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

PHASE II

FEBRUARY 1986

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

This report submitted hereby summarizes the results of the second 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, 1986

Keisuke Arita

Keisuke ARITA
President,
Japan International
Cooperation Agency

Masayuki Nishiie

Masayuki NISHIIE
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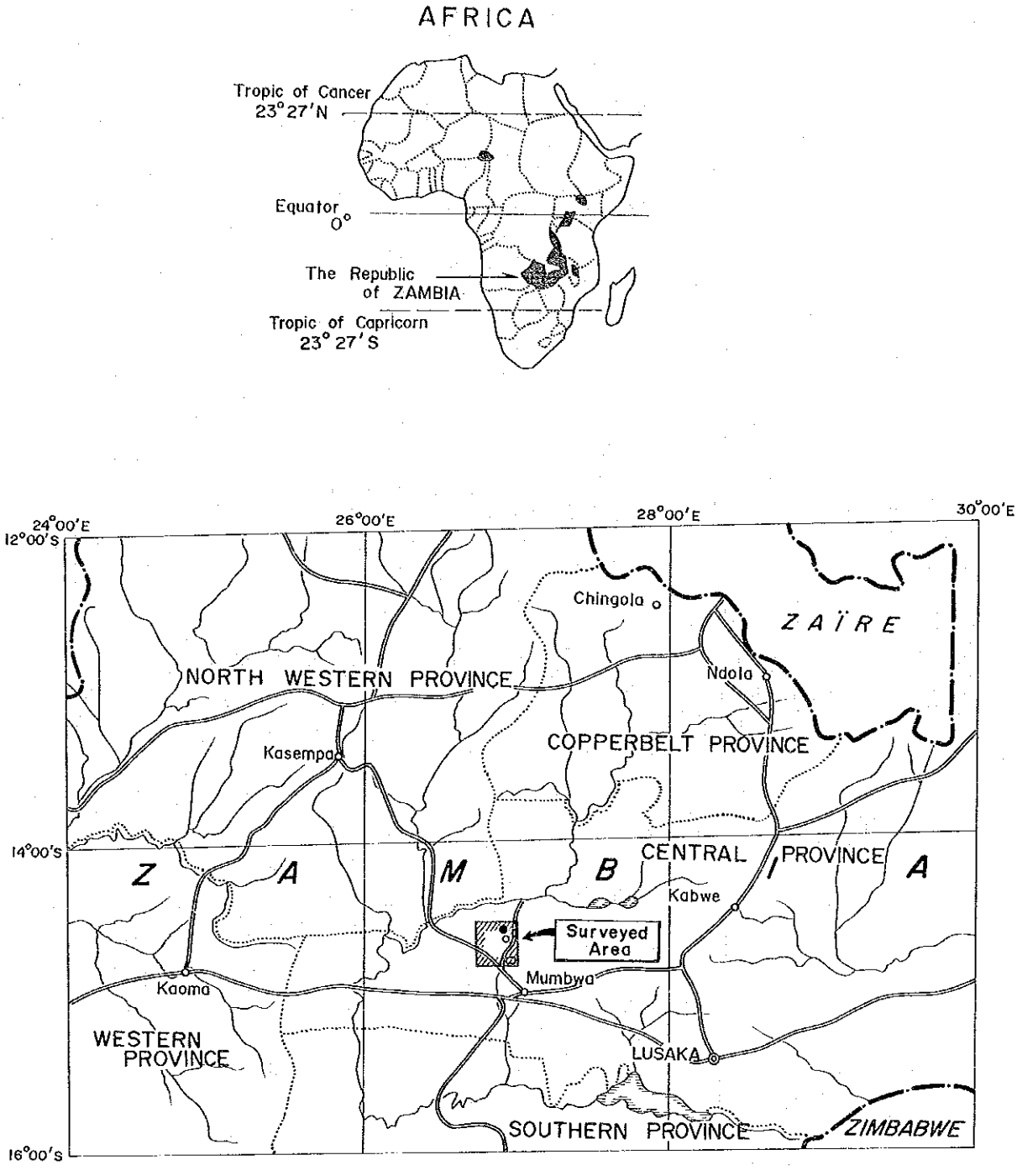

Fig. 1 Index Map of the Surveyed Areas

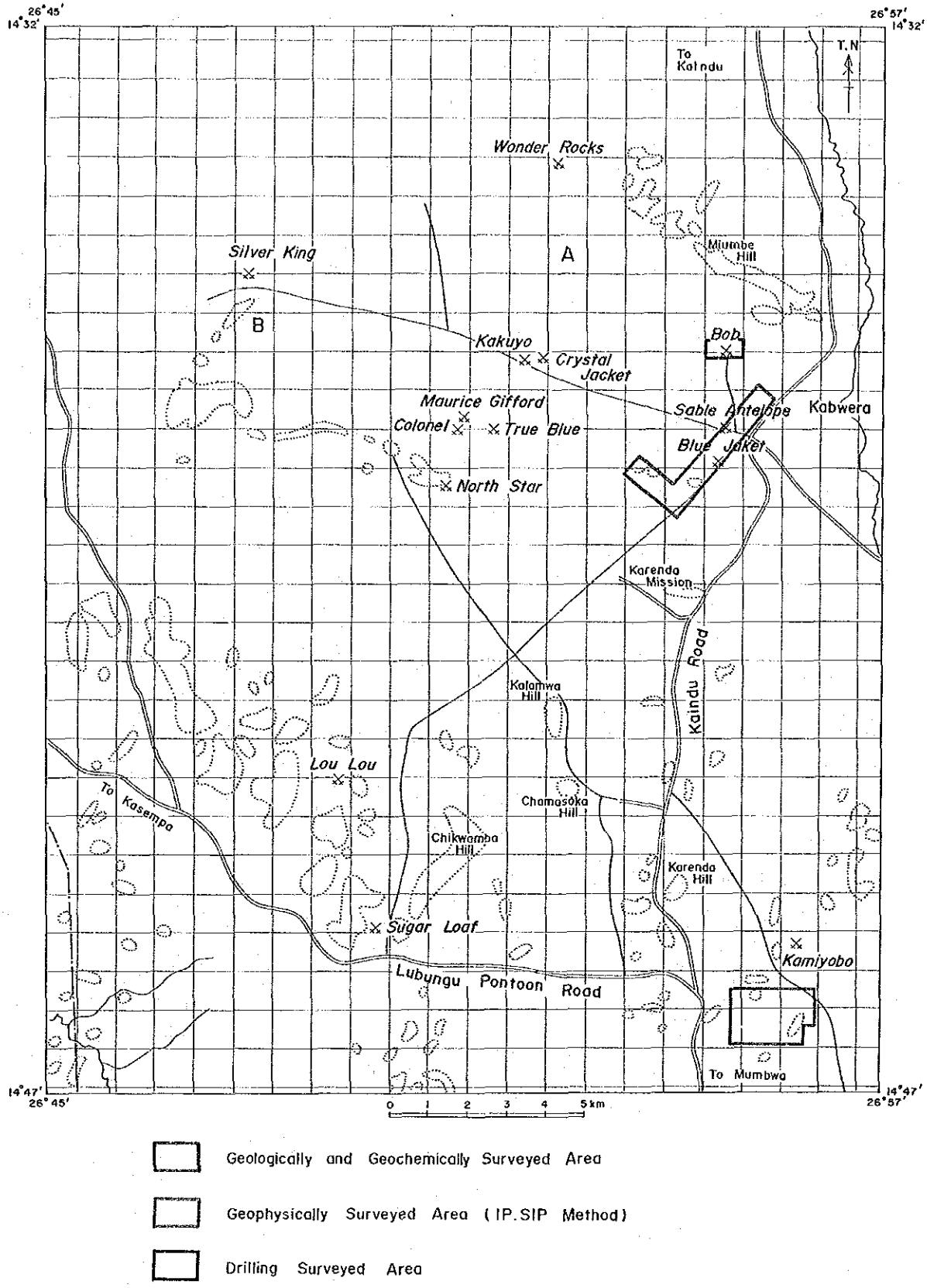

Fig. 2 Map of the Surveyed Areas

SUMMARY

This is the report of the survey conducted during the second year in the Karenda area with the objective of clarifying the silver, copper, lead and zinc mineralization.

It was known from the results of the survey of the first year that;

(1) the geological units of the Karenda area are carbonate and sandy to muddy metasedimentary rocks of the Kundelungu Series belonging to the Precambrian Katanga System, igneous rocks intruding these formations and rocks of the Quaternary System;

(2) there are many known mineral deposits and mineralized zones; most of the mineralization occur in the brecciated and fractured zones within the northern carbonate rocks; also mineralization is observed in several areas along fissures and weak zones within the metasedimentary rocks and igneous bodies; the deposits are pipes, lenses and veins; and also there are three promising areas, namely, kamiyobo area in the southeast, Sable Antelope and Bob Zinc areas in the north.

The present work (second year) consisted of geological geochemical and geophysical (IP, SIP) surveys and drilling in the above three areas.

Geochemical anomalies of Cu, Pb and Zn were found in the southwest and the southeast of the Kamiyobo area. The

relatively large anomalous zone in the southwest is depicted as an intersection of two vein-form anomalous zones extending in NNW-SSE and NE-SW directions. The zone in the southeast was found to occur as a smaller vein-type zone elongated in NNE-SSW direction.

The NNW-SSE trending anomalous zone occurs as a belt consisting of many high Cu, Pb, Zn anomalies and continues for more than 1km. The very high anomaly in the center also continues as a vein for approximately 300m and is larger than the known deposits of the area. Magnetite remains in the vicinity which indicates the relatively low effect of erosion and weathering. Therefore, the possibility of finding primary sulfide deposits is considered to be high in this area.

Three IP anomalous zones were detected over an area in the vicinity of Sable Antelope ore deposits to Blue Jacket mineralized zone, suggesting a possibility of mineral occurrences.

The Geophysical IP Anomaly No. 3 occurs near the Blue Jacket mineralized zone and it consists of vein-type low resistivity zone with high frequency effect which continues for more than 500m in WNW-ESE direction. Simulation indicates a continuous sulfide concentration in WNW-ESE direction at 100m-300m depth with vertical to steep southward dip and 60-70m wide. There is a high possibility of it being a primary sulfide deposit.

IP Anomaly Zones Nos.1 and 2 occur near the Sable Antelope Deposit. No.1 extends for more than 200m in WNW-ESE direction and No.2 continues for more than 500m in E-W direction. The Sable Antelope is located within the No.2 Anomaly Zone. The major alteration associated with this deposit is silicification and thus the resistivity is high. However, the fact that the frequency effect anomaly is continuous and high Zn anomaly is obtained from the pits dug over No.1 Anomaly Zone, indicates that the possibility of the occurrence of Sable Antelope type zinc sulfide deposit is high.

A weak zinc mineralization was confirmed at MJZ-5 and MJZ-6 by the drilling in the Bob Zinc area.

The mineralization at MJZ-5 occurs in a zone of 6.60m thick at a depth of 60m from the surface and the average grade is 0.31% Zn, and that at MJZ-6 occurs in an interval of 12.70m grading 1.64% Zn at a depth of 100m.

Zinc minerals such as zinc-silicates and Zinc carbonates were found but zinc-sulfide was not observed.

The results of drilling programme in the Bob Zinc area show that there is a concentration of secondary zinc-silicates in a shallower part of a fractured zone which is a target for present investigation, but the concentration repidly becomes poorer or pinches out towards a deeper zone.

This suggests that the main part of primary sulfide deposits has been eroded out and some remnants have yielded the concentration of secondary zinc minerals.

From the above, the characteristics of the mineralization in this area are summarized as follows.

The mineral deposits and mineralized zones have been eroded out to the deeper parts in the massive carbonate area. Primary sulfide deposits cannot be expected here, only secondary oxide, carbonate and silicate minerals occur in some parts. The secondary mineralized zones also deteriorate very rapidly in shallow parts. The geochemical anomalies of Zn in the carbonate zones are developed widely and the anomaly values are high, but Cu geochemical anomalies hardly occur.

The mineral deposits and mineralized zones near the border between massive and bedded carbonates are fairly deeply eroded, but there are primary sulfide deposits such as those of Sable Antelope, Crystal Jacket and Silver King. Both Cu and Zn anomalies are found here, but the distribution of the Cu and Zn anomalies are different.

The erosion of the mineral deposits and the mineralized zones in the area of bedded carbonates to muddy-sandy metasedimentary rocks is relatively weak and thus the occurrence of relatively large primary deposits is possible in these areas. The nature of the geochemical anomalies here is similar to those near the border of massive-bedded carbonates.

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PART I INTRODUCTION

PART I INTRODUCTION

Chapter 1 Outline of the Survey

1-1 Objective of the Survey

Geological, geochemical and geophysical (CSAMT) surveys were conducted during 1984, the first year of this project. Based on the results of the work in 1984, geological and geochemical surveys in Kamiyobo, geophysical survey (IP, SIP) in Sable Antelope and drilling was conducted in Bob Zinc in 1985.

This work was implemented with the objective of understanding the mineral occurrences of the Karenda area, Republic of Zambia through detailed geological investigation of the area.

1-2 Introduction

1-2-1 Surveyed Area

The area surveyed is shown in Figs. 1 and 2. The scope of work conducted is as follows.

Kamiyobo :	2.3 Km E-W, 1.5 Km N-S, 3.2 Km^2
Sable Antelope:	IP traverse 16 Km, SIP traverse 5 Km 2 Km^2
Bob Zinc :	Six holes, 1,107 m, 0.1 Km^2

1-2-2 Survey Methods and Amount of Work

(1) Geological and Geochemical Surveys (Kamiyobo Area)

The geochemical sampling lines were set in E-W

direction from the geochemical base point of the previous year. The lines were set at 100 m intervals and the stations were set at 50 m intervals in E-W direction. Pocket compass and tapes were used for the above. Geological and topographic survey were conducted along these traverses together with the geochemical work. Geological map of 1:5000 scale was prepared.

Geochemical sampling was conducted for an area of 2.3 Km^2 as originally planned. The results showed, however, that the anomaly extended further south and thus another $1km^2$ was added to the area for geochemical survey. The number of samples collected was 635 geochemical samples (indicators, Cu, Pb, Zn) and 1 ore sample (analysed elements, Ag, Cu, Pb, Zn). These were analysed and interpreted.

(2) Geophysical Survey (Sable Antelope Area)

Sable Antelope was selected for detailed geophysical survey because geophysical anomalies were detected along the weak linear zones by the CSAMT survey of the previous year.

In this area, first IP method was applied along five traverses with a total of 16 km-line. The traverse interval was 200m and the station interval 100m. SIP survey was then conducted on the anomalies obtained from the IP work. Four traverses with the same line and station intervals as the IP survey was set and a total of 5 km-line was measured.

A total of 13m of pitting was done at four IP anomaly

locations and 32 soil and rock samples (analysed elements, Cu, Pb, Zn), 4 ore samples (analysed elements, Ag, Cu, Pb, Zn) and 3 samples for spectrometry were collected.

(3) Drilling (Bob Zinc Area)

Bob Zinc Area was selected for drilling because the study of existing data during the first year showed that geochemical anomalies very similar to those of the Bob Zinc ore body extended northward.

Drill Hole No. 1 was designed so that it would cover the widest range of the geochemical anomaly zone because the accuracy of the existing data was not clear. The water well of the Bob Zinc ore body was used as the reference point for checking the location of the sites of the 1957 and 1964 drilling. The location, direction and inclination of the drilling operations of No. 2 to No.6 were determined by studying the results of the surface geological survey and geochemical check survey together with the immediate drilling data. Thus, six holes with a total of 1,107m were drilled and obtained 12 samples for microscopy, 12 for x-ray diffraction, 3 for EPMA, 69 for ore analysis (Ag, Cu, Pb, Zn), 23 for spectrometry and 66 for geochemical analysis (indicator Zn).

1-2-3 Duration of the Survey

The present work was conducted during the period from 12 June 1985 to 10 February 1986. The duration of the field work was as follows.

(1) Geological and geochemical survey

30 July 1985 - 29 October 1985

(2) Geophysical survey

12 June 1985 - 10 August 1985

(3) Drilling

30 July 1985 - 29 October 1985

1-3 Members of the Survey Team

(1) Japanese Members

Leader, Chief Geologist and Geochemist

Hiroyuki Fujioka (Nikko Exploration & Development Co., Ltd.)

Chief Geophysicist

Harunobu Sumida (Nikko Exploration & Development Co. Ltd.)

Geophysical prospecting

Toshiaki Fujimoto (Nikko Exploration & Development Co., Ltd.)

Saburo Tachikawa (Nikko Exploration & Development Co., Ltd.)

Chief Drilling Engineer

Yukio Kawamura (Nikko Exploration & Development Co., Ltd.)

Drilling

Mitsuo Sasaki (Nikko Exploration & Development Co., Ltd.)

Hiroshi Ishikawa (Nikko Exploration & Development Co., Ltd.)

Planning · coordination

Takahisa Yamamoto (Metal Mining Agency of Japan)

Yoshiyuki Kita (Metal Mining Agency of Japan)

(2) Zambian Members

General supervision

Dr. S.N. Punukollu (Director, MINEX (ZIMCO*)

Coordinator

Dr. L. Borsch (Chief Chemist, MINEX ZIMCO)

W.B. Sikombe (Chief Geologist, MINEX ZIMCO)

A.S. Sliwa (Exploration supervisor,MINEX ZIMCO)

G.R. Rao (Exploration supervisor,MINEX ZIMCO)

Field supervisor

Elias Mbumba (Project Geologist, MINEX ZIMCO)

Field survey

Albert Mutuma (Senior Field Assistant, MINEX ZIMCO)

Lazarus Tembo (Senior Field Assistant, MINEX ZIMCO)

Jesto Banda (Senior Field Assistant, MINEX ZIMCO)

Isaac Mwanza (Field Assistant, MINEX ZIMCO)

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

Chapter 2. Outline of the 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 by 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 by 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 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 this 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. Sorghum, millet and cotton are grown in various parts in the vicinity of the surveyed area, and there is a National Service Farm. These are the main activities of the area and others include production of charcoal for fuel, hunting and fishing.

2-2 General Geology and Ore Deposits

2-2-1 Karenda Area

The geological units of this area consists of carbonate and sandy to muddy metasedimentary rocks of the Kundelungu

Series of the Precambrian Katanga System, syenites, porphyrites and other igneous rocks intruding these formations and the rocks of the Quaternary System. The carbonates are mostly massive in the lower part and bedded in the upper horizons, the transition between the above two types is gradual. The sandy metasediments are mostly fine-grained quartz metasandstones and the muddy metasediments are mostly shale. The relation between these metasediments is alternations and gradual transition. They conformably overlie the beddedlimestone.

The geological structure is largely controled by large E-W and N-S fault systems. The area to the west of the N-S faults and north of the E-W faults (northern block) consists predominantly of carbonate rocks which show monoclinic structure with 30°-40°S dip. Many ore deposits including Sable Antlope and Bob Zinc Deposits occur in this block. The area to the east of the N-S faults (eastern block) consists mainly of upper carbonate rocks and the sandy to muddy metasedimentary rocks. These units strike in N-S direction and are frequently folded. Kamiyobo mineralized zone occurs in this block. The area to the west of the N-S faults and south of the E-W faults consists mainly of intrusive rocks and is not included in the present work.

Brecciated structures are frequently found in the carbonates of the northern block. These structures have circular to oblong shape at the surface and range from ten to several hundred meters in size. Each brecciated fractured part is independent, but they are distributed in zones harmonious with

the E-W geological structure and also along the weak lines perpendicular to the E-W structure.

Fourteen deposits and mineralized zones are known in this area. Some of these have been worked in the past, but many of them have not yet been completely mined out. The deposits are pipe to lens-shaped dissemination and veins with partly massive nature. Mineralization is observed in the brecciated fractured zones in the northern carbonates and along the fissures and weak zones in other areas.

The ore minerals observed at the outcrops are iron and copper oxides, but the mineral composition of the drill cores, mined ores and dumps differ by localities. For example, the mineralized zones of Wonder Rocks and Bob Zinc in the north have been eroded to the lower part of the mineralized zone, and in these zones only copper and zinc oxides and carbonates are found with no sulfides. On the other hand, Sable Antelope, Crystal Jacket, Silver King deposits have been mined. These deposits and the mineralized zone to the south contain chalcopyrite, pyrite and other sulfide minerals. Chalcocite, bornite, Chalcopyrite, tetrahedrite, pyrite are found in the mined wastes of Sable Antelope Deposit.

2-2-2 Surveyed Area

The area surveyed during the course of the present work was selected by considering the results of the previous year (first year). The outline is as follows.

(1) Kamiyobo Area

Pb-Zn anomalies were detected during the geochemical work of the previous year. The geological units are bedded limestone, quartz - sandstone, siliceous sandstone, shale and small syenite porphyry bodies.

The Kamiyobo Mineralized Zone is located approximately, 600m north of this area. The exposure shows malachite-iron oxide vein which fills a N70°W, 80°S trending fissure in shale. It overlies bedded limestone. The grade at 5m below surface is; vein width 2m, 3.60% Cu, at 10m below surface; it is 4m wide, 1.04% Cu, with very minor amount of Ag, Pb and Zn.

(2) Sable Antelope Area

Several geophysical anomalies were observed by CSAMT during the previous year along the N-S weak lineation from Sable Antelope Deposit to Blue Jacket Mineralized Zone.

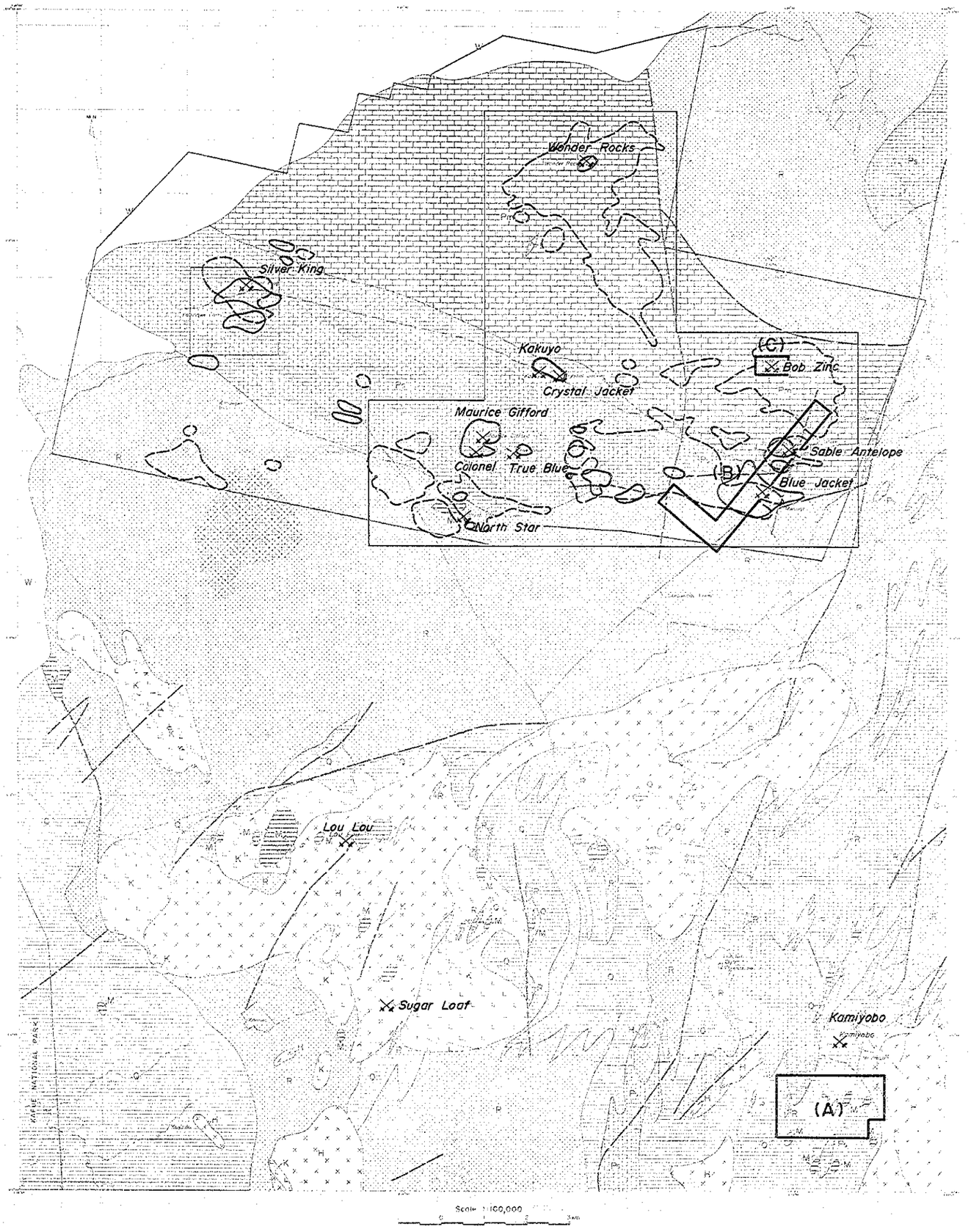
The geological units constituting this area are massive dolomite, bedded limestone, quartz sandstone, shale and others. The Sable Antelope Deposit occurs in the brecciated zone of the massive dolomite. The Blue Jacket mineralized Zone is located approximately 1km south of Sable Antelope Deposit and it consists of malachite veinlet-networks-dissemination and malachite-calcite veins developed along the fissures in the quartz sandstone and shale. The grade of the malachite-rich parts is 17.5 g/t Ag, 31.45% Cu, with minor Pb, Zn.

The geochemical prospecting data which were obtained by MINDECO-NORANDA many years back were analysed and interpreted during the previous year. The results show that the Sable Antelope Deposit and the Blue Jacket Mineralized Zone belong to different Cu and Zn anomalous zones (Fig. 3). The former anomaly zone is relatively small, but both Cu and Zn anomalies coincide, and it extends to the southwest of the deposit. The latter zone consists of relatively small Cu anomalies, but very widely distributed Zn anomalies, and the latter extends southward and is elongated westward.

(3) Bob Zinc Area

This is a Zn anomaly zone obtained from the reinterpretation of the old MINDECO-NORANDA geochemical data during the previous year. It is located approximately 2km north of the Sable ntelope Deposit.

The major geological unit is massive dolomite. The Bob Zinc Deposit and Zn anomaly zone occur in the brecciated fractured zone.



LEGEND

Exploration Area of Phase II
(A) : Geological and Geochemical Survey
(B) : Geophysical Survey
(C) : Drilling Exploration

Exploration Area of Phase I
Whole Area : Geological and Geochemical Survey
(a) : Geophysical Survey (CSAMT)

Old Surveyed Area
Geochemical Surveyed Area by Noranda Ltd. and Reanalysed on Phase I

Anomalies of Geochemical Survey
Cu : Over Critical Value (Threshold)
Zn : Over Critical Value (Threshold)

Disused Mine Site or Mineralized Area

Fig. 3 Exploration Map of Karenda Area

PART Ⅱ RESULTS OF THE SURVEY

PART II RESULTS OF THE SURVEY

Chapter 1 Kamiyobo Area (Geological and Geochemical Survey)

1. Geological Survey

1-1 General Geology

The major geological units of this area are carbonate rocks, sandy-muddy metasedimentary rocks, syenites intruding these formations and Quaternary residual units (laterite). The geological survey of this area was conducted parallel with geochemical work which will be reported later.

Geological map of the area is shown in Fig. 4 and the stratigraphy including volcanic and other activities are laid out in the column in Fig. 5. The geologic age correlation is that of the report of the previous year.

Carbonates: The lithology of the carbonates of the area is that of the upper horizon, namely bedded limestone. It is distributed in the northwestern part of the area. Thin beds several millimeters thick of metasandstone and shale are frequently intercalated. Limestone is gray and fine-grained. Metasandstone and shale are reddish brown and consists of two kinds, namely those of calcareous and siliceous nature. The metasandstone is fine-grained.

Sandy-muddy metasedimentary rocks: These units overlie the above carbonates conformably and are distributed widely throughout the area. Although the detailed distribution is

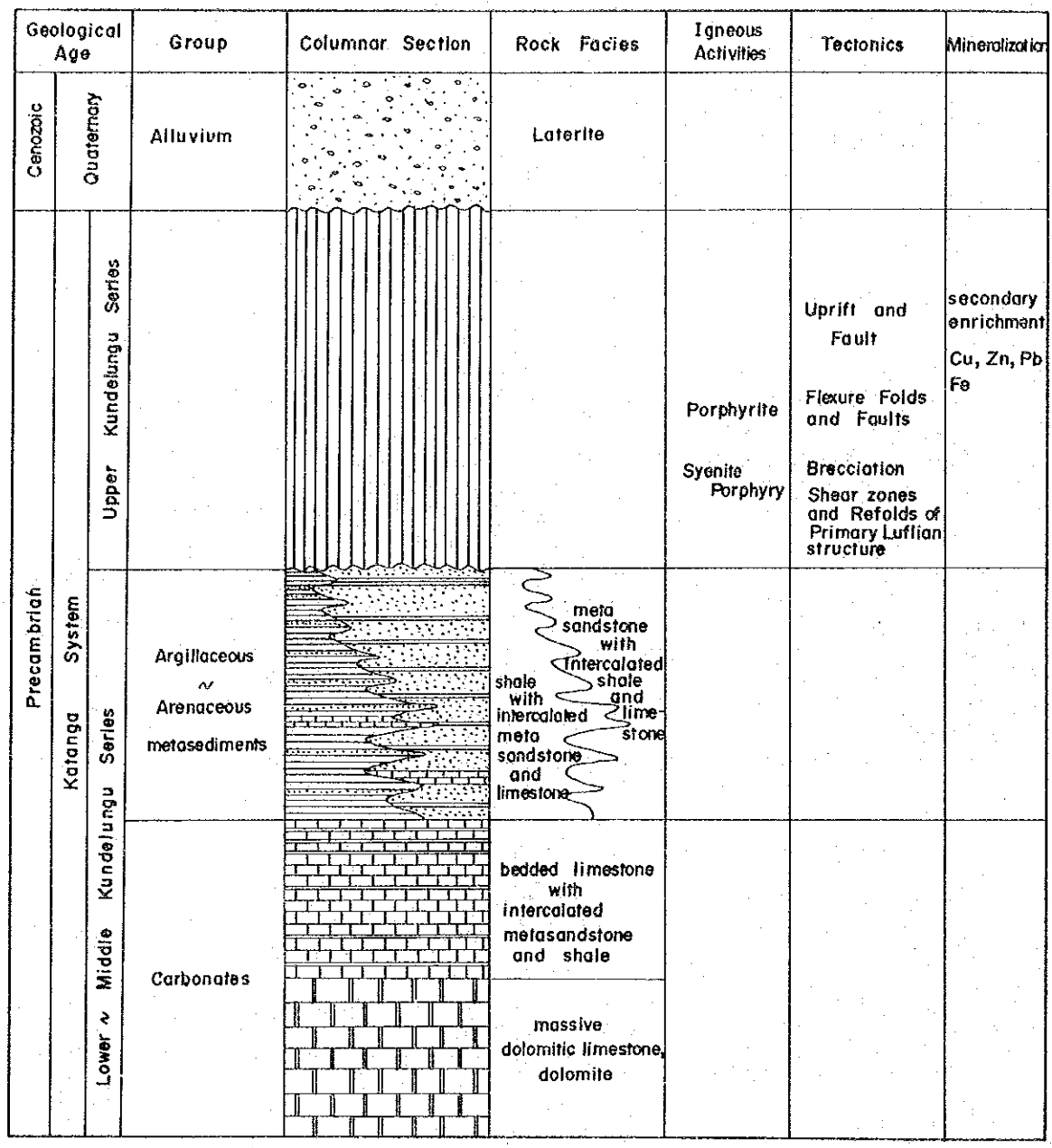


Fig. 5 Generalized Geological Column of the Areas

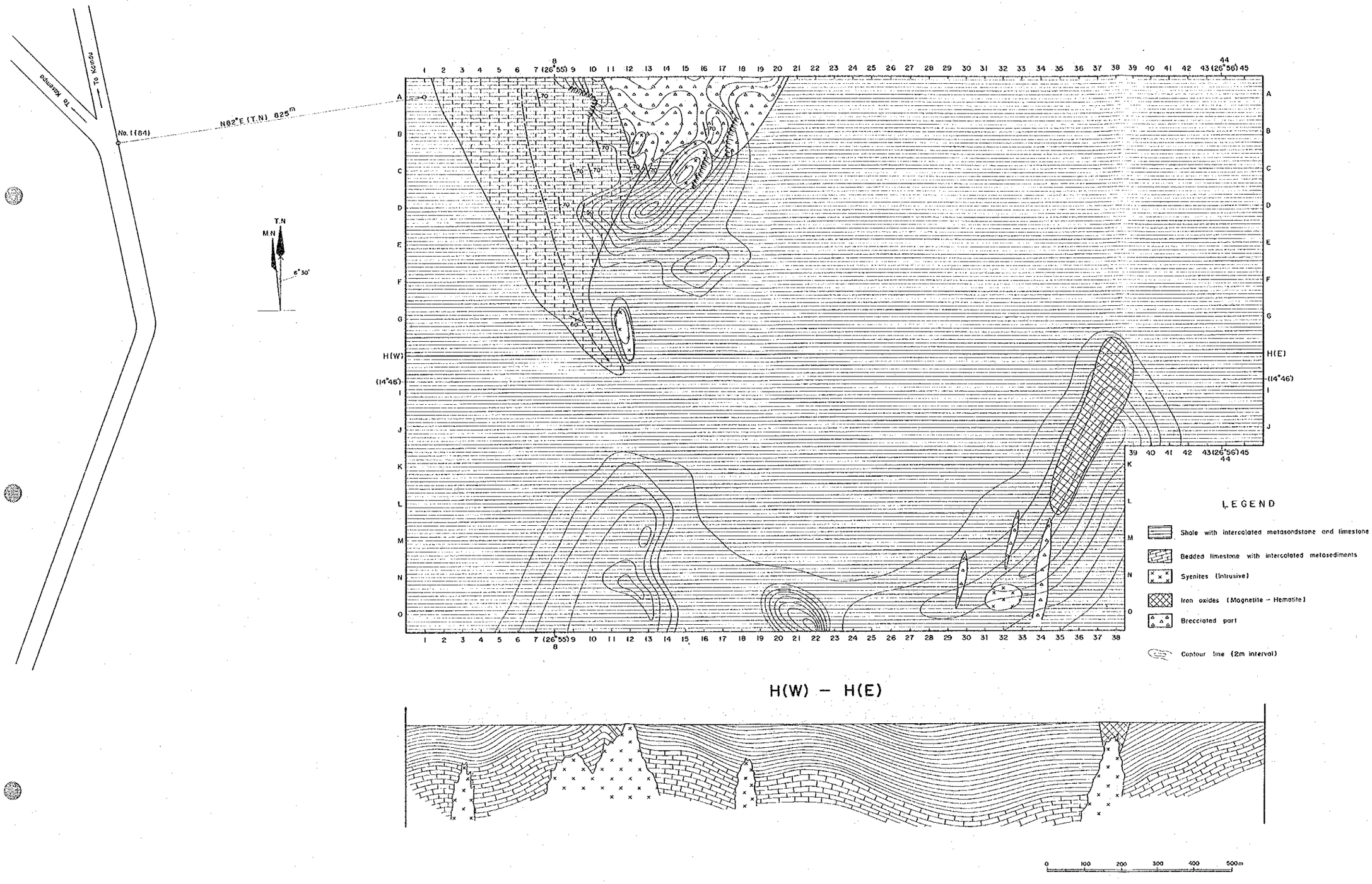


Fig. 4 Geological Map of Kamiyobo Area

not clear because of the poor exposure, muddy metasediments are generally predominant in this area and alternate or interfinger with the sandy metasediments. The muddy metasediments consist mainly of brown to yellow, in some cases, gray shale and calcareous rocks are partly intercalated. The sandy metasediments are mainly yellowish brown to reddish brown, fine to medium-grained sandy-siliceous metasandstone.

Intrusive rocks: These rocks occur as scattered small bodies in the northwestern and southeastern parts of the area. The rocks are strongly weathered and the lithology is not clear, but they are leucocratic and porphyritic and thus are judged to be igneous rocks. Compared with the weathered parts of the intrusive rocks studied during the previous year, they are similar to weathered syenite.

The geologic structure of this area is controled by the anticlinal structure with the carbonates of the northwest at its core. This anticline strikes NNW-SSE and plunges SSE. The exposure is poor on its western flank and the details are not clear. It dips approximately 60° westward and in the eastern flank, the dip is approximately 70°.

The exposure is not good in the eastern part and thus the number of folding is not clear, but the investigation of the previous year showed that the geological structure of the general area is controled by an anticlinorium. The eastern part is considered to have an intermediate structure to the anticline further to the east, that is the synclinal structure.

1-2 Economic Geology

The exposure of this area is very poor as mentioned earlier, and thus no exposures were found in the geochemical anomaly zones. Hematite-magnetite outcrop is observed near the NNE-SSW anomaly zone in the southeastern part, but the analysis detected only 90 ppm Cu, 200 ppm Pb and 80 ppm Zn, thus this iron mineralization is not considered to be associated with Cu, Pb, Zn.

There is, however, the Kamiyobo Mineralized Zone approximately 600 m north of this area, where strong copper mineralization was confirmed during the work of the previous year. Therefore, there is a possibility of finding base metal mineralization in this general area.

2. Geochemical Survey

2-1 Sampling and Analytical Methods

This area was delineated for detailed geochemical work because of the highest Pb-Zn anomaly (253 ppm Pb, 523 ppm Zn) and the large number of anomalies (3 localities) detected during the previous year's geochemical reconnaissance (traverse interval 1 km, sampling interval 500 m). During the present work, detailed geochemical exploration with sampling interval of 100 m N-S and 50 m E-W was conducted.

The sampling reference point for the previous year, namely the intersection of Kaindu Road and Lubungu Pontoon Road was used again as the base. Pocket compass and measuring tape were used for surveying the sampling points (Fig. 6).

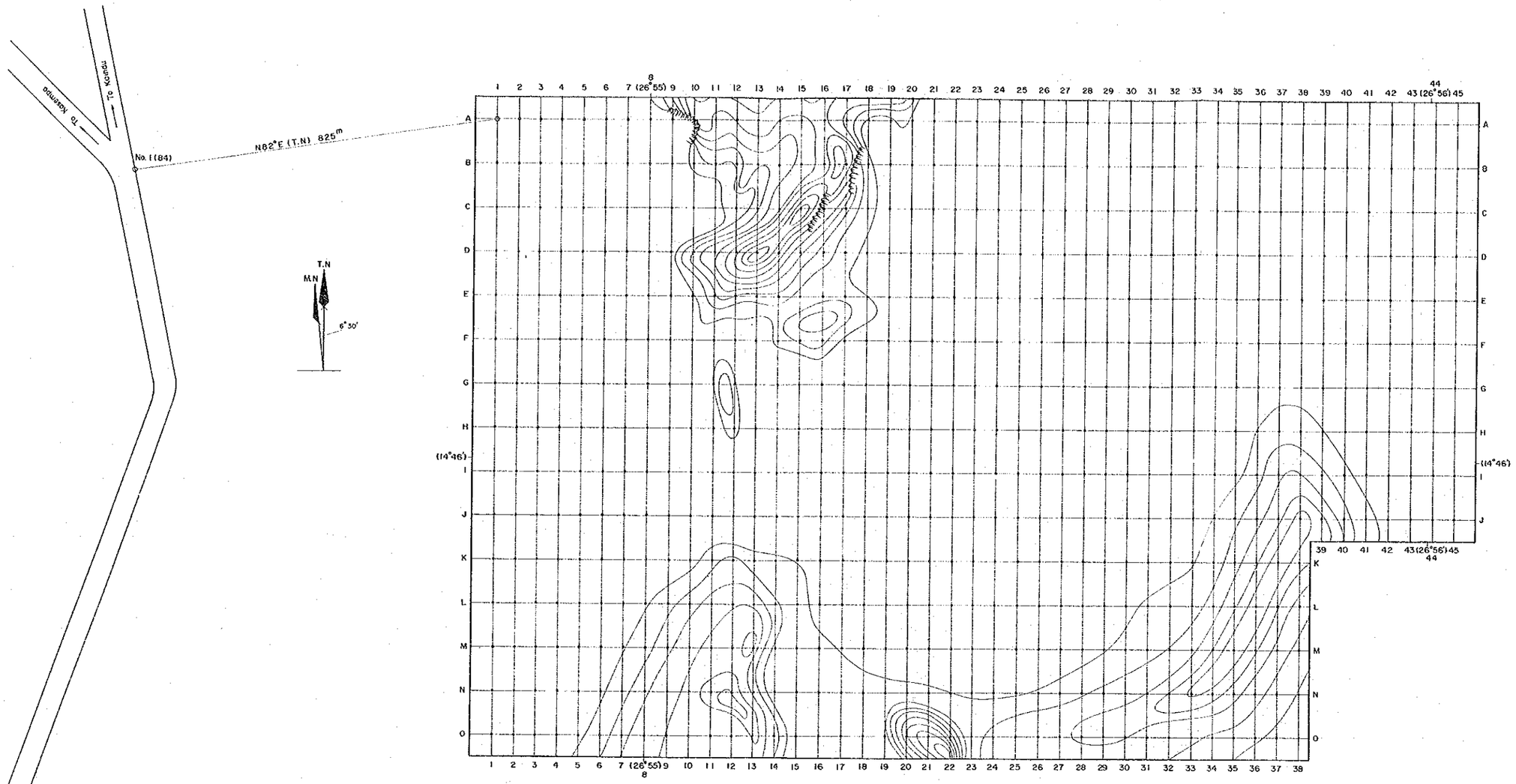


Fig. 6 Location Map of Geochemical Samples (Soil)