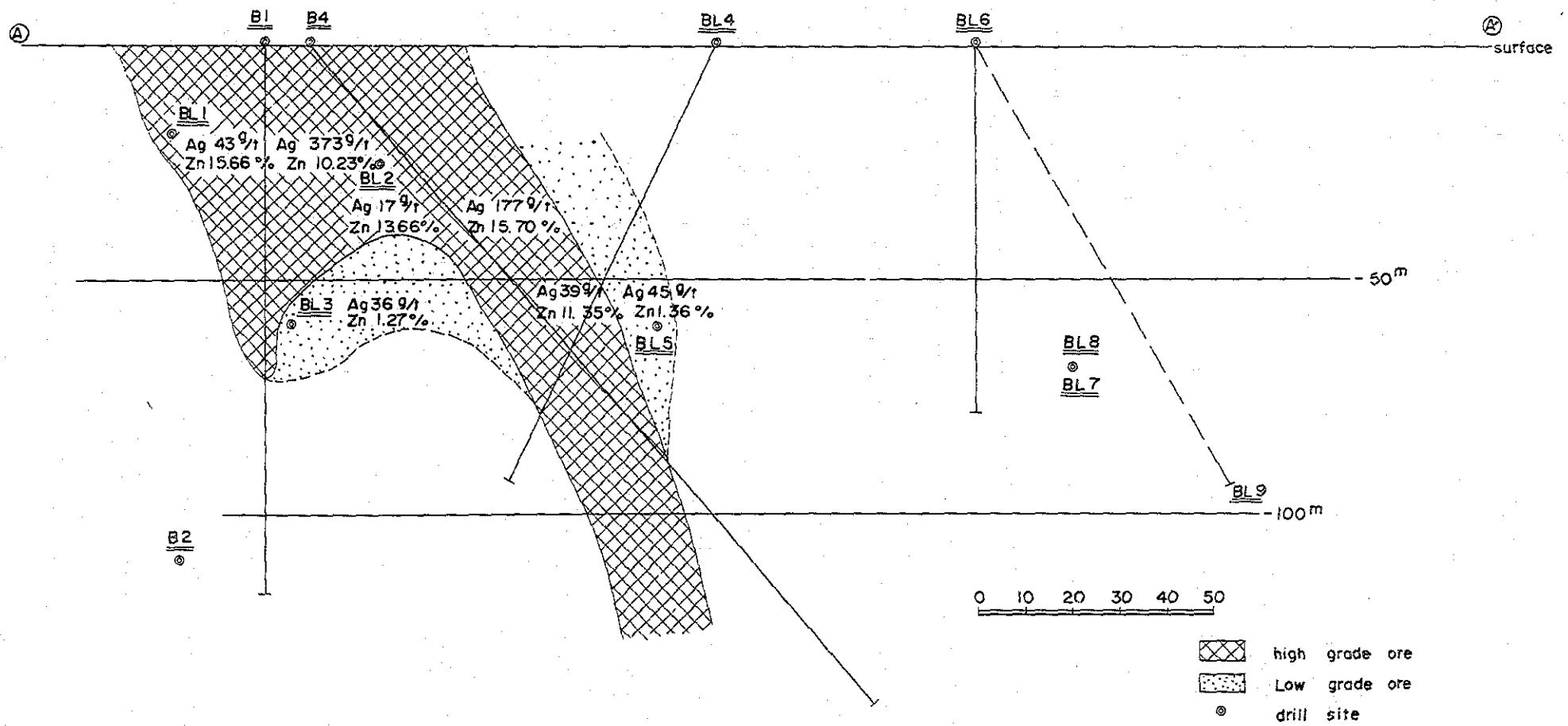


Fig. II－5 Geological Section along the Strike Direction of the Bob Zinc Mineralized Area

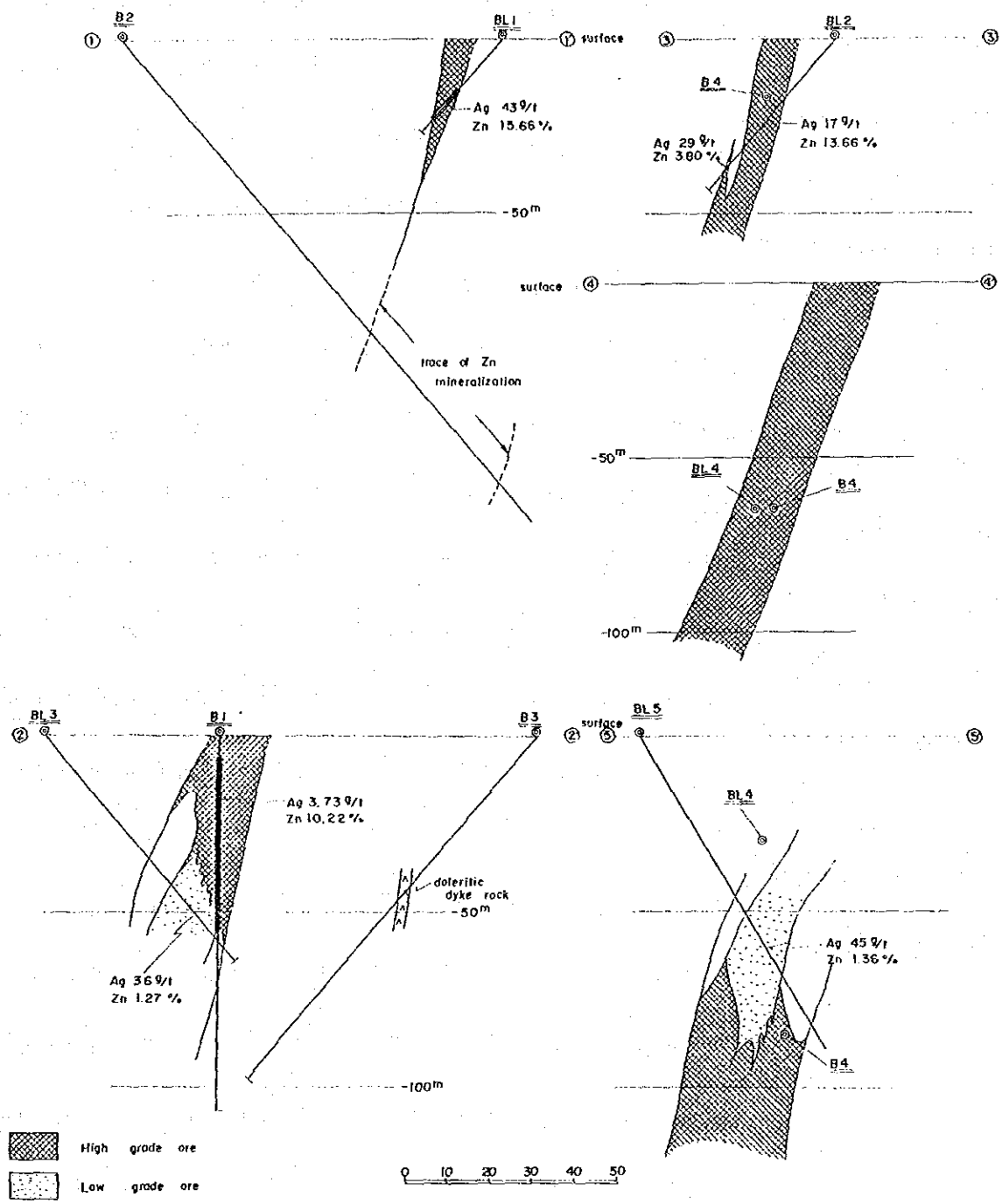


Fig. II－6 Geological Section Perpendicular to the Strike Direction of the Bob Zinc Mineralized Area

8, 9, 10, 11 was barren.

It is very interesting to note that further east of the above diamond drill holes, there is a high anomaly zone with distribution pattern similar to that of Bob Zinc vein. The distribution of this anomalous zone is wider than and the anomaly values are similar to those of Bob Zinc.

2-2-3 Wonder Rocks Mineralized Zone

This mineralized zone is located at the central part of the Northern Block of the surveyed area. The outcrop of this zone is very large extending 150 × 200m. In this exposure, iron oxide vein is developed associated with small amount of malachite and chalcocite. Also the occurrence of lumps of willemite in the manganiferous soil is known. Four diamond drill holes were made in 1964. The results of this drilling is shown below.

The Results Obtained from Boreholes in Wonder Rocks Prospect

Borehole	Inclination	From To (m)	Width (m)	Ag (g/t)	Cu (%)	Zn (%)	Final Length (m)
R 1	−50°	55.8 ~ 58.8	3.0	96	0.32	Trace	242
		137.2 ~ 141.1	3.9		0.23	4.06	
		141.1 ~ 149.4	8.3		nil	0.84	
		149.4 ~ 152.7	3.3		0.18	3.61	
R 2	Vertical	49.4 ~ 52.7	3.3			2.25	108
		52.7 ~ 57.5	4.8			2.15	
		87.2 ~ 89.9	2.7			2.20	
		96.6 ~ 106.2	9.6			2.10	
R 3	−50°	21.3 ~ 21.5	0.2			2.89	77
		24.4 ~ 28.2	3.8			4.35	
		58.5 ~ 68.7	10.2			3.04	
R 4	−40°	57.5 ~ 58.4	6.9	a narrow vein of willemite			137

By the present survey, mineralization was inferred to be distributed in the zone of the brecciated dolomitic limestone which form small conical ridges, and it extends from the western edge of the ridges to the former trenches and drill holes in the flat areas covered by soil (Fig. II-7). The size

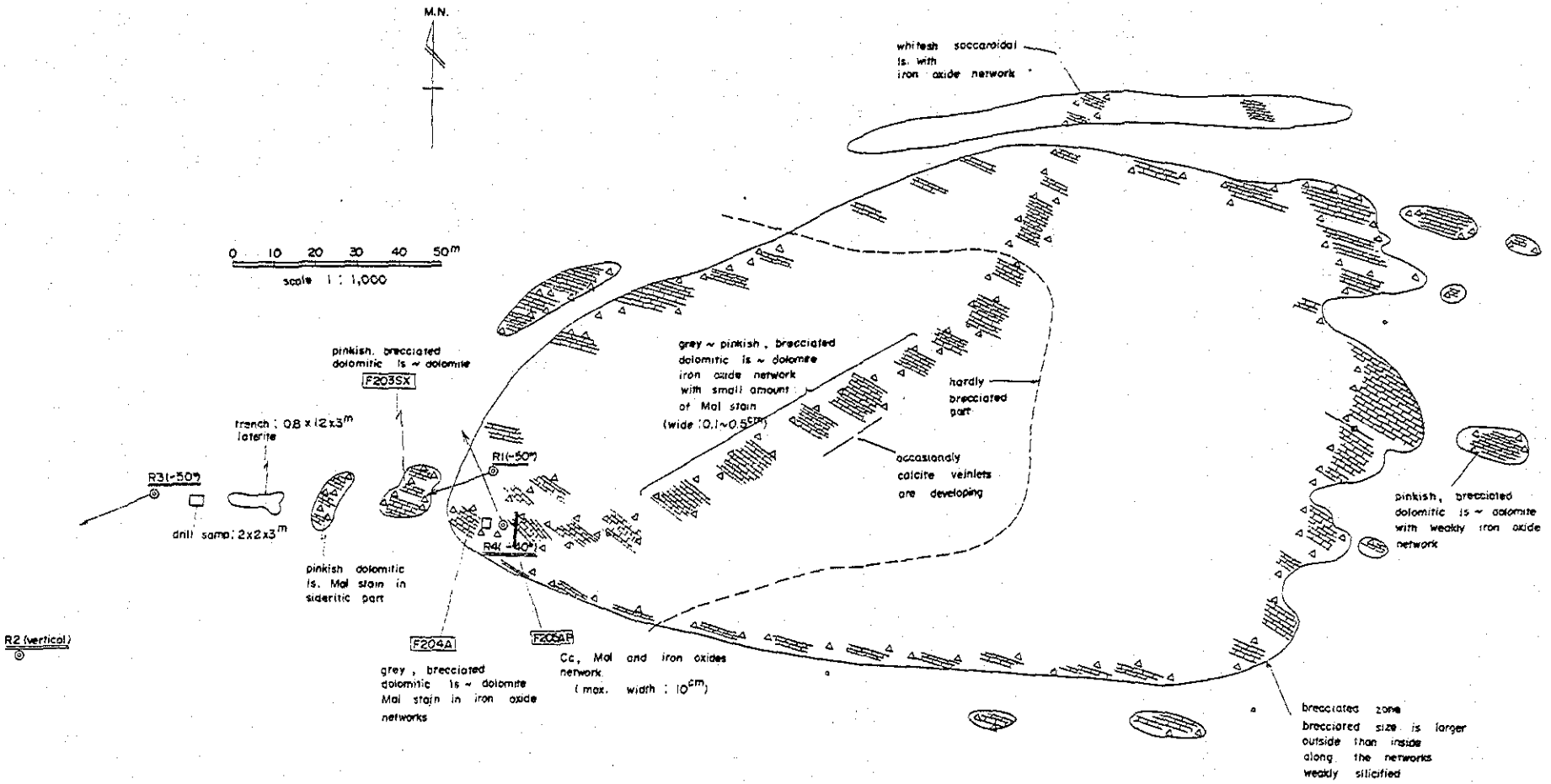


Fig. II－7 Gelogical Sketch of the Wonder Rocks Mineralized Area

of the zone is approximately 300m E-W and 150m N-S. The dolomitic limestone breccias are large to the northern - eastern - southern margins and small in the central to the western part of the zone. The mineralization consists mainly of iron oxides, goethite being the major mineral, and small amounts of malachite and chalcocite are sometimes associated. The network veins are dense where the breccias are small and sparse where breccias are large. The country rock near the mineralized zone is sideritic, but become barren and white to pale red colour at some distances from them.

The analyses of the samples from the veinlets at the western part of the exposure are shown in Ap. 2. The sample from 10cm wide vein show Ag 11,600g/t, Cu 53.10%, and that from network near bore hole R-4 gave Zn 1.60%. Thus silver, copper and zinc mineralization was confirmed, but the scale is very small. The analytical results of the geochemical prospecting by MINDECO/NORANDA show several tens of thousand ppm Zn, and the soil samples obtained by percussion drilling also contain several percent Zn. The high values indicate significant erosion in this area.

Microscopically, chalcocite, digenite, copper and iron oxides were identified. Also willemite was identified by X-ray diffraction. Large amounts of chalcocite and digenite occur scattered as irregular lumps in copper and iron oxides and gangue minerals.

2-2-4 Silver King Deposit

This deposit is located in the northwestern part of the surveyed area. Exploration and development of this deposit were conducted approximately parallel to those of Sable Antelope deposit. During 1914~1923, 1,523t of copper and 2,170kg of silver were produced mainly from this deposit.

The geology of the ore bodies which were worked are summarized as follows from available documents. The ore

deposit consists of dissemination and irregular massive chalcopyrite ores. They occur replacing lamprophyre dikes and dolomite. The sulfide ore shoot found at 35m depth is in chimney form consisting mainly of chalcocite. This ore shoot consists of malachite and is 15m in diameter at the surface, the size decreases to slightly over 1m at 60m depth and it becomes 3~5cm wide chalcopyrite veins further down. Bornite and chalcocite are found in this vein, but pyrite does not occur. Chalcocite is rare in silver rich parts where native silver is found in joints and fissures.

The ore minerals of this deposit is chalcocite, chalcopyrite, bornite, sphalerite, azurite, goethite and very minor amount of Ag-Cu-S minerals. The anlytical results of ores and concentrates are as follows and silver content is very high.

Data of the analyses in Silver King Mine

Samples	Components								Remarks
	Ag (g/t)	Cu (%)	S (%)	Insolubles (%)	FeO (%)	MnO (%)	CaO (%)	MgO (%)	
Average Ore	–	12.18	3.54	14.14	18.72	–	15.34	6.31	Murray-Hughes (1923)
Chalcocite Chimney	622	49.77	–	11.78	3.37	–	4.47	0.96	Murray-Hughes and Fitch (1929)
Dump	–	6.93	–	15.29	9.29	3.76	30.23	6.53	
−60 ML	1,619	18.03	4.80	14.18	17.14	1.50	25.78	4.79	

	Cu (%)	Insolubles(%)	FeO(%)	Ca (%)	
Heads	7.93	18.10	24.14	22.50	Murray-Hughes (1923)
Concentrate	27.06	12.78	14.58	15.04	

	Cu	Pb	Zn	V	Co	Ni	Ge	As	Ag	Cd	Bi	Spectrographic Analysis
Chalcocite	Mc	<5	nd	nd	nd	nd	nd	nd	300	nd	Present	Berning (1958) and Gersteling (1959)

Mc = Major constituent, nd = not detected, unit : ppm

It was not possible to enter the old adits and workings during the course of this work. And there were no ores in the dumps and thus the details of the mineralization of this deposit is not clear.

The result of investigation from the surface is as follows.

The old working has a pipe-form with a cross section of 15m × 7m. It is elongated in N10°W direction. The country rock near the ore body are brecciated limestone and sideritic limestone. Iron oxide network veins consisting mainly of goethite is developed in these rock. In the pits to the west and west-southwest of the old working, copper oxides, mainly malachite are associated with parts of the iron oxide network (Fig. II-8).

There is an old adit trending north at 250m southwest of the old shaft. We believe this to be a prospecting adit for the lower part of the iron oxide outcrop, but the waste is composed only of sideritic limestone with iron oxide network without any copper. The documents mention that limonite outcrop to the south of the deposit was drilled, but the drilling site is not shown on the map. This drilling was most probably done on the above outcrop judging from the conditions of the area. The drilling data are as follows and significant mineralization was not found.

SK I Drill Data in Silver King Mine

Length (m)	Rocks and Mineralization
0.00 ~ 79.55	Calcitized dolomite
79.55 ~ 90.10	Limonitized and calcitized dolomite, max. Cu 0.1%, average Cu < 0.01%
90.10 ~ 93.88	Calcitized dolomite
93.88 ~ 96.01	Dolomite
96.01 ~ 97.41	Calcitized dolomite

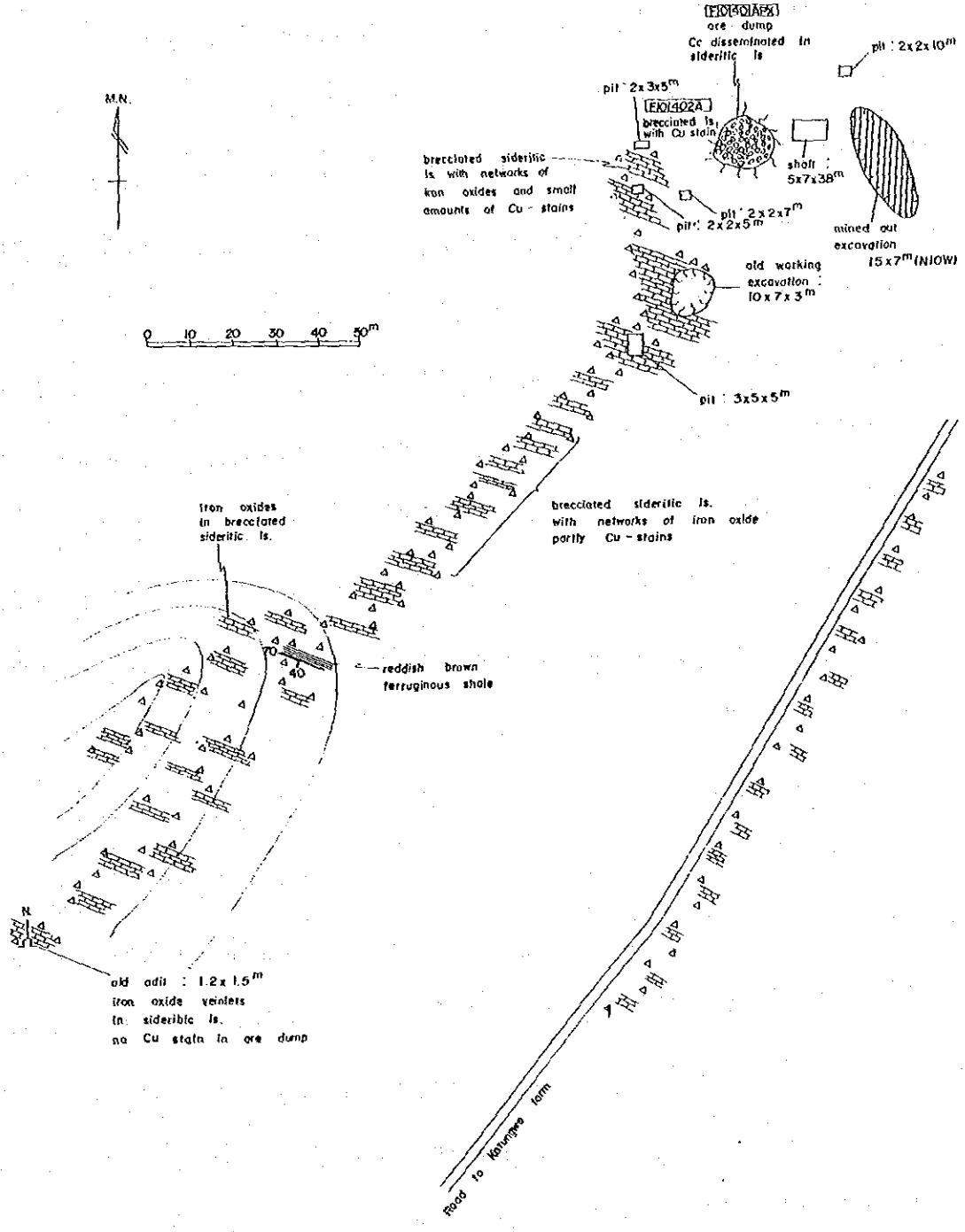


Fig. II – 8 Geological Sketch of the Silver King Disused Mine

There are no ores remaining in the waste dump, and the sideritic limestone samples containing the largest amounts of malachite and chalcocite were analysed (Ap. 2), the highest-grade material showed Ag 42g/t, Cu 2.02% and traces of Pb, Zn.

2-2-5 Crystal Jacket Deposit, Kakuyo Mineralized Zone

Crystal Jacket deposit was explored and developed parallel to Sable Antelope, Silver King Deposits and produced approximately 18t of copper in 1918. According to documents, this deposit occurs as argentiferous chalcocite dissemination in wedge-shaped brecciated sideritic limestone. It is very small, localized and all the ores were shipped.

During the present survey, we were able to study the waste from the pits which were dug near what we believe is the collapsed old shaft. Copper was detected from the wastes within a range of 50m × 30m (Fig. II-9). Mineralization is dissemination of copper oxides, mainly malachite, in sideritic limestone. The analyses of these samples show Ag 118g/t, Cu 7.6% and Ag 68g/t, Cu 3.0% and the Ag content is relatively high. There are also traces of Pb and Zn.

The wastes from pits other than those with evidences of mineralization mentioned above and exposures are barren, grey to pale reddish limestone and clear bedding is often observed.

Kakuyo mineralized zone is located approximately 400m west-southwest of the Crystal Jacket and consist of brecciated sideritic limestone with 100m × 40m distribution within dark grey barren limestone. This is similar to the setting of the Crystal Jacket Deposit (Fig. II-10). Iron oxide veinlets containing very minor amount of malachite are found in some of the rock in the waste of the pits dug in the sideritic limestone. But copper mineralization is very poor.

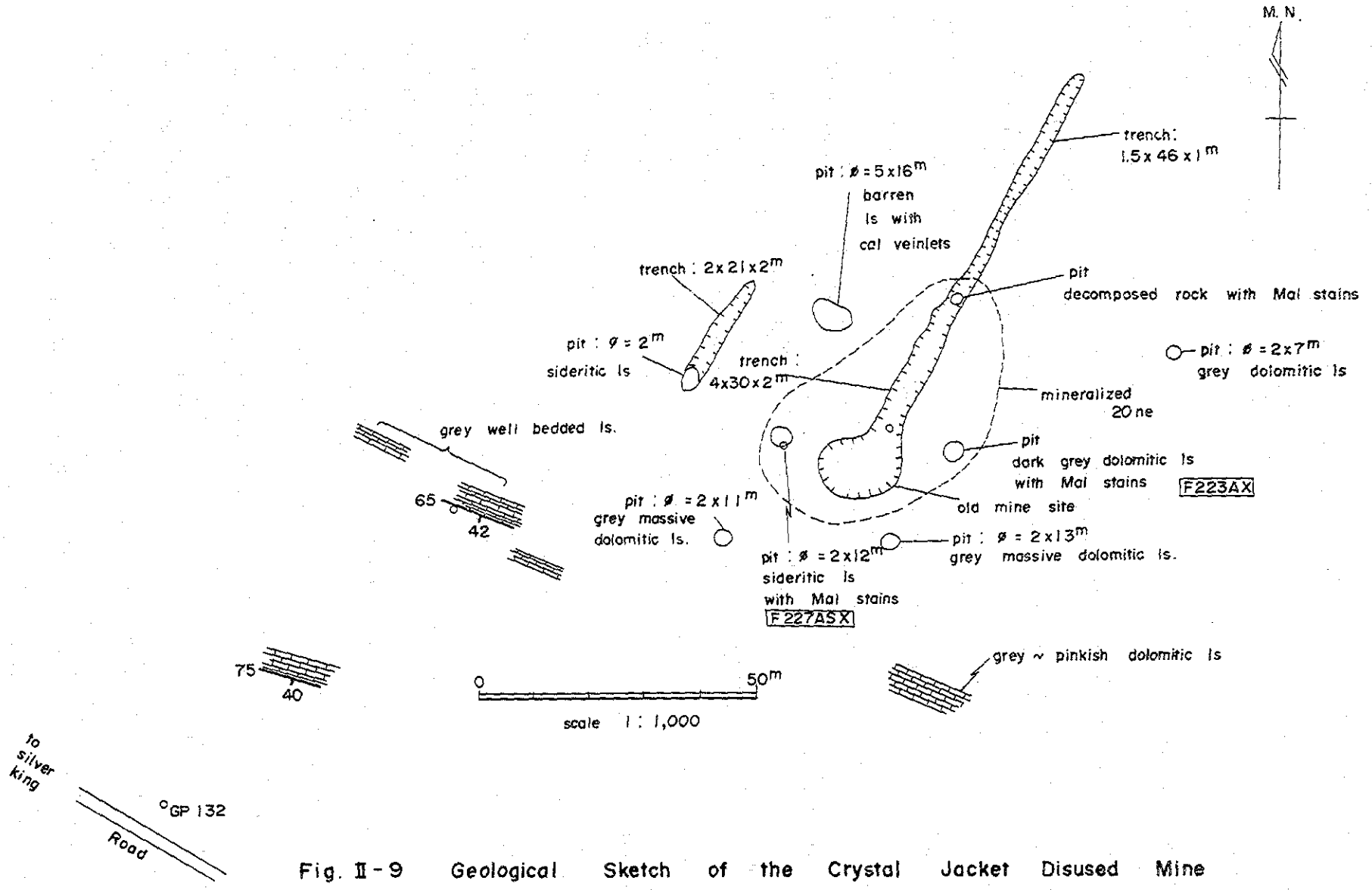


Fig. II-9 Geological Sketch of the Crystal Jacket Disused Mine

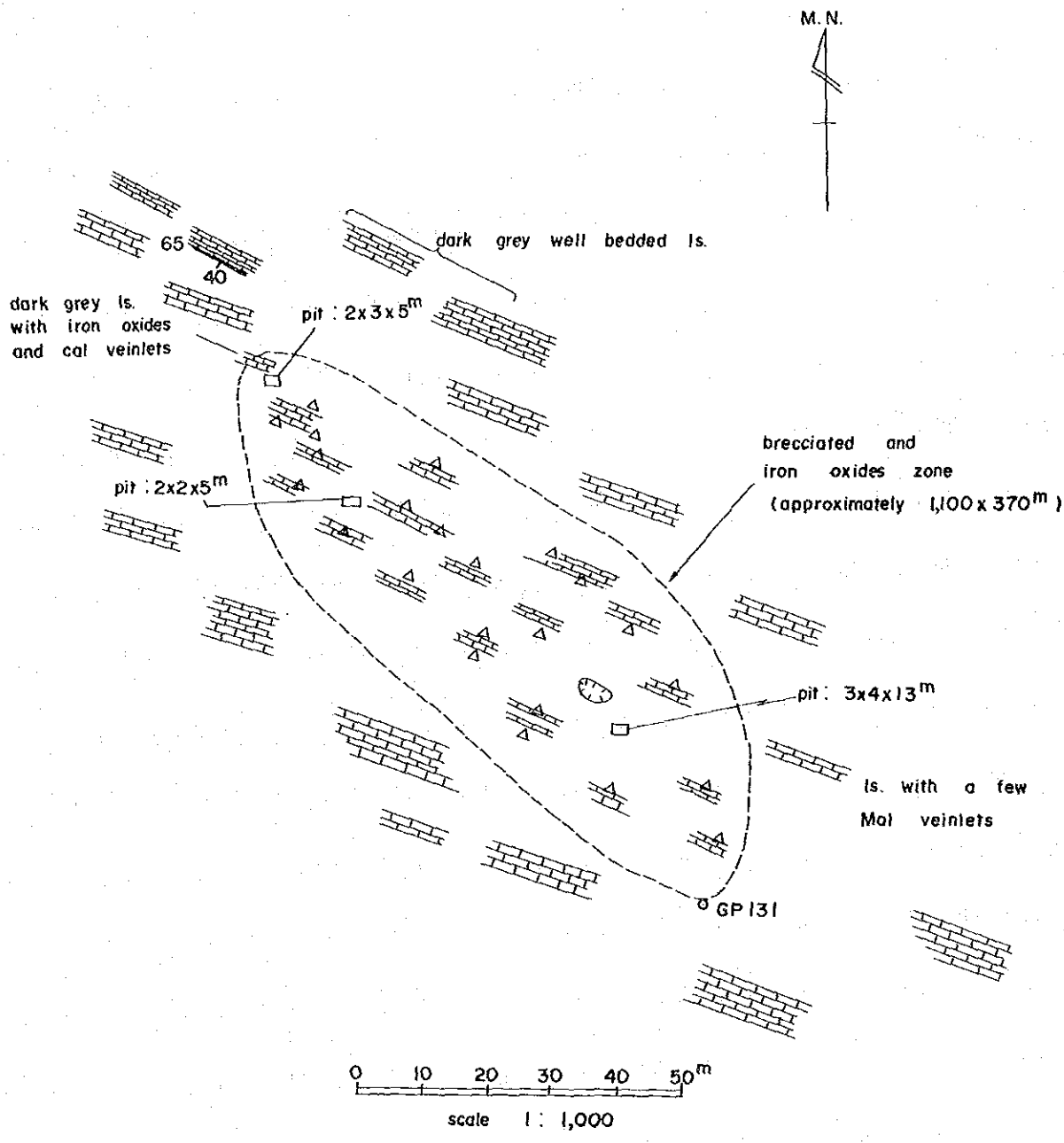


Fig. II-10 Geological sketch of the Kakuyo Mineralized Area

2-2-6 Colonel, Maurice Gifford, True Blue Mineralized Zones

These three mineralized zones are located in the central part of the Northern Block where the geology consists of bedded limestone. The distribution of these three mineralized zones is shown in Fig. II-11, Colonel lies approximately 350m west-southwest of Maurice Gifford and Ture Blue approximately 800m east-southeast of Maurice Gifford.

The geology of the area consists of barren bedded limestone with occasional intercalation of thin shale and meta-sandstone. Brecciated sideritic limestone with iron oxide network of 5m~20m scale are distributed in the limestone. Pitting and trenching were made many years back and iron oxide and calcite veinlets associated with malachite, azurite, chalcopyrite are found in their wastes.

The analysis of these samples are laid out in Ap. 2. The high-grade material are Ag 21g/t, Cu 5.20%, in brecciated sideritic limestone from Maurice Gifford; Ag 129g/t, Cu 12.30% in shale from Colonel; Cu 39.25%, Zn 0.62% in iron oxid veinlets in brecciated sideritic limestone and Ag 255g/t, Cu 26.50% in calcite veins from True Blue. The high content of Ag and the existence of Zn both in country rocks and veins are noted.

There are large amounts of barren limestone in the westes from the pits and they are piled on the upper part of the dump. This is particularly conspicuous for the pits in the marginal parts of the mineralized areas. It is inferred from these facts that the mineralized brecciated sideritic limestone occur in small scale funel-shaped fractured zone.

In the ores from True Blue, tennantite, chalcocite, small amounts of pyrite and copper oxides were identified microscopically. Tennantite occurs as unhedral grains of 2-3mm scattered in the gangue minerals and chacocite is found near the tennantite and along cracks.

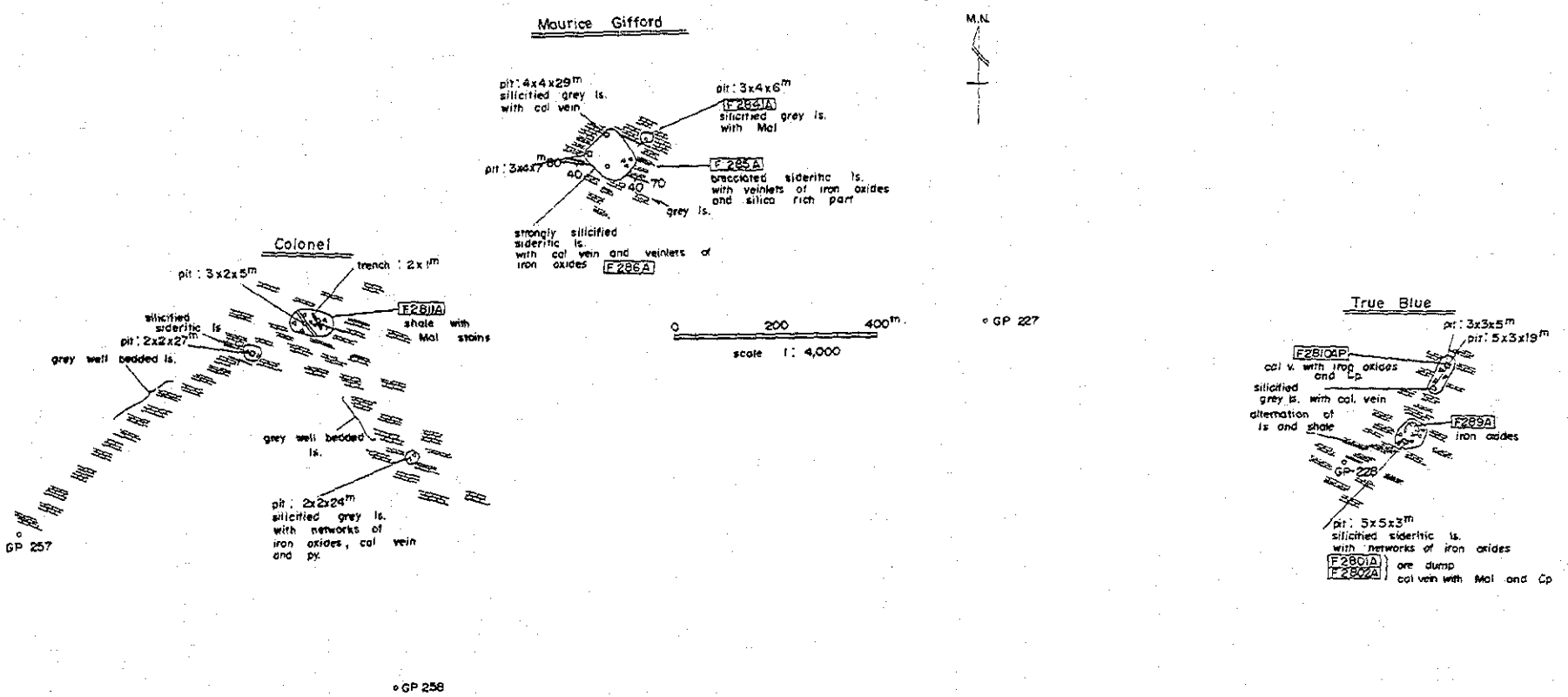


Fig. II - 11 Geological Sketch of the Colonel, Maurice Gifford and True Blue Mineralized Area

2-2-7 Blue Jacket, North Star Mineralized Zones

Blue Jacket mineralized zone is located approximately 1km south-southwest of Sable Antelope. Here, malachite veinlets, network veins, and dissemination occur along the small fissures in the metamorphosed sandstone. Calcite veinlets containing malachite are occasionally found. The trend of these veinlets are oblique to the bedding (Fig. II-12).

The analysis of these samples are listed in Ap. 2, and those relatively rich in malachite contain Ag 17.5g/t, Cu 31.45% and trace of Pb, Zn. We re-analysed the geochemical data of MINDECO/NORANDA and showed that Blue Jacket mineralization occurs within the Cu anamolous zone and that Zn anomalies extends to the south and west of the mineralized zone.

North Star mineralized zone is located in the central part of the Northern Block, in the metasediments of the surveyed area. Outcrops and traces of exploration activity could not be found at the location shown on the 1:50,000 topographic map, but marks of old trenches were found at the southern foot of Kakuyo Hill which is described in the literature. Judging from the wastes nearby, these trenches were probably after the weak malachite dissemination in the limestone intercalated in the metasandstone. In the trenches, however, only barren metasandstone and limestone were found (Fig. II-13).

2-2-8 Kamiyobo Mineralized Zone

This mineralized zone is located approximately 2.5km east-northeast of the intersection of the kaindu Road and the Lubungu Pontoon Road in the southeastern part of the surveyed area.

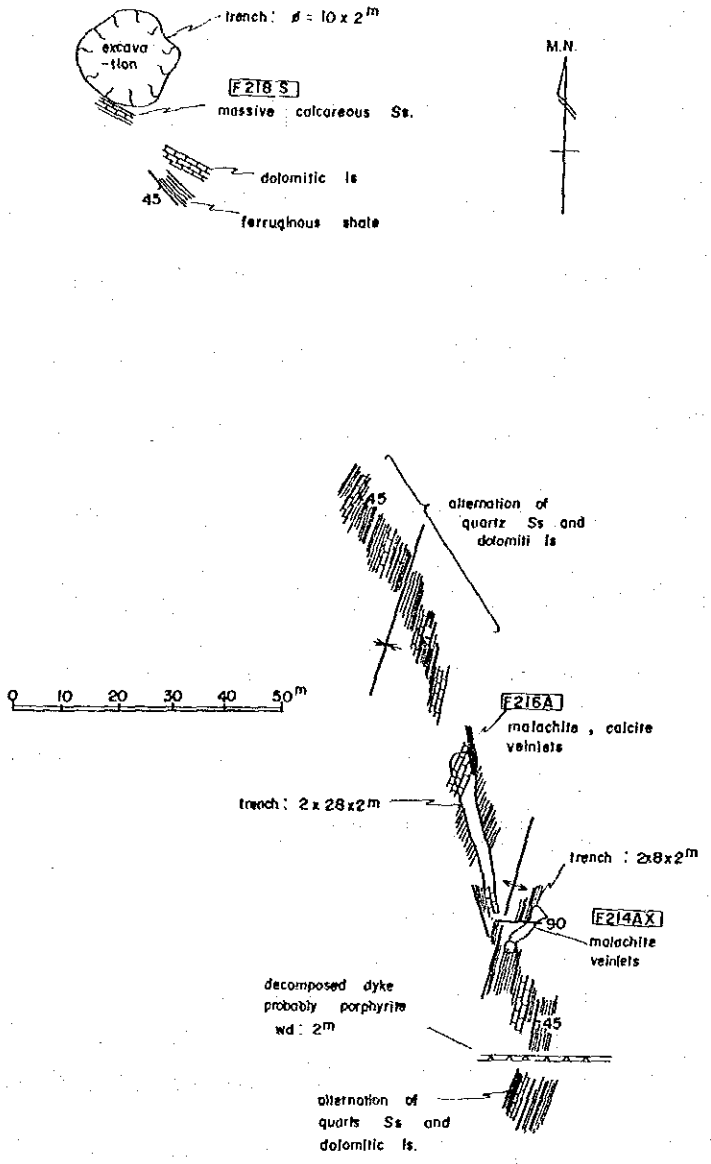


Fig. II – 12 Geological Sketch of the Blue Jacket Mineralized Area

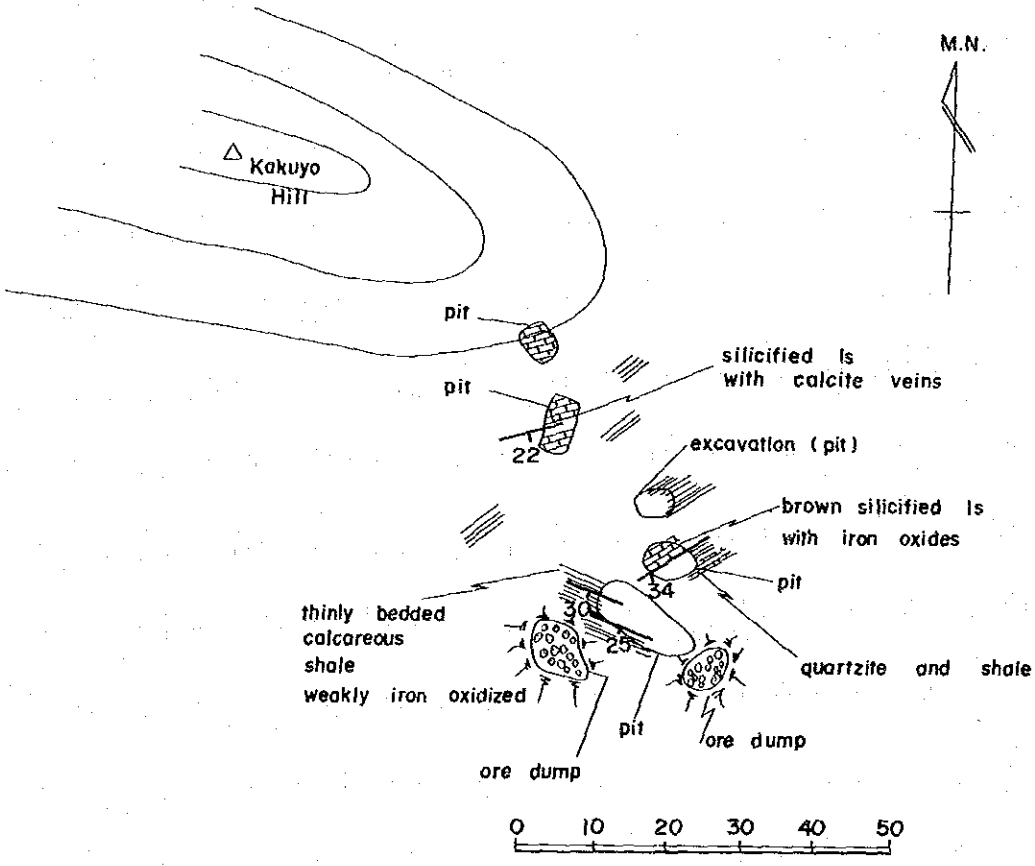


Fig. II-13 Geological Sketch of the North Star Mineralized Area

Silver content of 12g/t, Cu 26% from the ores of the weste dump and Cu 6.74% from the 4.5m line sample of the outcrop are reported from the survey of this zone in 1950 and 1954.

During the present work, the dip could be measured, but could not determine the direction of the strike because the outcrop was cut to a height of 10m in an open-pit like fashion (Fig. II-14). The outcrop is a malachite-bearing iron oxide vein in shale and filling a fissure trending N70°W, 80°S. The vein is 1 m wide at the surface, increasing the width to 4m at 5m depth and the eastern half of the vein includes a large amount of malachite. Further 5m down, the width of the vein is the same 4m, but large amount of malachite occurs throughout the vein. The analytical results of these samples are listed in Ap. 2. The width of ore is 2m at 5m depth with Cu 3.60%; at 10m depth the ore width 4m with Cu 1.04% and trace of Ag, Pb, Zn.

The major iron oxide mineral is goethite and small amount of magnetite remains unaltered. The iron oxides, in some places, have botryoidal texture indicating dissolution-precipitation, and they are also precipitated secondarily in cracks and bedding planes.

There are many iron oxide lumps scattered in the mountains in the direction of the strike of outcrop, but copper does not exist in these areas. Also further in the same direction, there are bedded limestone with no trace of mineralization. However, it is not possible to directly observe the relationship between the host rock shale and the underlying bedded limestone and thus it is not clear whether the vein thins out or is cut by faults.

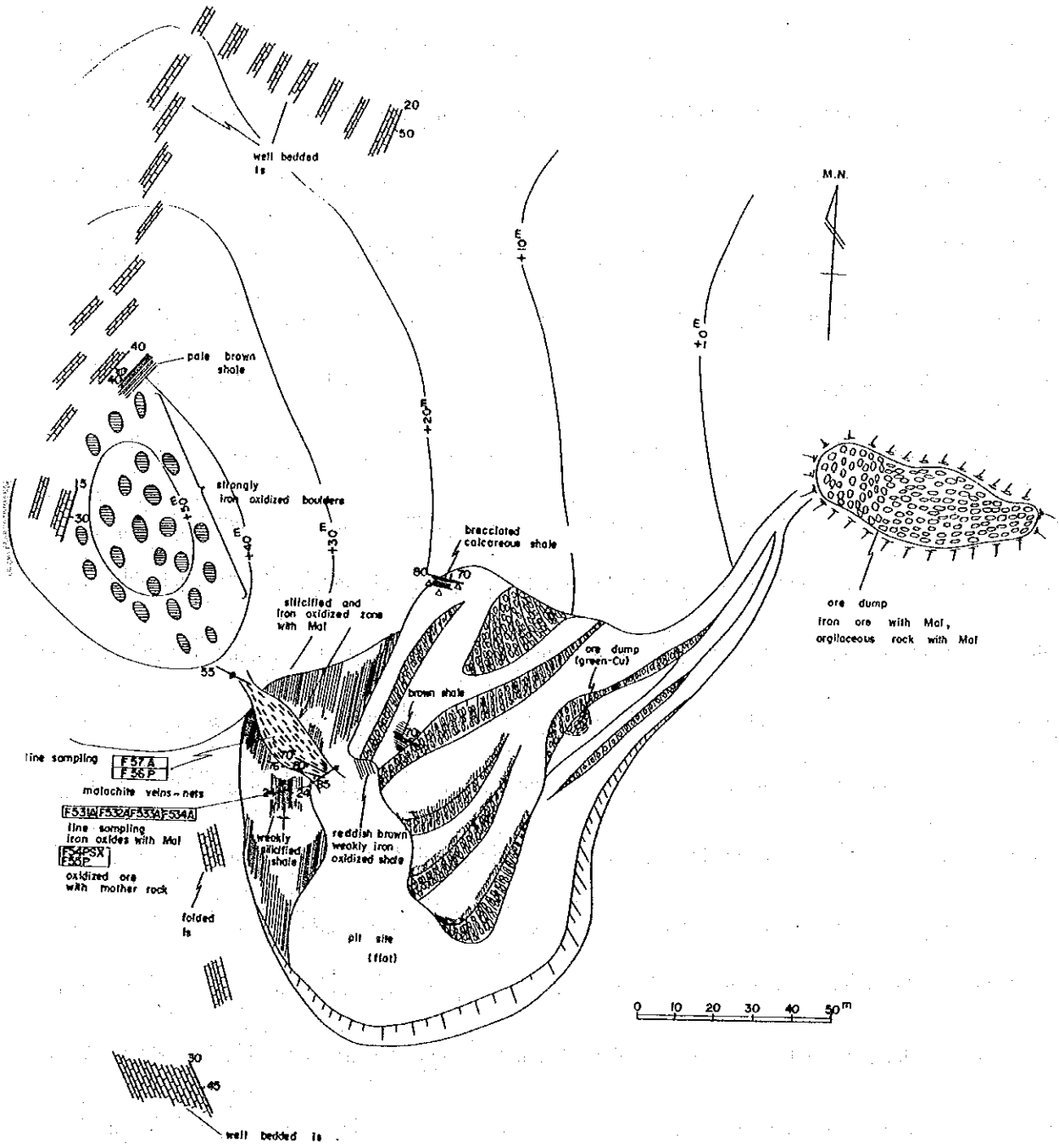


Fig. II – 14 Geological Sketch of the Kamiyobo Mineralized Area

2-2-9 Sugar Loaf, Lou Lou Mineralized Zone

Sugar Loaf mineralized zone is located immediately north of the Lubungu Pontoon Road in the southern part of the area and Lou Lou mineralized zone 4km north of Sugar Loaf.

According to documents, both mineralized zones were explored by adits, shafts, drilling, pitting and trenching since 1925 and Fe, Cu, P mineralization was confirmed in syenite. At present MINEX is conducting exploration for phosphates.

During the present survey, it was clarified that the outcrop of the mineralized zone is an iron oxide network dissemination of 50m × 50m scale in syenite and that small amount of malachite is associated with it. Goethite is the main iron oxide with minor amount of magnetite. The analysis of the samples revealed 3.9% Cu and trace amount of Ag, Pb and Zn.

There are old shafts and adits to the south of the outcrop. Documents report that the shaft was lowered 30m and the adit extended for 90m which cut through the mineralized zone for 10m. The Cu assay of the samples of the adit was Cu 0.4%. There are 3 old drilling sites aimed at the lower part of the outcrop (Fig. II-15), but there are no descriptions in the available documents. Although the location is unknown, there are the following data on drilling the outcrop, Cu 3.88% is reported down to approximately 20m.

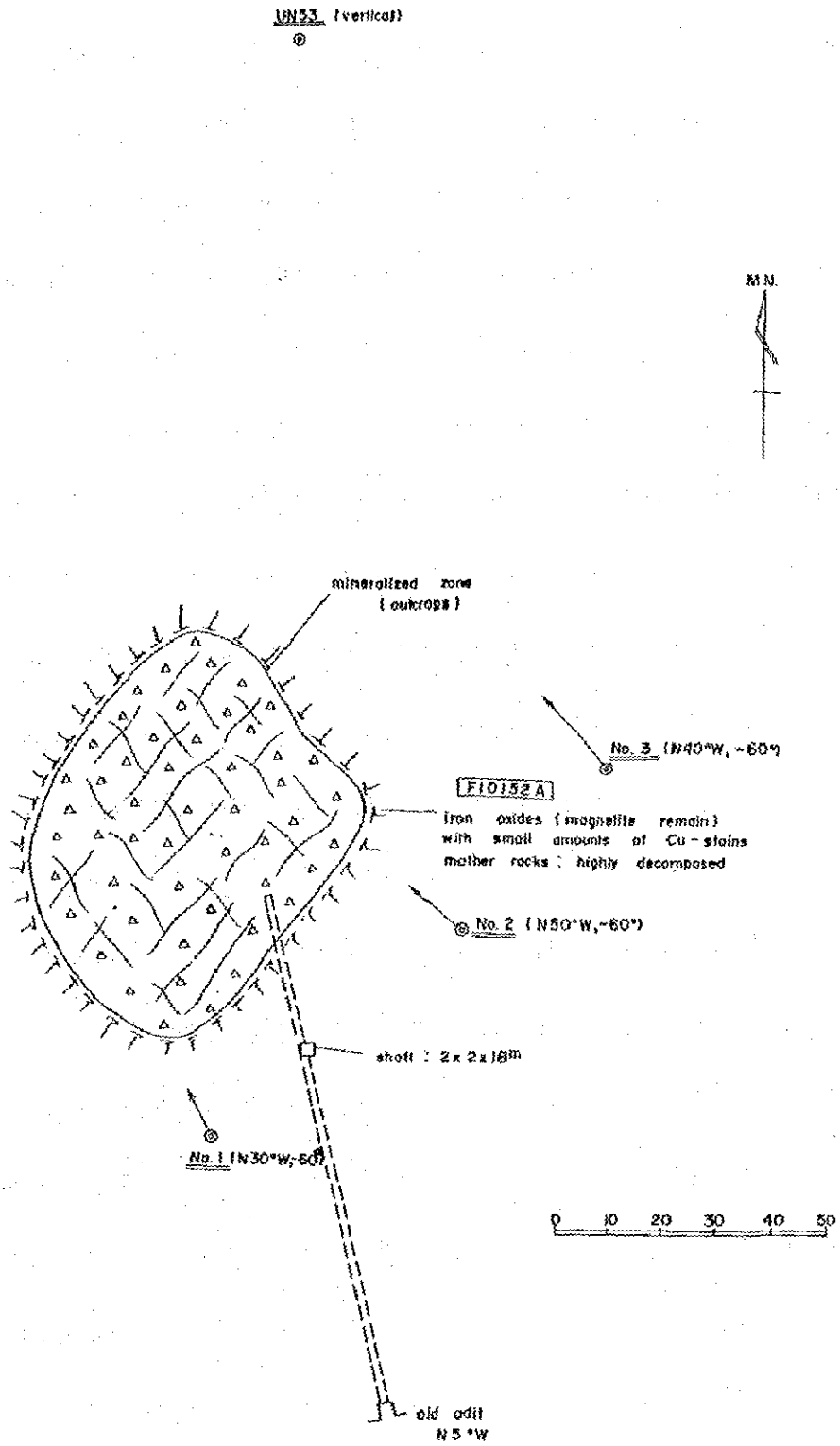


Fig. II - 15 Geological Sketch of the Sugar Loaf Mineralized Area

Drill Data in Sugar Loaf Prospect

Borehole	Length(m)	Rocks and Mineralization			
No 1	0.0~118.9	Decomposed syenite with limonite, a little pyrite and trace of chalcopyrite.			
	118.9~147.5	Syenite and basic rock with magnetite and pyrite.			
	147.5~209.7	Syenite with magnetite, pyrite, apatite and specks of chalcopyrite.			
	209.7~235.9	Decomposed syenite with stringers of pyrite.			
No 2			Length(m)	width(m)	Cu(%)
	0.0~100.6	Ferruginous rock with malachite.	0.0~ 3.2	no core	
			3.2~ 23.3	20.1	3.88
	100.6~190.5	Pyrite-magnetite-apatite rock.	23.3~ 84.7	61.4	0.38
			84.7~107.3	22.6	1.68
	190.5~213.4	Syenite with pyrite and magnetite.	107.3~190.5	83.2	0.35
	213.4~295.4	Porphyritic syenite.			

We investigated the trenches and pits in the outcrop and the vicinity of the Lou Lou mineralized zone. The outcrop is an iron oxide with very minor amount of malachite in a weathered material whose original rock is unknown (Fig. II-16). The samples of this outcrop contain Ag 49g/t, Cu 4.80% with trace amount of Pb, Zn. According to literature, the mineralized zone is a Cu, P dissemination in syenite and the Cu-grade of outcrop is 0.3~0.7%.

United Nations conducted drilling for both mineralized zones (Table II-2), but the location of only those shown in Fig. II-15~17 are known and significant ores have not been reached.

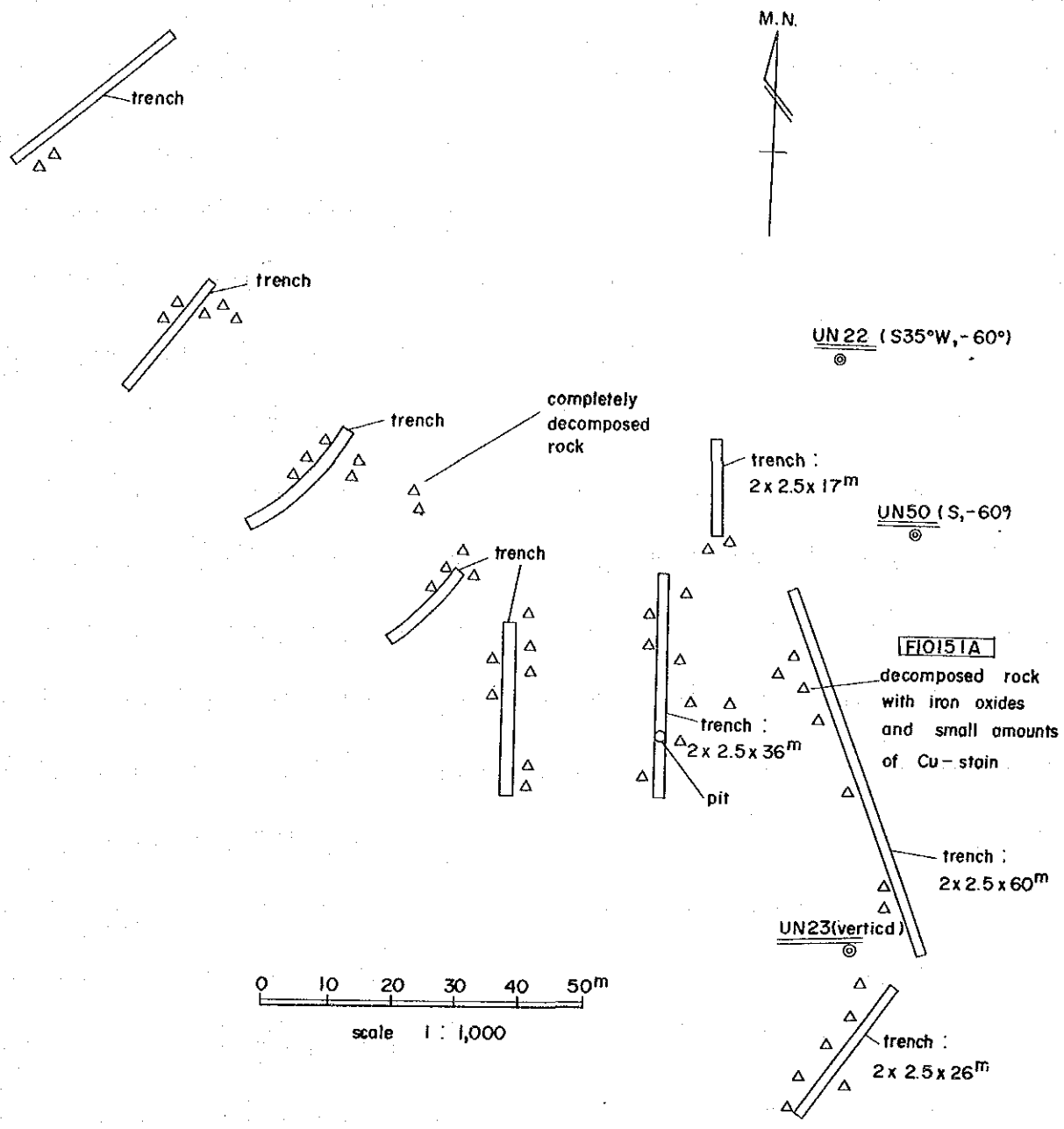


Fig. II-16 Geological Sketch of the Lou Lou Mineralized Area

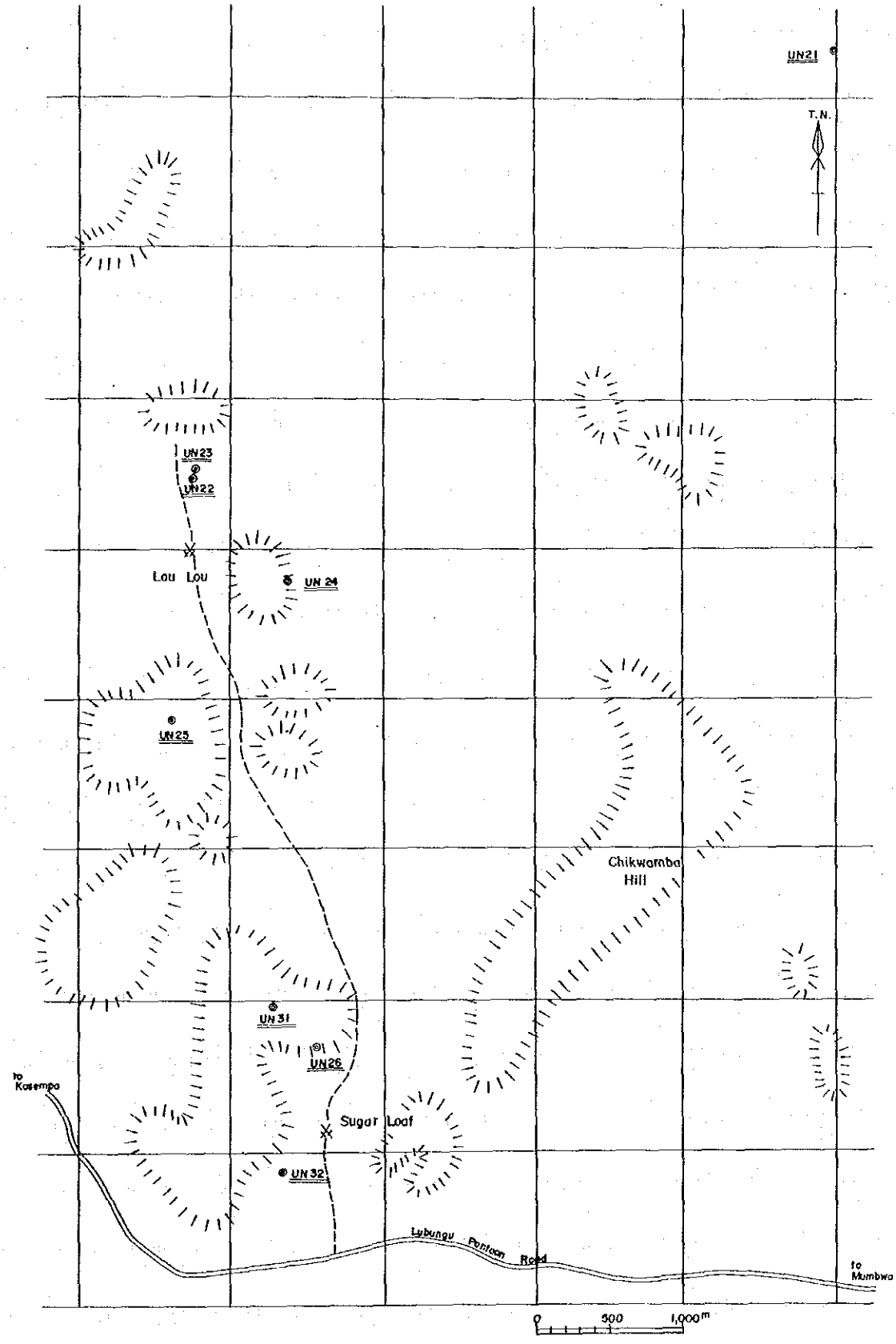


Fig. II - 17 Location Map of Drilling Site around Lou Lou and Sugar Loaf Mineralized Area

Table II-2 UN Drill Data of Lou Lou Sugar Loaf Area

Drill No.	Inclination	Locality	Length (m)	Rocks and Mineralization	Final Length (m)
UN21	-	Chitepetepe	-	No Data	
UN22	"	Lou Lou	-		
UN23	-	"	-		
UN24	-60 (M.N.270°)	Middle part between Lou Lou and Sugar Loaf	0.00~67.00 ~ 156.21	Sericitized monzonite and syenite. Sericitized syenite and porphyritic monzonite.	156.21
UN25	-60° (M.N.245°)		0.00~4.20 ~ 11.40 ~ 30.00 ~ 69.20 ~ 98.91	Soil Weathered monzonite Sericitized monzonite with quartz-sericite veins and iron oxides (Cu: 110~560 ppm) Completely sericitized monzonite replaced by quartz and iron oxides(47.80~57.90m, Cu:0.31%) Sericitized and silicified monzonite (Cu : 0.1 ~ 0.29%)	98.91
UN26	vertical	Northern part of Sugar Loaf	0.00~6.00 ~ 24.38 ~ 70.00 ~ 115.52 ~ 125.58	Soil with fragments of decomposed monzonite Sericitized and silicified monzonite associated with quartz and copper phosphates.(Cu:170ppm ~ 0.3% with the main concentrate at 12m) Sericitized monzonite with quartz - sericite veinlets and trace of copper phosphates (Cu: less than 800 ppm) Sericitized monzonite with veinlets and dissemination of pyrite,magnetite and hematite (Cu : <0.1 ~ 0.3%) Sericitized monzonite (Cu: 300 ~ 700 ppm)	125.58
UN31	vertical	Near Sugar Loaf	0.00~8.00 ~ 11.58 ~ 60.00 ~ 65.00 ~115.00	Soil with fragments of decomposed monzonite Weathered monzonite with concentration of copper phosphates (Cu: 0.33 ~ 0.44%) Sericitized monzonite and monzonite porphyries with quartz-sericite and quartz-iron oxides veins after and small veinlets of copper phosphates (Cu: 0.06~0.3%, but decreases sharply to 300 350ppm approching the zone of primary pyrite) Almost completely sericitized monzonite,disseminated pyrite with chalcopyrite inclusions and scatterd grains of chalcopyrite (Cu: average 1.0%) Sericitized and partly silicified monzonite(101.78 ~ 103.36m, Cu: 0.09~0.19% with disseminated pyrite)	115.00
UN32	vertical	400m Southwest from Sugar Loaf	0.00~6.10 ~ 52.73 ~ 79.00 ~ 97.08	Soil with weathered apatite,iron oxides and quartz. Completely sericitized monzonite with disseminated pyrite incleasing with depth. (Cu:6.10~29.00m:average 0.17%,29.00~51.50m 0.47% and apatite is abundant) Sericitized monzonite with apatit of small concentrations.(Cu: 52.73~69.00m average 0.32%) Sericitized monzonite syenite porphyry (79.00~90.00m, zone of pyrite with apatite and +580ppm of Cu. From 90.00m trace of copper phosphates, Cu: less than 570ppm.	97.08
UN50	vertical	2.4 Km North of Lou Lou	0.00~1.20 ~ 15.00 ~ 50.00 ~ 76.30	Soil with 0.16% of Cu. Soil with syenitic fragments. Fault clay zone (48.5~50.00m,copper-phospates.Cu:0.2%) Cu : average 0.1%	76.30
UN52	vertical	233m Nort East of Sugar Loaf	Whole	Porphyritic syenite and microsyenite (Cu average less than 0.09%, Ag, Pb, Zn and apatite are rare.)	62.3
UN53	vertical	150m North of Sugar Loaf	Whole	Mainly micro syenite, no mineralization	51.0