No. 23

REPORT
ON
THE MINERAL EXPLORATION : SUPRA-REGIONAL SURVEY IN CENTRAL SABAH, MALAYSIA

(PHASE IV)

(Geochemical and Geological Surveys)

MARCH 1994

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

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PREFACE

In response to the request of the Government of Malaysia, the Japanese Government agreed to conduct a Supra-Regional Survey Project in the Sabah area and entrusted the survey to the Japan International Cooperation Agency(JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to Malaysia a survey team headed by Mr. Masahiko Nono from 21st June 1993 to 7th September 1993.

The team exchanged views with the officials concerned of the Government of Malaysia and conducted a field survey in the central Sabah area. After the team returned to Japan, further studies were made and present report has been prepared. This report includes the survey results of a semi-detailed geochemical survey and geological survey in Phase IV.

We hope that this report will serve for the development of the mineral resources and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of Malaysia for their close cooperation extended to the team.

March, 1994

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

Takashi Ishikawa

Takashi Ishikawa
President
Metal Mining Agency of Japan

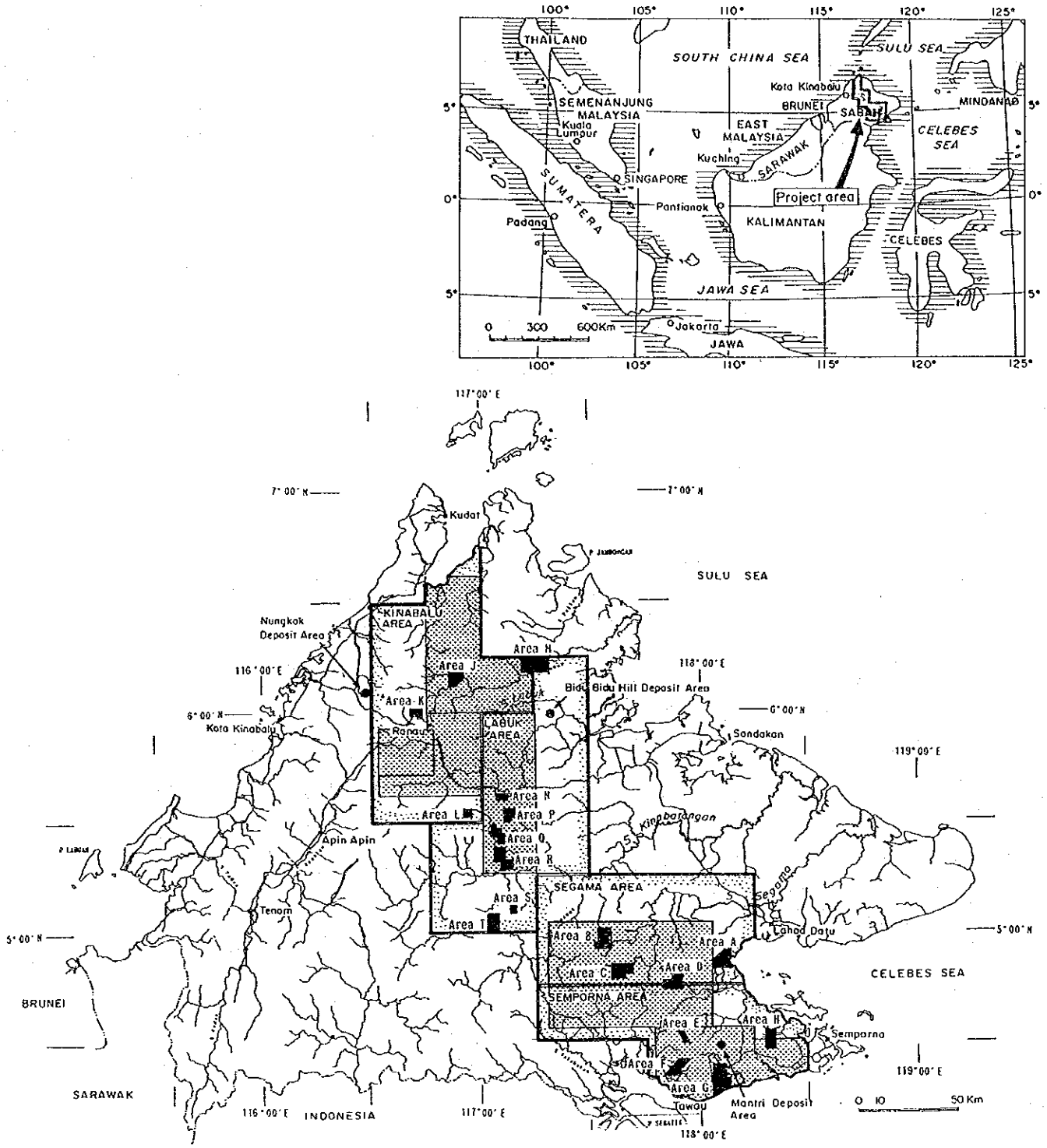


Fig. 1 Location map of the project area

ABSTRACT

The Government of Malaysia and the Government of Japan agreed a four-year mineral exploration project, starting from 1990, in the central Sabah area. The Scope of Work for this project was signed by both governments on 1st August 1990. Objectives of this project are to clarify the mineral potential and to obtain useful data for future development of mineral resources in this area. This report includes the survey results of the forth year(Phase IV).

Geochemical and geological surveys were conducted in this final phase. The semi-detailed geochemical survey was carried out for the ten selected areas in the Kinabalu and Labuk areas. From the results of regional geochemical survey in Phase III, these ten areas were delineated as potential areas for mineral resources. Furthermore, detailed geological suvey was carried out in Area B in the Segama area where mineralization was confirmed as the results of the semi-detailed survey in Phase III.

From the result of the semi-detailed geochemical survey, conspicuous geochemical anomalous zones of As, Au, Cu, Hg, S and Zn were delineated in Area T at the southern margin of the Labuk area. Significant gold mineralization was also confirmed in this area. Assay results for the samples collected in this area indicate high values of Au ranging from 9.4 g/t to 18.4 g/t and Ag ranging from 115.7 g/t to 931.4 g/t.

Concentration of nickel in the lateritic soil which developed in the area of ultra-basic, was confirmed in Area K in the Kinabalu area and Area N in the Labuk area. Several ore samples show more than 1.00 % Ni. Deep parts show higher concentration of nickel than shallow part. Higher concentration is recognized in Area N compare to the concentration in Area K.

Significant geochemical anomalous zones of Au, Cu and Ni are found in Area Q situated in the southern central part of the Labuk area. The assay result for a float gossan sample shows 4.1 g/t Au. Exploration work for copper and nickel was previously conducted in this area.

Other than above mentioned areas, no conspicuous anomalous zone or mineralized zone was recognized in the areas of Area J, L, M, P, R and S. potential for mineral deposit is thought to be low.

A geological survey was conducted in Area B in the Segama area. Geology in the area consists of gabbro, dolerite and basalt which possibly belong to Ophiolite series rocks and Kuamut formation. The Ophiolite series rocks thrust over the

Kuamut formation. Mineralized zones in the area occur mostly in dolerite, and vein, stockwork and dissemination of quartz and/or sulfide minerals are observed. Occurrence of the mineralization is different to typical Cyprus-type massive sulfide deposit. The mineralized zones sporadically occur in a direction of NE-SW. The assay results locally indicate comparatively high values of Cu ranging frpm 2 % to 10 % and Ag ranging from 4.0 to 31.2 g/t.

The mineralization confirmed in Area T is significant gold-silver mineralized zones. Further investigation should be conducted in these zones and the extensions in the future. Generally, concentration of nickel in lateritic nickel ore deposits is observed nearby the boundary between laterite and basement ultra-basic rocks. Therefore, further exploration work should be carried out in Area K and N to clarify the potential of nickel ore deposit at the depth. In addition to copper and nickel, potential for gold is also expected in Area Q. Further exploration work should be conducted in this area. Some parts of the mineralized zones in Area B indicate high copper grades. Further detailed investigation should be carried out for these mineralized zones.

CONTENTS

Part II Survey results

Part III Conclusions and recommendations

Part I General

Chapter 1 Introduction

1-1 Background and objectives

In accordance with the Scope of Work signed between the Government of Malaysia and the Government of Japan on 1st August 1990, the Supra-regional Survey was carried out in the central part of Sabah, Malaysia. The area selected for this survey (Fig. 1) is thought to have higher mineral potential in Sabah, as many known mineral occurrences are distributed. This project is four years project starting from 1990 and this report includes the survey results of Phase IV.

Purpose of this survey is to clarify the mineral potentiality in this area for the future development of mineral resources. In order to execute this purpose, a semi-detailed geochemical survey for selected ten areas in the Kinabalu and Labuk areas, and a geological survey in Area B in the Segama area are carried out in this survey. The semi-detailed survey areas are the areas delineated by the results of the regional geochemical survey in Phase III.

1-2 Survey results of Phase I, II and III

(1) Survey results of Phase I

In the Phase I, the satellite image analyses using MSS and TM data, orientation geochemical survey over three known mineral deposit areas, and heliborne survey including data acquisition and data processing over selected areas were completed. The results of these survey are conclusively summarized as follows;

1) Satellite image analysis
   - ① The ring structure delineated in and around Ranau and N-S trending fault zone in the Kinabalu area shows close relationship with intrusives in which mineralization is recognized.
   - ② These ring structures observed over the survey area are thought to be important for the mineral exploration in the area.

2) Orientation geochemical survey
   - ① All the sample medias (stream sediments, soil and pan concentrates) adopted in this survey are useful for the mineral exploration in this project area.
   - ② Stream sediment geochemical samples indicate longer distance of influence compare to other sample medias. Consequently, stream sediment sample is the optimum sample media for the regional geochemical survey and the soil sample is suitable for more detailed survey.
   - ③ Optimum sample density of stream sediments is 2 km^2/sample, and soil is 0.5 km^2/sample.

④ Optimum sampling point for stream sediments is the edge of water flow and upper part of B horizon for soil.

⑤ Useful pathfinder elements for the geochemical survey in this project area are twelve elements including As, Au, Ba, Cr, Cu, Mn, Mo, Pb, S, U, W and Zn.

(2) Survey results of Phase II

In the period of Phase II, the regional geochemical survey, using stream sediments as the sample media, was carried out over the areas of Segama and Semporna. Continuing from Phase I, data acquisition and data processing of the heliborne geophysical survey were conducted during this phase. The data analyses of the heliborne geophysical survey, excluding Northern Kinabalu area, were also conducted in this phase.

From the results of these surveys, following areas were delineated as the promising areas in the Segama and Semporna areas.

① Between Sungai Sabahan and Sungai Diwata area (Segama area)
② Upper stream of Sungai Segama area (Segama area)
③ Upper stream of Sungai Danum area (Segama area)
④ Surroundings of Silam village (Segama area)
⑤ Between Sungai Balung and Sungai Kalumpang (Semporna area)
⑥ Nearby Nagos (Semporna area)
⑦ Upper stream of Sungai Sipit (Semporna area)
⑧ Upper most stream of Sungai Kalumpang area (Semporna area)
⑨ Sungai Apas area (Semporna area)
⑩ Surroundings of Tawau Hill (Semporna area)

Among these promising areas, ①, ② and ③ have potentiality of Cyprus-type copper deposits. Target of area ④ is chromite deposits. The areas from ⑤ to ⑩ have potential for vein-type hydrothermal gold deposits.

(3) Survey results of Phase III

In the period of Phase III, the regional geochemical survey, using stream sediments as the sample media, was conducted in the Kinabalu and Labuk areas. The data analyses of the heliborne geophysical survey for the Northern Kinabalu area was also conducted in this phase. The semi-detailed geochemical survey was carried out for eight promising areas (Area A, B, C, D, E, F, G and H) delineated by the regional geochemical survey in Phase II.

From the results of the regional geochemical survey, following areas were selected as the promising area in the Kinabalu and Labuk areas.

① Lower stream of Sungai Sugut (Kinabalu area)

② Middle stream of Sungai Sugut (Kinabalu area)
③ East of Ranau (Kinabalu area)
④ Most upper stream of Sungai Karamuak (Kinabalu area)
⑤ Along a tributary of Sungai Imbak (Labuk area)
⑥ Middle stream of Sungai Imbak (Labuk area)
⑦ Lower stream of Sungai Karamuak (Labuk area)
⑧ Middle stream of Sungai Karamuak (Labuk area)
⑨ The area between Sungai Karamuak and Sungai Milian (Labuk area)
⑩ Along Sungai Mailo at the south of Telupid (Labuk area)
⑪ Along Sungai Sugut at the northern margin (Labuk area)
⑫ West of Telupid (Labuk area)

Among these promising area, ①, ② and ⑪ are the potential areas for porphyry type copper deposits. Concentration of nickel in lateritic soil was recognized in the areas of ③ and ⑫. Conspicuous geochemical anomalous zones of titanium (maximum; 51.07 %) was confirmed in the area of ④. Judging from the geochemical nature, the areas of ⑤, ⑥ and ⑦ are the promising areas of gold mineralization. Copper and /or chromite ore deposits are expected in the area of ⑧. Potential for copper ore deposit is thought in the area of ⑨ and chromite ore deposits is thought in the area of ⑩.

From the results of the semi-detailed survey, Area B was selected as the potential area of copper ore deposits. Significant mineralized zones were confirmed in this area.

1-3 Coverage and outline of Phase IV survey

The semi-detailed geochemical survey was carried out for ten promising areas (Area J, K, L, M, N, P, Q, R, S and T) in the Kinabalu and Labuk areas. These ten areas were delineated by the results of the regional geochemical survey in Phase III. In addition, detailed geological survey was conducted in Area B where significant copper mineralized zones were confirmed in Phase III. Locations of the survey areas are shown in Fig. 1. The work amounts conducted in this phase are summarized in Table I-1 and the laboratorial studies for these surveys are shown in Table I-2.

The survey in this phase emphasizes to delineate mineral potential areas in the Kinabalu and Labuk areas using the semi-detailed geochemical survey method and to examine the mineral potential in Area B using the detailed geochemical survey method.

The base camp for the survey was established at Ranau in the Kinabalu area. The field survey was conducted by camping and flying camp along stream.

Table I-1 Summary of work amounts

(1) Semi-detailed geochemical survey

Method	Samples	Area J	Area K	Area L	Area M	Area N	Area P	Area Q	Area R	Area S	Area T	Total
Coverage	km^2	38	30	20	119	21	26	42	75	12	70	453
Stream sediments	Samples	—	—	80	—	—	105	85	150	25	—	445
Soil	Samples	150	240	—	476	170	—	85	150	25	280	1,576
Ore	Samples	0	3	0	0	2	0	2	0	0	13	20

(2) Semi-detailed geological survey

Method	Samples	Area B
Coverage	km^2	32
Traverce length	km	48
Ore	Samples	46

Table I-2 Work amounts of laboratorial studies

Study item	Semi-detailed geochemical survey	Semi-detailed geological survey	Total
(1) Thin section	12 samples	5 samples	17 samples
(2) Polishes section	10 samples	13 samples	23 samples
(3) X-ray diffraction analyses	10 samples	10 samples	20 samples
(4) Chemical analyses			
stream sediments (2 elements)	80 samples 160 elements	— —	80 samples 160 elements
stream sediments (5 elements)	105 samples 525 elements	— —	105 samples 525 elements
stream sediments (21 elemnts)	260 samples 5,460 elements	— —	260 samples 5,460 elements
Soil (5 elements)	410 samples 2,050 elements	— —	1,902 samples 39,942 elements
Soil (21 elements)	1,166 samples 24,486 elements	— —	131 samples 2,751 elements
Ore (7 elements)	20 samples 140 elements	46 samples 322 elements	66 samples 462 elements

1-4 Survey member

The members of the project are as following;

(1) Project planning and prior negotiation

Japanese counterpart		Malaysian counterpart		
Takafumi Tsujimoto	MMAJ	Fateh Chand	Director General	GSM
Haruhisa Morozumi	MMAJ	David T.C. Lee	Director	GSM
Yoshiaki Igarashi	MMAJ	Lim Peng Siong	Principal geologist	GSM

MMAJ; Metal Mining Agency of Japan GSM; Geological Survey of Malaysia

(2) Field survey

Japanese counterpart			Malaysian counterpart		
Masahiko Nono	Team leader	BEC	Lim Peng Siong	Principal Geologist	GSM
Masatsugu Okazaki	Geochemical	BEC			
Motomu Goto	Geochemical	BEC	Joanes Muda	Geologist	GSM
Makoto Kawamura	Geochemical	BEC	Paulus Godwin	Geologist	GSM
			Cleafos Totu	Geologist	GSM
			Salleh Adanan	Geologic Assist.	GSM
			Japili Samin	Geologic Assist.	GSM
			Jolouis Supilin	Geologic Assist.	GSM

BEC; Bishimetal Exploration Co., Ltd. GSM; Geological Survey of Malaysia

1-5 Survey period

Period of the field survey in this phase is as following;

Geochemical Sampling ; 21st June 1993 to 28th August 1993.

Geochemical field analysis ; 25th August 1993 to 7th September 1993.

Chapter 2 Geography of survey area

2-1 Location and accessibility

Malaysia, being a principal member of ASEAN countries, consists of Western Malaysia situated in the Malay Peninsular and East Malaysia situated in the northern and the southwestern parts of Borneo. The total population of West and East Malaysia is 16.5 millions. The area of the whole country is approximately 330,000 km^2.

Eastern Malaysia comprises the State of Sabah and State of Sarawak. The project area is situated in the State of Sabah, streching from its northwestern part to its southeastern part and covers an area of 26,500 km^2. The area is subdivided into four areas (Fig. 1). These are named Kinabalu area, Labuk area, Segama area and Semporna area.

The capital of the State of Sabah is Kota Kinabalu on the west coast of the state. In Kota Kinabalu, international airline services are available. Regular flight are also available between Kota Kinabalu and some cities on the east coast of Sabah. Principal road connects Kota Kinabalu, Ranau and Sandakan and other main road connects Sandakan to Tawau through Lahad Datu. These roads pass through the central part of the Kinabalu and Labuk areas and eastern part of the Segama and Semporna areas. In the Kinabalu area, many roads branch out from Ranau. In the Labuk area, there are several roads for log transportation. However, it is inaccessible for vehicle in the southern and northern part of the area. In the Segama and Semporna areas, there are some roads used for the plantation estate and for log transportation on the east coast area. In the western part of the Segama area, rivers are the main mode of transportation. In the eastern to southern part of the Semporna area, roads for the plantation estate are developed.

2-2 Topography and drainage system

The State of Sabah is divided into three categories in terms of topographic features. Steep mountains trending north northeast dominate in the western side along the coast. Highland occupies the eastern area and volcanic mountains are found in the southern part. Flat plain is along rivers and their lower tributary. Mt. Kinabalu which is the highest mountain in the southeast Asia, rise up to 13,455 ft in westernend of the Kinabalu area which is occupied by steep topography. Highland dominates in the Labuk and Segama areas. Swamps are found at the lower part of main rivers where they are extremely meandered. Highland dominates in the Semporna area except the young volcanics region with volcanic topography.

The main drainage systems in the project area are Sungai Pegalan, Sungai Sugut

Sungai Labuk, Sungai Kinabatangan, Sungai Segama, Sungai Tingkayu, Sungai Kalumpang, Sungai Kalabakan etc. Among these river systems, Sungai Pegalan flows into the South China Sea, Sungai Kalumpang and Kinabatangan flows down to the Celebes Sea and other river systems into the Sulu Sea in the east. These river systems generally form deep valley at the upper stream and extremely meandered down stream. The river also forms swamp area at the mouth of the river.

2-3 Climate and vegetation

The survey area is situated in the tropical monsoon region. From February to July, it is dry to little rain season, from August to January is the rainy season. Precipitation in the dry season is 100 - 250 mm in a month and in the rainy season is 200 - 450 mm in a month. Temperature is 22 C to 33 C throughout the year.

The maximum and minimum temperature and monthly rainfall for each month in Kotakinabalu at the west coast, Sandakan at the east coast and Tawau at the south coast are shown in Table I-3. As shown in this table, east coast has more rainfall than the west coast.

Vegitation in the survey area mainly consists of primary and secondary jungles except the area under plantation. The project area is mostly situated in the secondary jungle.

Table I-3 Statistics of temperature and rainfall

Month	Kota Kinabalu			Sandakan			Tawau		
	Temperature(℃)		Rainfall	Temperature(℃)		Rainfall	Temperature(℃)		Rainfall
	Max.	Min.	(mm)	Max.	Min.	(mm)	Max.	Min.	(mm)
January	30.5	22.4	95.1	29.7	24.2	398.2	31.4	22.2	161.4
February	31.6	22.5	61.6	30.5	23.6	229.9	31.9	22.3	132.4
March	31.8	22.8	47.1	31.0	23.8	120.0	32.4	22.6	107.7
April	32.5	23.4	137.5	32.2	23.8	87.5	32.6	22.8	101.3
May	32.5	23.9	287.9	32.5	24.3	110.8	32.8	23.5	113.6
June	31.7	23.3	248.7	32.8	23.6	209.3	32.3	23.0	185.5
July	31.6	23.0	257.2	32.4	23.5	214.5	31.6	22.7	226.3
August	31.7	23.3	263.4	32.9	23.5	183.6	31.3	22.6	217.7
September	31.8	23.2	315.8	32.3	23.5	241.2	31.7	22.5	196.9
October	32.0	23.5	292.9	31.8	23.6	271.9	31.9	22.8	188.1
November	31.4	23.2	314.6	31.2	24.0	324.8	32.4	23.1	174.0
December	31.3	22.7	149.7	29.8	24.4	453.0	32.4	22.4	135.3

Temperature: 1989 and 1990 Rainfall: average of last 10 years(1981 - 1990)

Chapter 3 Previous surveys

3-1 General geology

The survey area occupies a wide area, streching from the northwest to the southeast corner of the State of Sabah. Known mineral showings are found mostly in this region.

This area is underlain by crystalline rocks (Cb), sedimentary rocks accompanied by spilite eruption (K, KP), sedimentary rocks characterized by flysch sediments (P_1, P_2, P_3 and P_4) and other sedimentary rocks (N_1, N_2, N_3, N_4 and N_5). Cb is pre-Triassic rock and forms a basement in this area. K and KP were deposited in the age from Cretaceous to Eocene, during the earlier time of the Northwestern Borneo geocyncline. P_1, P_2, P_3 and P_4 were deposited in Eocene through middle Miocene. N_1, N_2, N_3, N_4 and N_5 were deposited during early Miocene through Pleistocene. Orogenic movement is begun in middle Miocene through Pliocene.

Cretaceous ultra-basic intrusives, syn- and post-orogenic plutonic intrusives and extrusive rocks such as dacite, andesite and basalt of Pliocene to Holocene age are the result of the igneous activities during this period.

Geological map (Y.E. Heng, 1985) of the State of Sabah including the survey area is shown in Fig. I-1. This map tells that crystalline rocks such as schists and gneisses, which form the basement, and sedimentary rocks are mainly distributed in the Segama area. Sedimentary rocks accompanied by spilite effusion occupied wide area both in the Labuk and Segama areas. Ultra-basic rocks are found in the Kinabalu, Labuk and Segama areas, and closely relates with the sedimentary rocks associated with spilite. Plutonic intrusions such as adamellite and granodiorite are typically found in the Kinabalu area. Volcanic rocks such as dacite, andesite and basalt are found mainly in the Semporna area. This volcanic belt extends northeast toward the southern part of the Philippine.

3-2 Mineralization and mining activities

Principal metallic ore deposits in the survey area comprise porphyry copper deposit closely related with plutonic rocks, Cyprus-type massive sulfide deposit related to spilite extrusion and hydrothermal gold-silver deposits closely related with volcanic rocks. Chromium or platinum deposits are related to the ultra-basic rocks, lateritic aluminum and nickel deposits and manganese deposits in sedimentary rocks are also found. The distribution map of the main metallic ore deposits and mineral showings in the project area (after K.M. Leong, 1976) are shown in Fig. I-2.

The Mamut mine is the only active mine in the project area. The Mamut deposit

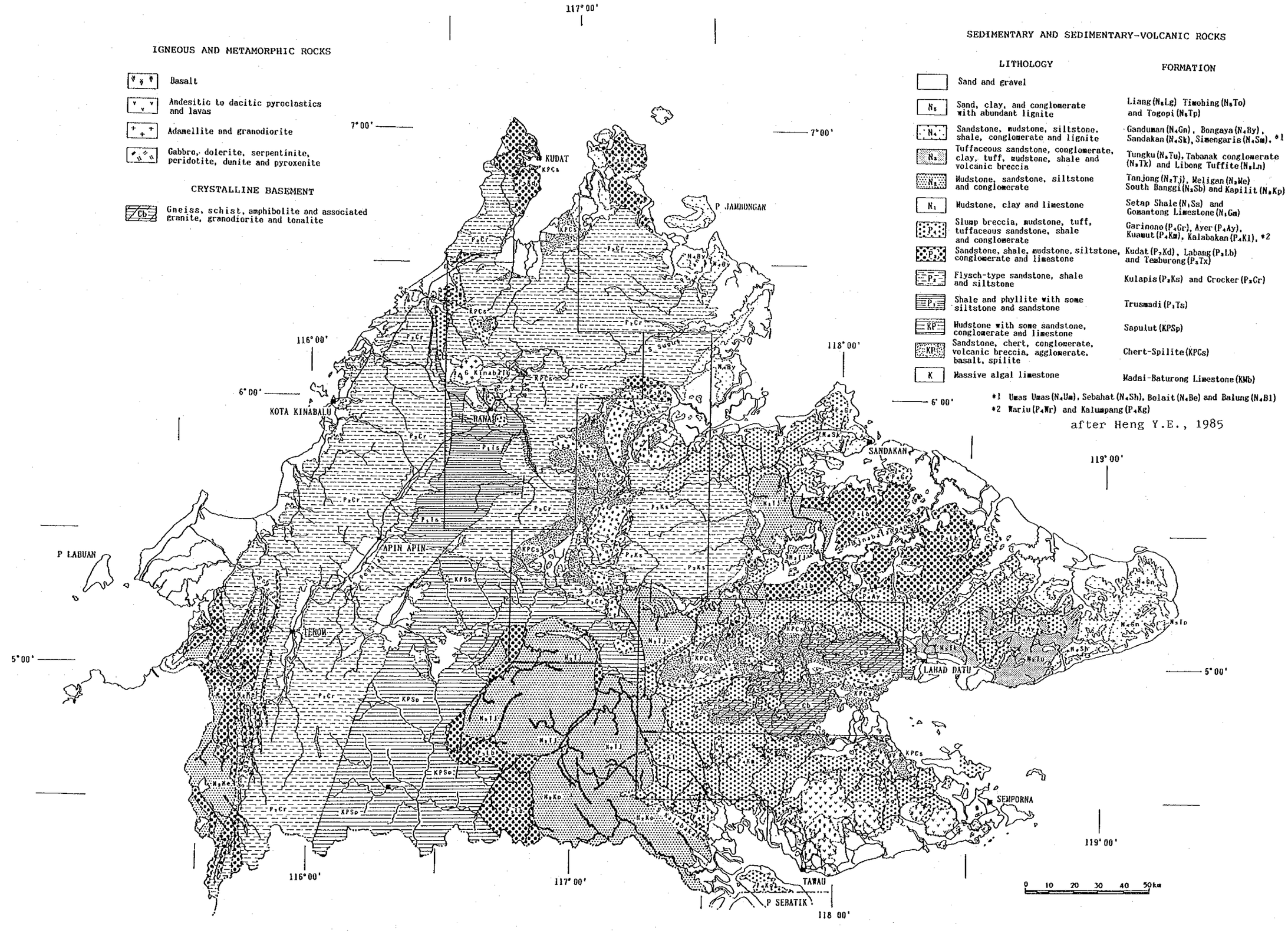
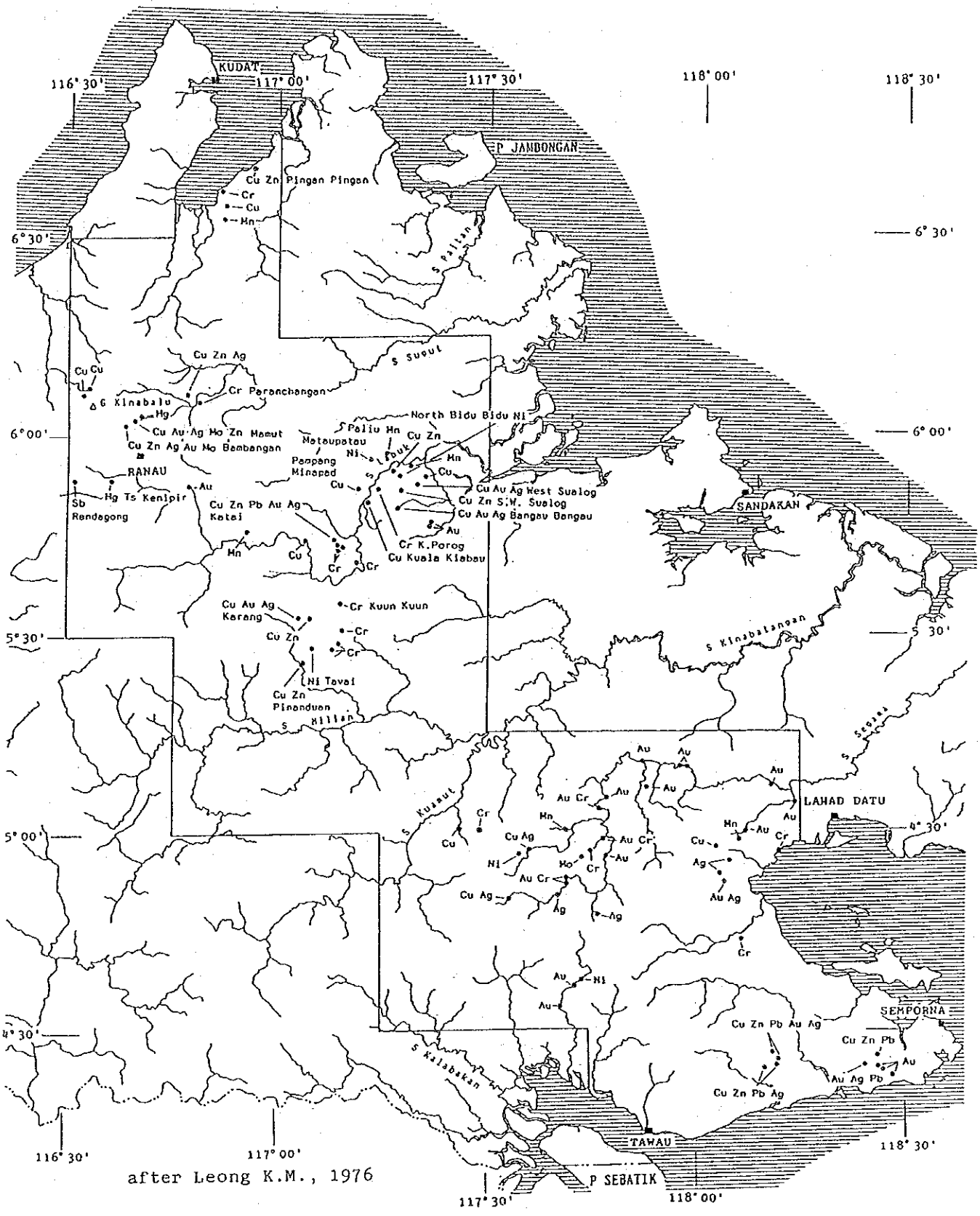


Fig. I-1 Geologic map of Sabah, Malaysia



after Leong K.M., 1976

Fig. I-2 Distribution of mineral occurrences in the project area

is porphyry copper type, located to the north of Ranau in the Kinabalu area. This ore deposit was discovered by a geochemical survey conducted by the United Nations Development Program (UNDP). The Overseas Mineral Resources Development Co., Ltd., Japan, obtained the exploration right on the Mamut area through international tender in 1968, and carried out further exploration work from 1968 to 1972, and began development work in 1973. The mine has been operating since May, 1975. The current production of crude ore is 20 thousand tons per day with the grade of 0.47 % Cu. Staffs and workers of the Mamut Copper Mining Sdn. Bhd. are about 1,300.

The Bidu Bidu Hill ore deposit is in the latest stage of the exploration work and the development will be made in the near future. This ore deposit is a Cyprus-type massive sulfide deposit emplaced in spilitic extrusive rocks. Exploration work for this ore deposit is being carried out by Leadstar Sdn. Bhd. Ore reserves of 3,600 thousand tons with 3.6 % Cu, 1 - 2 g/t Au and 8-15 g/t Ag have been confirmed by drilling work (approximately 40,000 m) for this deposit.

Exploration work for gold-silver deposits occured in volcanic rocks in the Semporna area is being carried out by Zamia Sdn. Bhd. The area surveyed by this company covers a wide area from the west of Semporna to northern Tawau. The survey consists of mainly soil geochemical survey and trenching. A few drill holes have been completed for the Mantri area recently.

Chapter 4 Survey results

4-1 Semi-detailed survey

Based on the results of the regional geochemical survey for the Kinabalu and Labuk areas in Phase III, ten (10) areas (Area J, K, L, M, N, P, Q, R, S and T) were selected as the potential areas of mineral resources. Locations of these areas are shown in Fig. II-1-1. These promising areas were investigated by a semi-detailed geochemical survey in this phase. The results are summarized as follow;

(1) Sample media

The sample medias in this survey were selected depending on the type of ore deposits of the target and the topography in each area. The sample medias used for each survey area are as follow;

Area J, Area K, Area M, Area N, Area T: soil
Area L, Area P : stream sediments
Area Q, Area R, Area S : soil and stream sediments

(2) Elements

Relationship among the elements adopted, sample media and srvey area are as follow:

① Analyzed elements (2 elements) : Fe, Ti
Type of media and area name : stream sediments (Area L)

② Analyzed elements (5 elements) : Al, Co, Fe, Cr, Ni
Type of media and area name : stream sediments (Area P), soil (Area K, N)

③ Analyzed elements (21 elements): As, Au, Ba, Co, Cr, Cu, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, S, Sb, Sr, Ti, U, W, Zn
Type of media and area name : Stream sediments (Area Q, R, S)
Soil (Area J, M, Q, R, S, T)

Elements of ① were used for the potential area of titanium deposits. Elements of ② were used for the potential areas of chromite and nickel ore deposits. Twenty one elements were adopted for the potential area of copper and gold ore deposits.

(3) Data processing and analyses

The analytical results of the geochemical samples were input into computer. Statistical data treatment, single element and multi element analyses were adopted using these data. In order to clarify the distribution tendencies, distribution

maps of each element were drawn by computer. Exploratory Data Analysis (EDA) method was applied to delineate the threshold value (anomalous value) for each element. As for the multi element analyses, factor analysis was utilized in this survey.

The EDA method delineates threshold value by means of statistic data processing, and the distribution pattern of each element is not affected in this method. The factor analysis is the method to delineate the factor which forms the relationship among the samples.

During the sampling work, rock and ore samples were collected for the laboratorial studies. Observation of thin sections (Table II-1-1), observation of polished sections (Table II-1-2), X-ray diffraction analyses (Table II-1-3) and assaying of ore samples (Table II-1-4) were carried out. These results were used for the interpretation.

(4) Survey results

Area J

Area J is situated along the middle stream of Sungai Sugut in the central part of the Kinabalu area. From the results of the regional geochemical survey, anomalous zones of Au, Cu and Hg were confirmed in this area. A soil geochemical survey was carried out to assess the potential for porphyry copper deposits in this area.

Geology in this area consists of sandstone and mudstone (Crocker formation) of Eocene to Pliocene age and alluvium deposits in the central part. No mineralized and/or altered zones were confirmed in this area.

Results of the geochemical survey show low contents (maximum Cu: 133 ppm). Anomalous zones of the pathfinder elements including Au, Cu, Hg and Sb overlap in the area of Alluvium at the west bank of Sungai Sugut in the western central part of this area. The threshold values of these elements are low compare to the results of other semi-detailed survey areas. No factor indicates the mineralization in the factor analyses. Judging from the survey results, the potential for mineral ore deposits is thought to be low. As the anomalous zones are found in the area of alluvium deposits, mineralized gravels supplied from the Mamut ore deposits which situated at the upper stream, may play some role for these anomalies.

Area K

Area K is situated at the east of Ranau in the central part of the Kinabalu

area. Sungai Luhan flows eastward in the northern central part of the area. A soil geochemical survey was completed in this area in order to assess the potential for lateritic nickel deposits. Two samples from different depths (50 cm and 150 cm) were collected from one sampling site.

The central part of this area is widely occupied by ultra-basic rocks such as harzburgite and dunite. The eastern and western parts of the area are underlain with sandstone and mudstone of the Crocker formation which is in fault contact with the ultra-basic rocks. The northern part along Sungai Luhan and the south east of the area are covered with terrace deposits.

Reddish brown laterite and yellowish green saprolite are found in the area of ultra-basic rocks. Three samples for assaying were colected from saprolite and the results were 0.50 %, 1.50 % and 1.44 % Ni.

Results of the geochemical survey show high contents of Ni and Fe. The samples collected at the depth of 50 cm show 8,636 ppm Ni and 47.01 % Fe as the maximum values. On the other hand, the samples from 150 cm in depth show 10,136 ppm Ni and 47.29 % Fe as the maximum values. The anomalous zones of Ni and Fe for the samples from 50 cm and 150 cm are found in the eastern, central and western parts of the area where ultra-basic rocks occurs.

Peridotite contains Ni ranging from 0.3 to 0.4 % in general. Therefore, enrichment of Ni and Fe occur in this area. Usually, maximum enrichment of Ni is found at the boundary between the laterite and basement rocks. As significant enrichment was recognized near surface, further survey should be carried out at deeper part.

Area L

Area L is situated at the upper most stream of Sungai Karamuak in the southern part of the Kinabalu area. A stream sediment geochemical survey was completed in this area in order to assess the potential for titanium deposits.

Geology of this area consists of ultra-basic rocks, gabbro and basaltic pillow lavas. These basic rocks were thrust over the Crocker formation of Eocene to Pliocene age.

From the results of the stream sediment geochemical survey, the maximum content of Ti is 12.40 % and the mean value is 0.83 %. During the regional survey in Phase III a sample with 51.07 % Ti was confirmed in this area. But such significant value was not confirmed in this survey. Anomalous zones of Fe and Ti, which are overlapping each other, are found in the area of gabbro. Only one samples

with more than 10 % Ti is found in this area. Good correlation is found between Fe and Ti. Both Fe and Ti show higher contents compare to the normal contents of these elements in Gabbro. Concentrations of Ti are expected in the gabbro. However, secondary enrichment of ilmenite are also expected in the stream of the sampling site of this survey. Overall the potential for titunium deposits in this area is thought to be low, because no significant concentrated zones were confirmed in this survey.

Area M

Area M is situated at the lower stream of Sungai Sugut. The area covers the eastern part of the Kinabalu area and the northern part of the Labuk area. A soil geochemical survey was completed in this area in order to assess the potential for porphyry copper deposits.

This area is widely occupied with the Crocker formation of Eocene to Pliocene age. Terrace depoists are found along Sungai Sugut. No mineralized and/or altered zones were confirmed in this area.

From the results of this survey, the maximum values of Au and Cu are 57 ppb and 498 ppm respectively. The means of Cu is 10.7 ppm and is comparatively low. Anomalous zones of As, Au, Cu, Hg and S are centered along Sungai Sugut at the north eastern part of the area. Other than these anomalous zones, no significant anomalous zones are recognized. These anomalous zones show close relation with terrace deposits. Mineralized gravels supplied from Mamut copper deposit area may have some relation with these anomalous zones. No significant mineralized zone was confirmed in this area. Judging from these results, potential for porphyry copper deposits in this area is thought to be low.

Area N

Area N is situated in the west of Telupid in the central part of the Labuk area. In this area, Sungai Labuk, Sungai Tapang, Sungai Telpid and Sungai Mailo flow northeastward. A soil geochemical survey was completed in this area in order to assess the potential for lateritic nickel deposits. Two soil samples with different depth were collected, same as the samples in Area K.

Three ultra-basic rock bodies consisting of harzburgite occur in this area The bodies are surrounded by the Ckert-Spilite formation consisting of chert, basalt and dolerite with fault contact. The flat area is covered with terrace deposits. Alluvium deposits are found along Sungai Labuk and Sungai Telupid.

Reddish brown lateritic soil develops in the area of ultra-basic rocks. Two samples were collected from strongly weathered ultra-basic rocks. The assay results for these samples show 0.80 % and 1.32 % of Ni.

Results of the soil geochemical survey show the maximum values of 13,114 ppm Ni and 46.17 % Fe in the case of the samples collected from 50 cm in depth, and 14,497 ppm Ni and 43.29 % Fe in the case of the samples from 150 cm in depth. Anomalous zones of Ni, Fe and Co from both the samples of 50 cm and 150 cm are found in the area of ultra-basic rocks at the central part of the area. Generally peridotite contains nickel ranging from 0.3 % to 0.4 %. As lateritic soil contains more than 0.5 %. in this survey, enrichment of Ni is recognized. The Ni contents in the samples from 150 cm are generally higher than the samples from 50 cm in depth. As a significant enrichment of Ni, potential for nickel ore deposits is thought to be high.

Area P

Area P is situated along Sungai Mailo in the central part of the Labuk area. The target in this area is Chromite ore deposits and a stream sediment geochemical survey was completed in this area.

Geology in this area consists mainly of peridotite. Gabbro in the north western part and chert in the north eastern part have faults contact with the peridotite. No chromite showings were confirmed in this survey.

The maximum of Cr was 10.73 % and the mean was 2.85 %. Anomalous zones of Cr are found from south western to north eastern part of the area where anomalous zones of Ni and Co are also recognized. In veiw of the high contents of Cr further exploration work should be carried out in the area of peridotite. However, the scale of the showing might be small, because no chromite floats were recognized during this survey.

Area Q

Area Q is situated at the middle stream of Sungai Karamuak in the southern central part of the Labuk area. In order to examine the potential for chromite and copper ore deposits, soil and stream sediment geochemical surveys were completed in this area.

Geology in this area consists of peridotite which is emplaced on to the Crocker formation. Small bodies of gabbro occur in the peridotite. Between the boundary of gabbro and peridotite, mineralized zones of pyrrohtite with some copper mineral

are reported in the previous survey approximately 30 years ago. The north western part, at the top of the mountain, is named the Tavai Plateau. This area is occupied by lateritic soil over ultra-basic rocks. A gossan float sample collected from a stream in the south western part indicates a grade of 4.1 g/t Au. An assay result collected from lateritic soil from the Tavai Plateau shows low content (0.3 %) of Ni.

From the results of the geochemical surveys, the elements including Au, Co, Cr, Cu, Hg and Ni of soil and stream sediments show higher values compare to those from other semi-detailed survey areas. Anomalous zones of Au, Cu and Ni by soil and stream sediment surveys are found along Sungai Pinanduan in the central part of the area. Anomalous zones of Cr are found at the southern part of the area. From the results of a factor analysis, factors related to mineralization were confirmed in both the soil (Au-Cu) and stream sediments (Au-Cu-Hg). High factor score zones of these factors are found along Sungai Pinanduan. Exploration work for copper and nickel had been conducted in this area, but the results indicated no sufficient ore reserves. During this survey, potential for gold is also recognized. Further exploration work should be carried out to assess the potential.

Area R

Area R is located in the area between Sungai Karamuak and Sungai Milian at the south central part of the Labuk area. As anomalous zones of Au and Cu were confirmed in the regional geochemical survey, soil and stream sediment geochemical surveys were conducted in this area in order to assess the potential for gold and copper ore deposits.

Ultra-basic rocks with subordinate gabbro and basalt cover widely in the central part of this area. The ultra-basic bodies are emplaced over the Crocker formation with thrust contact. Amphibolite and green schist are found nearby the thrust fault. No significant mineralized and/or altered zones were confirmed in this survey.

The pathfinder elements which possibly have direct relationship with mineralizaion show low values in both the soil and stream sediments surveys. Anomalous zones are concentrated in the eastern part of the area where ultra-basic rocks occurs. In case of soil geochemical survey, anomalous zones of Au, Cu and S overlap each other or are found in adjacent area. In case of stream sediment survey, anomalous zones of Cr, Cu, Hg, Ni and Zn mostly overlap each other. High factor score zones of the facter which may have relationship with mineralization, are found at the eastern part of the area.

Contents of the pathfinder elements show low values and no mineralized and/or altered zones were confirmed in this survey. Judging from these facts, potential for copper and/or gold in this area is thought to be low.

Area S

Area S is situated along a tributary of Sungai Imbak in the southern central part of the Labuk area. Anomalous and high content zones of Au and Hg were confirmed in this area from the results of the regional geochemical survey. In order to assess the epithermal gold deposits, soil and stream sediment geochemical survey were completed in this area.

Geology of the area consists of the Sapulut formation of Late Cretaceous to Late Eocene age. The Sapulut formation consists mainly of sandstone and mudstone. Ultra-basic rocks which emplaces over the Sapulut formation by a thrust fault are found in the eastern part of the area.

Contents of pathfinder elements including As, Au, Cu, Hg, Pb and S show low values. The samples with comparatively high values of Cr and Ni are limited in the area of ultra-basic rocks. In the area of ultra-basic rocks, anomalous zones of As, Cu, Hg and Zn are found, but the threshold values themself are low values. No factors which have some relation with mineralization were obtained.

The values of pathfinder elements which directly indicate mineralization are low. No significant mineralized and/or altered zones were recognized in this area. These facts may indicate low mineral potentiality in this area.

Area T

Area T is also situated along a tributary of Sungai Imbak in the southern marginal part of the Labuk area. Significant anomalous zones of Au and Hg were detected over this area in the regional geochemical survey. In order to assess the potential for gold, soil geochemical survey was conducted over this area.

Geology in this area consists of the Labang formation and the Tanjoung formation. Diorite porphyry dikes with several tenth of meter in width are found in the area of Tanjong formation. Alluvium deposits are found along stream in the north of the area. Mineralized and/or altered zones are restricted in the southern part of the area. Nearby the diorite porphyry dikes, pyritization, silicification and quartz veins are recognized. The intrusives are also affected by different degree hydrothermal alteration from white argillization to almost fresh. Several floats of gossanized ore are recognized in places in the stream. Ore assaying was

conducted for the mineralized samples and float gossan samples. Among these assay results, three samples indicate high grades of Au and Ag. These assay results are 9.0 g/t Au 278.3 g/t Ag, 18.4 g/t Au 115.7 g/t Ag and 15.4 g/t Au 931.4 g/t Ag. Observation results from polished section for these samples indicate ruby silver, freibergite and argentite as the silver minerals. Ratio of Au to Ag is low and the silver minerals occuring in the area are relatively low temperature type. These facts suggest that the mineralized zones in this area also indicate a possibility of being the upper part of porphyry copper type mineralization.

The contents of As, Au, Hg and S show higher values comparing to other semi-detailed survey areas. Anomalous zones of As, Au, Cu, Hg, S and Zn occur together in the southern part of the area. Other than this area, small anomalous zones are scattered. From the results of factor analyses, the factor which has relationship with mineralization was clearly delineated. The high factor score zones of this facter are concentrated in the area of the anomalous zones at the south. From the results of this survey, significant gold mineralization was confirmed in this area. Distribution of anomalous zones also suggest that the mineralized zones extend further south. Further exploration work must be carried out for these potential areas.

4-2 Geological survey

A detailed geological survey was carried out in Area B where mineralized zones were confirmed by the semi-detailed geochemical survey in Phase Ⅲ. Area B is situated at the upper stream of Sungai Danum in the Segama area.

Geology of this survey area consists of basic rocks of ophiolite series rocks which thrust over the Kuamut formation of Oligocene to middle Miocene age. The basic rocks consist of dolerite with subordinate layered gabbro. Basaltic pillow lavas are intercalated in the dolerite. The mineralized zones are found in the area of dolerite and are scatterly aligned in a direction of NE-SW. Three types of mineralization including quartz vein, stockwork and disseminations of pyrite and chalcopyrite are recognized in this area. The most significant mineral showing was found at the central part. The width of the mineralized zone is approximately 6 m and quartz veins with pyrite and chalcopyrite occur in this zone. The width of the quartz veins range from several centimeters to one meter. The average grade is not high but some parts have good Cu grade (best sample; 0.60 m in width and 2.66 % Cu). Assay results of samples from stockwork and/or disseminated zones ranges from 2 to 10 % of Cu, but the widths are several tenth centimeters.

The mineralization confirmed in this survey is not typical Cyprus-type copper deposits, because the mineralization is vein and/or stockwork and is hosted by dolerite. The mineralized zones are scattered, but some parts show good Cu grades. It is better to carry out more detailed survey in order to clarify the potential.

Chapter 5 Conclusions and recommendations

5-1 Conclusions

A semi-detailed geochemical survey for the selected ten areas was carried out in this phase. These ten areas are situated in the Kinabal and Labuk areas and are selected areas as potential areas of mineral resources in the regional survey of Phase III. In addition, a geochemical survey was conducted for the mineralized zones in Area B in the Segama area. These mineralized zones were deliniated by the semi-detailed survey in Phase III.

The results of the semi-detailed survey are conclusively summarized as follow:

Area J: Potential for copper ore deposit is thought to be low. The anomalous zones delineated by the regional geochemical survey possibly related to mineralized gravels in alluvium.

Area K: Concentration of nickel is recognized in the lateritic soil over ultra-basic rocks. Assay rsults give maximum value of 1.50 % Ni and the deeper part show higher concentration comparing the shallow part. Potential for lateritic nickel ore deposit is expected in this area.

Area L: No significant concentration of titanium minerals was confirmed in this area. Potential fot titanium ore deposit is interpreted to be low.

Area M: Potential for porphyry copper deposit is thought to be low, as the geochemical anomalous zones are found in the area of terrace deposits which may contain mineralized gravels from the upper stream.

Area N: Comparing to Area K, higher concentration of nickel is recognized in the lateritic soil in this area. Potentiality for nickel ore deposits is thought to be high at the deeper parts.

Area P: Distribution of geochemical anomalous zones is limited. Potentiality of chromite ore deposit seems to be low.

Area Q: Consupicuous geochemical anomalous zones of Au, Cu and Ni were found and assay result of a gossan sample indicated 4.1 g/t Au. Mineralized zones are known in this area by the previous survey. Potential for gold and copper are thought to be high.

Area R: No significant geochemical anomalous zone and mineralized zone are confirmed in this area. Potential for copper ore deposit in this area is interpreted to be low.

Area S: Pathfinder elements indicate lower values comparing to other semi-detailed survey area and no mineralized zone was found during the survey. Potential for gold deposit is thought to be low.

Area T: Conspicuous geochemical anomalous zones and mineralized zones were

confirmed in this area. Assay results give high grades of Au ranging from 9.4 g/t to 18.4 g/t and Ag ranging from 115.7 g/t to 931.4 g/t. Potentiality of this area is thought to be very high.

Among the ten areas investigated in this survey, it is possible to delineated Area K, Area N, Area Q and Area T as the potential areas of mineral resources in the Kinabal and Labk areas. The highest potentiality is expected for Area T among these four areas.

From the results of the geological survey in Area B, the mineralized zones occurs as veins, stockwork veins and disseminations of copper minerals. The mineralized zone does not indicate the occurrences of typical Cyprus-type copper deposit. The mineralized zones are scattered, but some parts show high copper grade ranging from 2 % to 10 %. The potential for copper ore deposit in this area is thought to be high.

5-2 Recommendations

The sample density of the semi-detailed geochemical survey is four samples per one square kilometer. Because of the limited number of samples, only the outline of the mineralized zones were confirmed in this survey. Further exploration work should be carried out for the geochemical anomalous zones and mineralized zones confirmed in this survey in order to clarify the potentiality. Based on the results of the semi-detailed survey and geological survey in Area B, following areas and the survey methods are recommended for the future exploration work:

① Area T in the southern margin of the Labuk area:
geological survey, trenching and geophysical survey (IP method)

② Area N at west of Telupid in the Labuk area:
geological survey, pit survey and trenching

③ Area Q along Sungai Karamuak in the Labuk area:
geological survey and geophysical survey (IP method)

④ Area B along Sungai Danum in the Segama area:
trenching

⑤ Area K east of Ranau in the Kinabalu area:
geological survey, pit survey and trenching

The target for Area T is gold mineralization. Area N and Area K are the potential areas of lateritic nickel ore deposits. Copper and/or gold mineralization is expected in Area Q. The target in Area B is copper ore deposit. These areas are shown in Fig. I-3. If these survey give attractive results, drilling survey should be conducted.

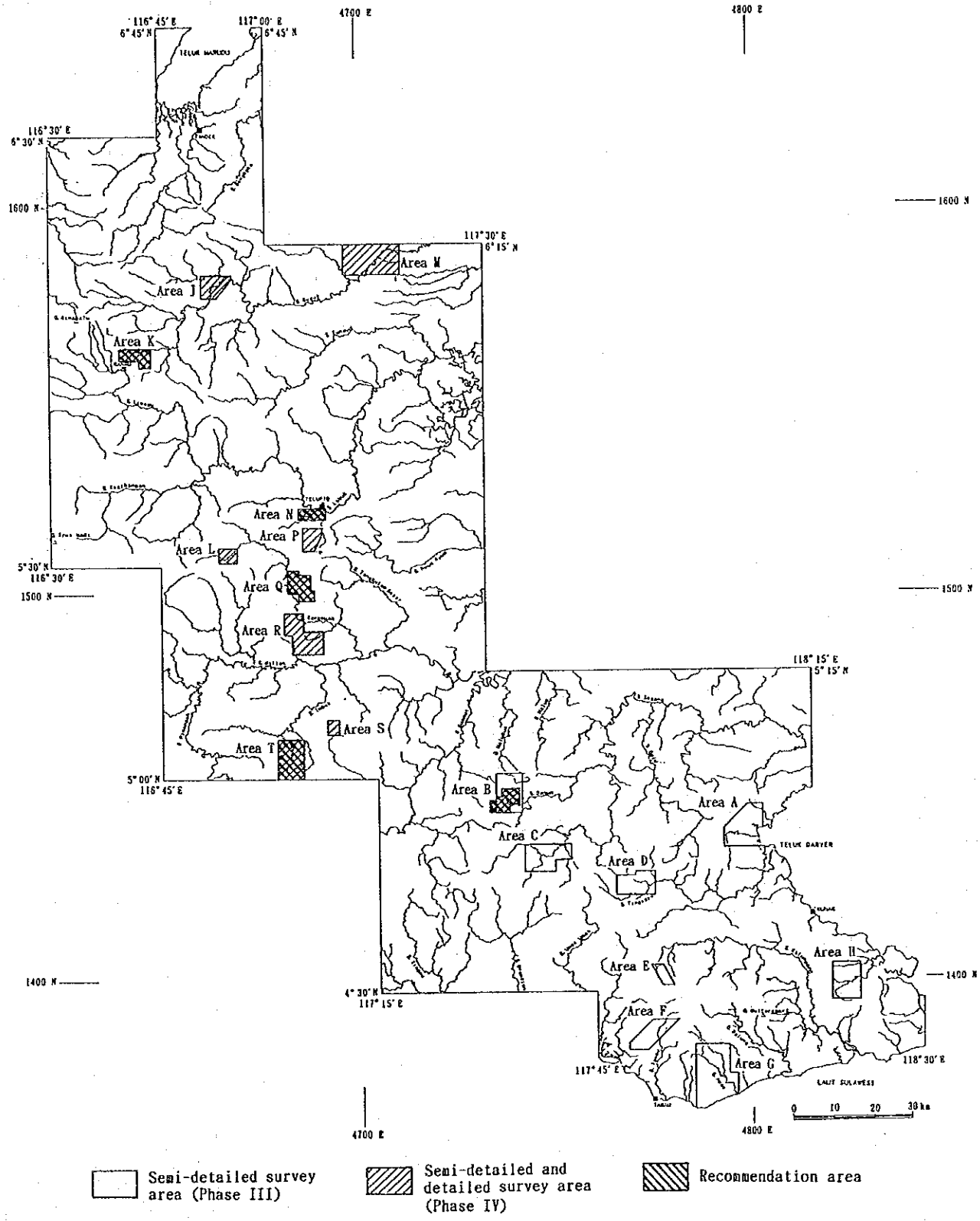


Fig. I-3 Recommendation for future work

Part Ⅱ Survey results

Chapter 1 Semi-detailed geochemical survey

1-1 Survey methods and work amounts

1-1-1 Methodology

As the results of the regional geochemical survey of Kinabalu and Labuk areas in Phase III, ten areas were selected as the potential areas of mineral resources. A semi-detailed geochemical survey was conducted for each of following ten areas in this phase.

① Area J (Kinabalu Area) Middle stream of Sungai Sugut area
② Area K (Kinabalu Area) East of Ranau area
③ Area L (Kinabalu Area) Upper stream of Sugai Karamuak area
④ Area M (Kinabalu Area) Lower stream of sungai Sugut area
⑤ Area N (Labuk Area) West of Telupid area
⑥ Area P (Labuk Area) Sungai Mailo area
⑦ Area Q (Labuk Area) Middle stream of Sungai Karamuak area
⑧ Area R (Labuk Area) The area between Sungai Karamuak and Sungai Milian
⑨ Area S (Labuk Area) Middle stream of Sungai Imbak
⑩ Area T (Labuk Area) Tributary of Sungai Imbak area

Locations of these areas are shown in Fig II-1-1.

Soil was used as the sample media for Area J, Area K, Area M, Area N and Area T. While, stream sediments were used as the sample media for Area L and Area P. Both soil and stream sediment samples were collected for Area Q, Area R and Area S. A geologic survey and sampling of laboratorial studies were simultaneously carried out along the geochemical sampling routes. Based on the results of orientation survey in Phase I, soil samples were collected at the upper part of B horizon except the samples of Area K and Area N. For an evaluation of nickel laterite mineralization in the Area K and Area N, two samples at each sampling site, at 50 cm deep and at 150 cm deep, were collected. Following the sampling method of regional geochemical survey, the stream sediment sample of -60 mesh fraction was collected at the edge of stream. The density of soil sample is 4 samples/km^2.

During the sampling each sampling site was described on the samplng list. The amount of sample collected at each sampling site is more than 1 kg for soil sample and more than 150 g of -60 mesh fraction for stream sediment sample. After drying up soil sample, -80 fraction was prepared, then it was splite into two portions, one for chemical analyses and the other for spare sample stored at the Geological Survey of Malaysia, Sabah office. The samples were sent to the laboratories in Japan and Canada for chemical analyses.

Base camp was established for each area during the survey and for the remote

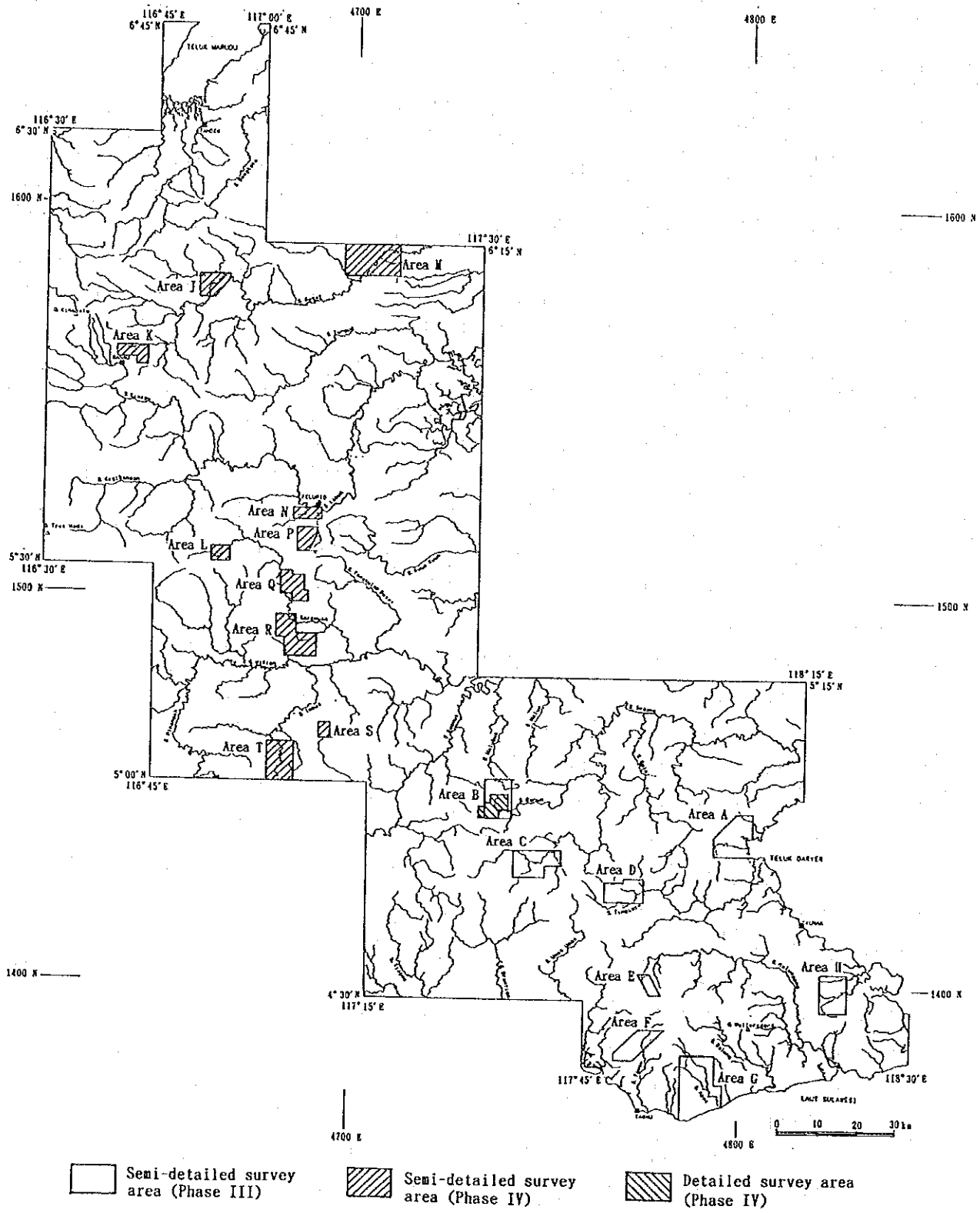


Fig. II-1-1 Location map of semi-detailed survey areas

areas survey was conducted by fly camp.

1-1-2 Coverage of work

The followings are amount of work completed for each area.

Area	Geochemical survey		Laboratorial studies			
	Soil	Stream sediment	Thin section	Polished section	X-ray diffract	Ore assaying
Area J	150 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area K	240 spls.	0 spls.	0 spls.	0 spls.	0 spls.	3 spls.
Area L	0 spls.	80 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area M	476 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area N	170 spls.	0 spls.	0 spls.	0 spls.	0 spls.	2 spls.
Area P	0 spls.	105 spls.	1 spls.	0 spls.	0 spls.	0 spls.
Area Q	85 spls.	85 spls.	0 spls.	0 spls.	0 spls.	2 spls.
Area R	150 spls.	150 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area S	25 spls.	25 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area T	280 spls.	0 spls.	11 spls.	10 spls.	10 spls.	13 spls.
Total	1,576 spls.	445 spls.	12 spls.	10 spls.	10 spls.	20 spls.

The elements applied in this survey were determined based on the results of the orientation geochemical survey in Phase I. The number of elements analyzed for geochemical survey differ depeding on the target of each area. The chemical analyses of the following 21 elements were conducted for soil and stream sediment samples of Area J, Area M, Area Q, Area R, Area S and Area T.

Element	Detection limit	Element	Detection limit	Element	Detection limit
As	1 ppm	K	0.01 %	S	0.001 %
Au	2 ppb	Mg	0.01 %	Sb	0.2 ppm
Ba	10 ppm	Mn	5 ppm	Sr	1 ppm
Co	1 ppm	Mo	1 ppm	Ti	0.01 %
Cr	2 ppm	Na	0.01 %	U	0.2 ppm
Cu	1 ppm	Ni	1 ppm	W	2 ppm
Hg	10 ppb	Pb	2 ppm	Zn	1 ppm

Only two elements of Fe and Ti were selected as pathfinders for stream sediment of Area P. For Area K, Area N and Area P, 5 elements given below were selected for pathfinders.

Element	Detection limit	Element	Detection limit	Element	Detection limit
Al	0.01 %	Cr	2 ppm	Ni	1 ppm
Co	1 ppm	Fe	0.01 %		

The elements of ore assay and their detection limits are as the following:

Element	Detection limit	Element	Detection limit	Element	Detection limit
Au	0.1 g/t	Pb	1 ppm	S	0.01 %
Ag	0.1 g/t	Zn	1 ppm		
Cu	1 ppm	Mo	1 ppm		

1-1-3 Data processing and analyses

The analytical results of the geochemical samples were input in computer and statistical data treatment, single element and multi element analyses were conducted.

For the single element analyses, statistic figures such as maximum, minimum, mean values and standard deviation for each element were calculated. A half value of the ditection limit was used for the sample showing value less than the detection limit. The mean values calculated are geometric means. Based on this calculation, distribution map of each element was drawn by computer. For the distribution map fllowing ranks were used.

Less than background (B) value.
More than background value, less than B + standard deviation(SD).
More than B + Standard deviation, less than B + 2SD.
More than B + 2SD.

The drainage system of the survey areas were input in the computer using digitizer and distribution maps of each element were prepared. The coorelation matrix among the elements were also calculated. Exploratory Data Analysis (EDA) method was applied to delineate the threshold value (anomalous value) for each element.

As the multi element analyses, factor analysis was utilized in this survey. The factor analysis is a method to delineate the factor (group of elements) controling the chemical nature of of the samples.

The data analyses and interpretation were made using newly prepared geological maps of each survey area.

1-2 Results of laboratorial studies

Geological survey was carried out along the sampling route and also rock samples were collected for the laboratorial studies. Location of these samples are shown in the geologic map of each semi-detailed survey area.

The samples for the laboratorial studies are thin section, polished section and x-ray diffraction analysis.

Results of the microscopic work of thin sections and polished sections and x-ray diffraction analyses are shown in Table II-1-1, Table II-1-2 and Table II-1-3, respectively. Ore samples were also collected from mineralized zones. The list of ore sample and the assay results are shown in Table II-1-4.

Table II-1-1 Descriptions of thin sections of the semi-detailed geochemical survey areas

Ser. No.	Sample No.	Area	Coordinates		Rock Name	Texture	Phenocryst, crystal. & Rock Fragment							Groundmass, matrix, Accessory Minerals.								Secondary Minerals							Remarks
			N	E			quartz	plagioclase	clinopyroxene	hornblende	biotite	garnet	epidote	quartz	plagioclase	apatite	sphene	zircon	tourmaline	opaque mineral	hematite	quartz	sericite	calcite	chlorite	biotite	plagioclase	epidote	
1	K708	P	1516.71	4690.89	Amphibolite	nematoblastic		◎		◎		o	o			·	○			·			○	o	·				amphibolite with garnet porphyroblast.
2	M713	T	1454.65	4680.45	Mudstone	clastic	◎	o										·	·	·		·	○	○					mudstone with calcite sericite alteration.
3	M714	T	1453.97	4681.03	Mudstone	clastic	◎	o						◎				·	·	·		·	○	○					mudstone with calcite sericite alteration.
4	M715	T	1453.97	4681.03	Diorite porphyry	porphyritic									◎					·		○	○	○	○				strongly altered.
5	M719	T	1453.90	4681.04	Diorite porphyry	porphyritic intergranular		○		○					◎					○		o		○	◎	·			carbonated, chloritized
6	M721	T	1453.65	4682.08	Mudstone	clastic	◎	o						◎				·	·	o		·	○	○	o				carbonated, chloritized
7	M723	T	1453.53	4682.15	Strongly altered rock	granoblastic														·		◎	◎				◎		original rock is probably diorite porphyry.
8	M724	T	1453.12	4682.07	Strongly altered rock	granoblastic															o	◎	◎				◎		original rock is probably diorite porphyry.
9	M729	T	1453.48	4681.60	Diorite porphyry	porphyritic		○		○					o	·	o			o		○	◎	◎	○		○		strongly altered.
10	M730	T	1454.03	4682.65	Diorite porphyry	porphyritic, hypidiomorphic granular		◎		o	o				◎	·	·			·		o	◎	◎	○				altered.
11	M734	T	1453.33	4683.80	Diorite porphyry	porphyritic intergranular		◎	○	o					◎		·			o			o	o	o			o	slightly altered.
12	P701	T	1452.82	4685.32	Diorite porphyry	porphyritic, hypidiomorphic granular		○		◎					◎	·	·						o	○	o				slightly altered.

◎: abundant ○: common o: a little ·: rare

Table II-1-2 Descriptions of polished sections of the semi-detailed geochemical survey areas

Ser. No.	Sample No.	Area	Coordinates		Descriptions	Ore minerals													Remarks
			N	E		chalcopyrite	cubanite	covellite	bornite	Ag-minerals	galena	sphalerite	pyrite	arsenopyrite	pyrrhotite	mackinawite	marcasite	goethite	ganque mineral	
1	M717	T	1453.97	4681.03	py.veinlet in dio.porphyry								○				○	○	◎	
2	M718	T	1453.97	4681.03	sili.,argil.rock with py.	·							·						◎	
3	M722	T	1453.65	4682.08	sili. rock with py.and sph.	○						○	○		·	·			◎	float
4	M724	T	1453.12	4682.60	sili.,argil.dio.porphyry								◎					○	◎	
5	M725	T	1453.00	4682.08	py.veinlet in sili.rock							○	◎				○		◎	float
6	M727	T	1452.50	4682.10	qz.veinlet with py.and apy.	·		·			·		○	◎	·	·	○		○[Q]	float
7	M728	T	1452.32	4682.02	qz.veinlet in sili.rock								○	◎			○	○	○	
8	P703	T	1456.10	4682.75	qz.vein in mudstone	○	·	·					○	◎			○	·	◎[Q]	float
9	P707	T	1455.85	4682.55	qz.vein in sili.sandstone	·						·	○						◎	float
10	P708	T	1456.70	4683.20	qz.vein with py.and apy.	○			·	○		○		○					◎[Q]	float,few minute gold-like grains

◎: abundant ○: common ○: a little ·: rare

Ag-minerals:
Proustite(·),Pyrargyrite(·),Freibergite(·),Miargyrite(·),Argentite(·),Argyropyrite(·)

Table II-1-3 Results of X-ray diffraction analyses in the semi-detailed geochemical survey areas

Ser. No.	Sample No.	Area	Coordinates		Descriptions	Detected mineral										Remarks
			N	E		quartz	plagioclase	chlorite	sericite	pyrite	chalcopyrite	arsenopyrite	scordite	magnetite	hematite	
1	M715	T	1453.97	4681.03	sili.,argil. diorite porphyry	◎	◎	o	o							
2	M717	T	1453.97	4681.03	py.veinlet in diorite porphyry	◎		·	o							
3	M718	T	1453.97	4681.03	strongly sili.,argil.rock	◎	o		○							
4	M723	T	1453.53	4682.15	strongly sili.,argil.rock, (diorite porphyry)	◎	◎	○	o							
5	M724	T	1453.12	4682.07	strongly sili.,argil.rock, (diorite porphyry)	◎	◎		○							
6	M725	T	1453.00	4682.08	py.veinlet in sili. rock	◎	o		○	o				o		float
7	M728	T	1452.32	4682.02	qz.veinlet with py.in sili.rock	◎						○	○			
8	M729	T	1453.48	4681.60	sili.,argil. diorite porphyry	◎	◎	o	o	·	·					
9	M730	T	1454.03	4682.65	altered diorite porphyry with py. dissm.	◎	◎	○	o						·	
10	M731	T	1453.15	4682.38	strongly sili.,argil.rock, (diorite porphyry)	◎	◎	o	○						·	

◎: abundant ○: common o: a little ·: rare

Table II-1-4 List of ore samples and assay results of the semi-detailed geochemical survey areas (1)

Ser. No.	Sample No.	Area	Coordinates		Descriptions	Assay results							Remarks and sampling width (m)
			N	E		Au (g/t)	Ag (g/t)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	S (%)	
1	N712	T	1461.75	4680.50	qz. veinlet in sili. sandstone	0.2	1.0	23	< 1	45	30	0.06	float, w.0.4
2	M717	T	1453.97	4681.03	py. veinlet in diorite porphyry	< 0.1	1.2	37	< 1	8	70	0.34	w.0.03
3	M718	T	1453.97	4681.03	sili., argil. rock	< 0.1	0.3	28	< 1	26	62	0.05	w.0.2
4	M722	T	1453.65	4682.08	sili. rock with py.& sph. dissm.	< 0.1	23.8	393	< 1	346	12,020	6.33	float, w.0.5
5	M723	T	1453.53	4682.15	sili., argil. diorite porphyry	< 0.1	0.4	386	< 1	31	109	0.44	w.0.5
6	M724	T	1453.12	4682.07	sili., argil. diorite porphyry	< 0.1	2.4	22	< 1	250	140	0.09	w.0.5
7	M725	T	1453.00	4682.08	py. veinlet in sili. rock	< 0.1	6.6	55	< 1	247	176	4.82	float, w.0.1
8	M727	T	1452.50	4682.10	qz.veinlet with py.& apy.	9.0	278.3	4,458	< 1	338	162	14.51	float, w.0.1
9	M728	T	1452.32	4682.02	qz.veinlets in.sili rock	18.4	115.7	412	< 1	168	31	6.82	w.0.1
10	M730	T	1454.03	4682.65	sili.diorite porphyry with py.	< 0.1	0.2	52	< 1	28	342	0.26	w.0.5
11	M731	T	1453.15	4682.38	sili., argil. diorite porphyry	< 0.1	2.4	31	< 1	133	60	0.30	w.3.5
12	P707	T	1455.85	4682.55	quartz vein in sili.sandstone	< 0.1	10.3	95	< 1	55	21	1.76	float, w.0.4
13	P708	T	1456.70	4683.20	qz. vein with py. and apy.	15.4	931.4	2,740	< 1	9,860	316	3.04	float, w.0.1

Table II-1-4 List of ore samples and assay results of the semi-detailed geochemical survey areas (2)

Ser. No.	Sample No.	Area	Coordinates		Descriptions	Assay results							Remarks and sampling width (m)
			N	E		Au (ppb)	Co (ppm)	Cr (ppm)	Fe (%)	Ni (ppm)	Pd (ppb)	Pt (ppb)	
14	N701	K	1560.30	4642.00	yellow green saprolite	120	104	3,010	8.02	5,003	6	5	w.1.0
15	N715	K	1561.30	4642.77	yellow green saprolite	44	152	4,524	10.06	15,038	8	10	w.1.0
16	N716	K	1561.30	4642.77	yellow green saprolite	336	159	4,736	10.06	14,414	< 2	< 5	w.1.0
17	N717	N	1521.78	4688.60	weathered peridotite	< 2	100	850	5.57	8,043	2	5	w.0.8
18	N718	N	1521.65	4688.65	weathered peridotite	< 2	116	897	6.80	13,187	10	10	w.0.8
19	M709	Q	1501.80	4683.60	reddish brown gossan	4,050	121	1,300	57.66	691	4	< 5	float, w.0.3
20	M710	Q	1505.50	4684.90	reddish brown gossan	12	172	35,948	43.81	3,461	12	< 30	float, w.0.3

1-3 Area J

1-3-1 Geology and mineralization

(1) Survey area

Based on the geology and the regional geochemical survey results, this area was selected as a potential area for porphyry copper deposits. A soil geochemical survey was carried out in this area.

Area J is located at central east of Kinabalu area, middle stream of Sugai Sugut. Sungai Mirali, which flows northward in the central part of the area, is the main drainage system of the area and Sungai Kapuakan cut through the northwestern part of the area. Both of them are tributaries of Sungai Sugut. The topography in the area is generally gentle hilly with the maximum elevation of 400 m. The area both side of Sungai Mirali in the south of the Area J is occupied by flat low land. The area is generally covered by secondary jungle except the area along the Sungai Mirali where small scale agriculture activities are found.

(2) Geology

The area is covered by Crocker formation (P_2Cr) of Eocene to Oligocene age and alluvium is found along the main rivers. Geologic map is given in Fig. II-1-2.

The Crocker formation (P_2Cr), consisting of pale gray sandstone and mudstone, covers a whole area except along the main streams. The formation generally stricks NW-SE and dips approximately 40° toward northeast. The southwest dips obtained at a few locations in the northwestern part of the area suggest an existence of folding structure. The alluvium, consisting of sand and gravels, is widely distributed along the Sungai Mirali in the south of the area and is narrowly distributed along the sungai Kapuakan at the northwestern edge of the area.

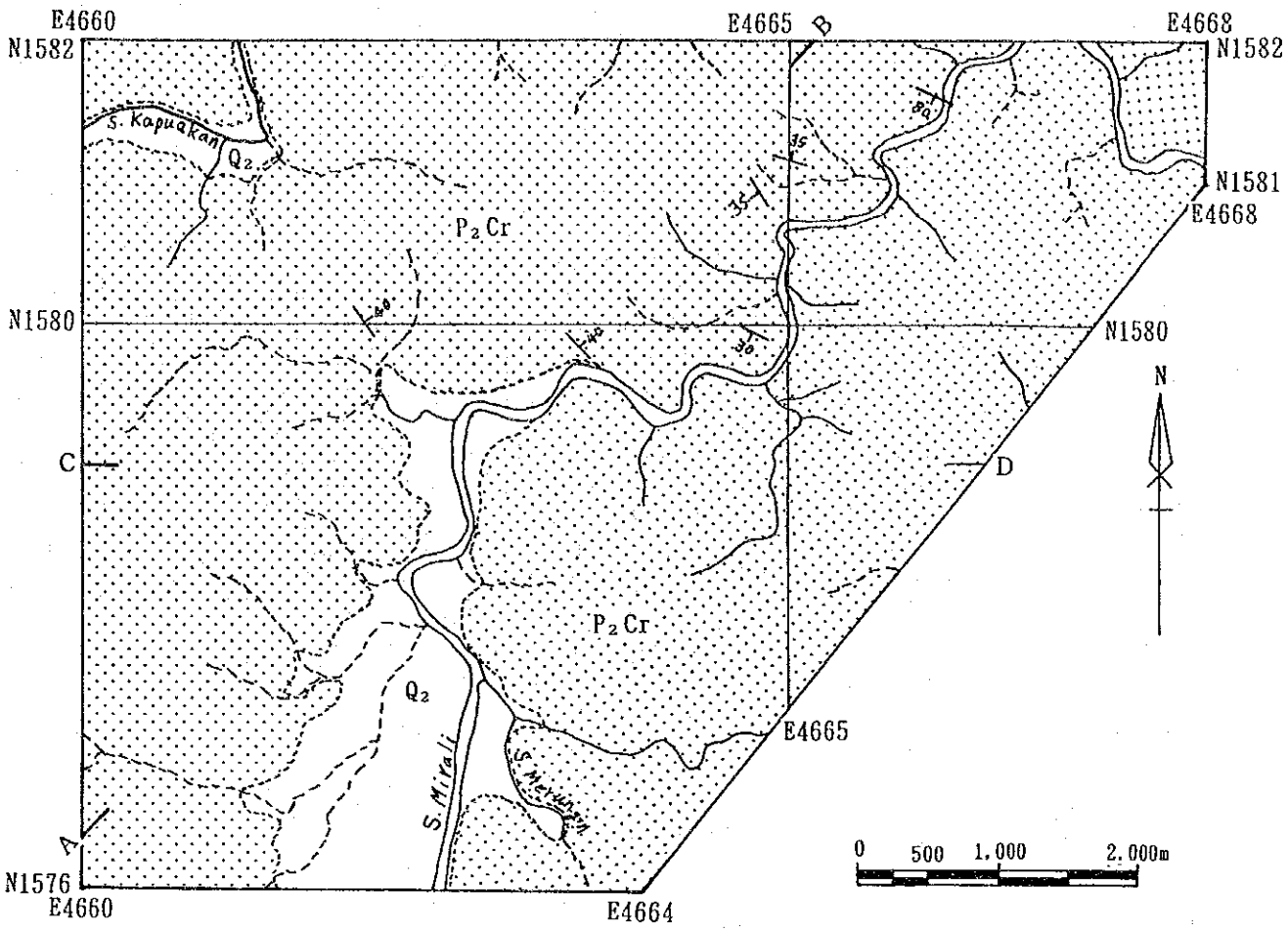
(2) Mineralization

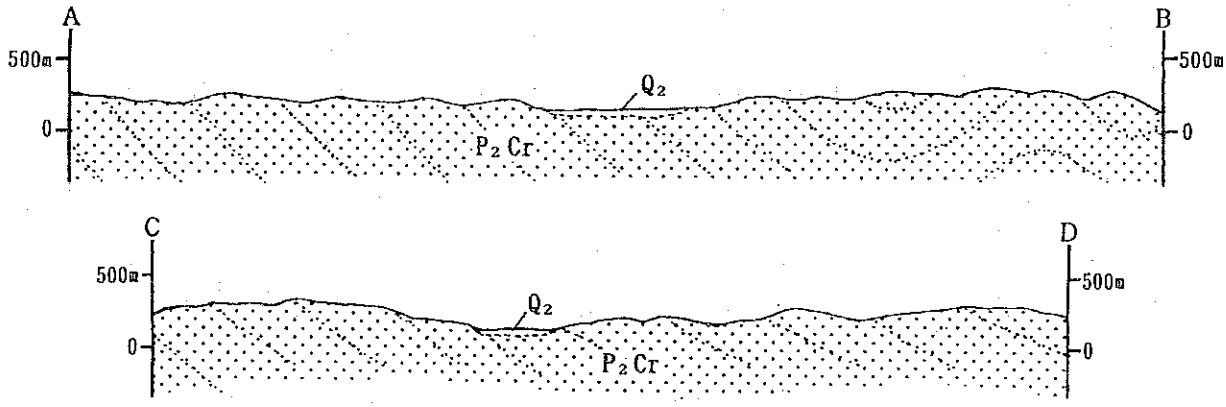
A small scale quartz veinlets was found in the Crocker formation, however, no significant mineralization and alteration were found in Area J.

1-3-2 Soil geochemical survey

(1) Sampling

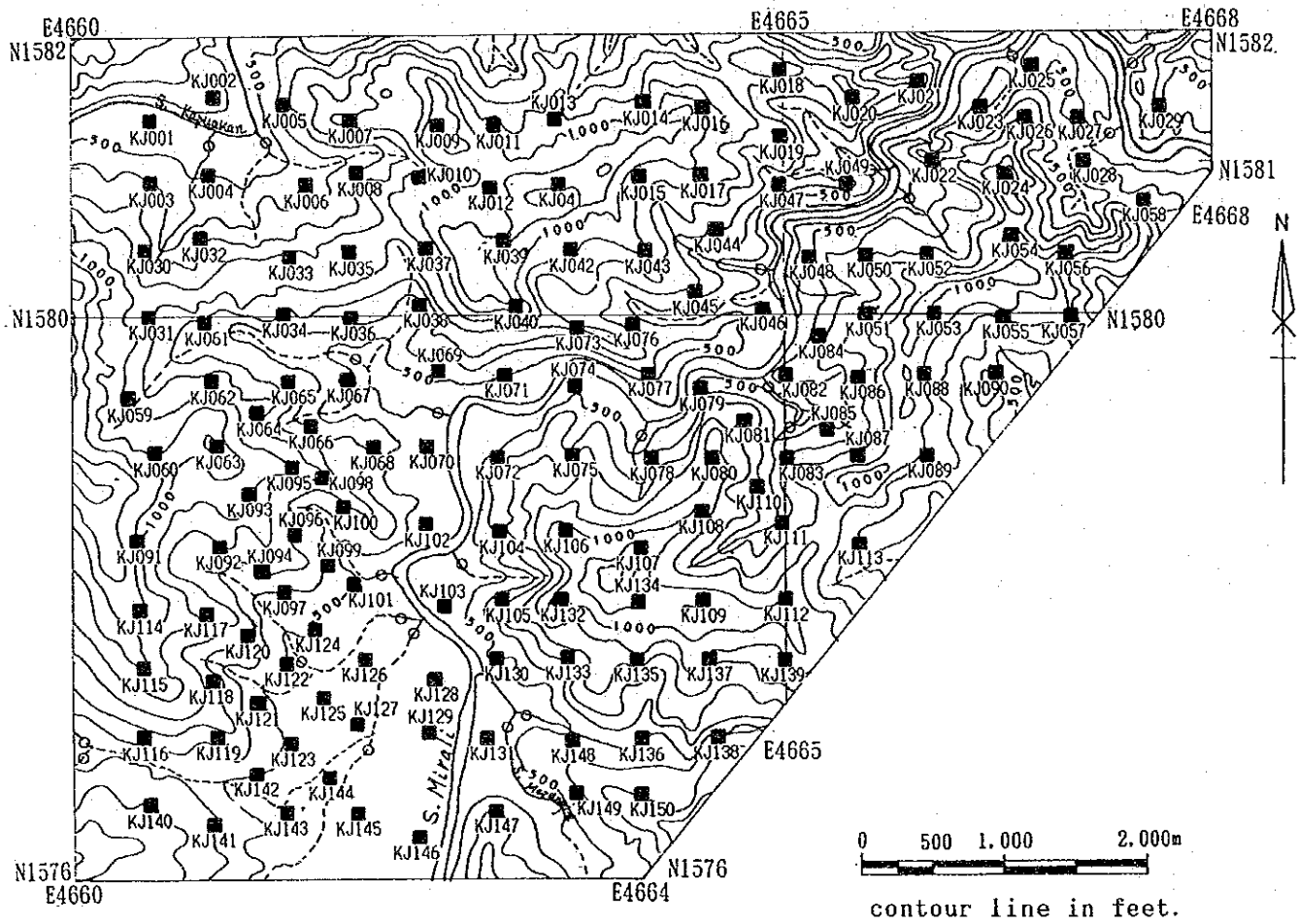
A soil geochemical survey was conducetd in the Area J. Locations of collected samples and their list are, respectively, shown in Fig. II-1-3 and Appendix 1. After drying up these samples, -80 mesh fractions were prepared for chemical analyses.





Recent	Q_2	Riverine alluvium.
Eocene-Oligocene	P_2Cr	Crocker Formation: sandstone and mudstone.

Fig. II-1-2 Geologic map and cross sections of Area J



■ KJ001 Location of soil samples and sample number.

○ Location of stream sediment samples collected in phase III.

Fig. II-1-3 Location map of geochemical samples in Area J

(2) Statistical data treatment

Analytical results are shown in Appendix 2. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-5.

The calculated geometric means of the Area J give following tendencies comparing with other areas of similar geological environment.

Element indicating higher value: Ba.

Element indicating lower value : As, Co, Cr, Cu, Mg, Ni.

Coinside with the evidence of no significant mineralization and alteration found in the area, the maximum values of As, Au, Cu, Hg, Pb are low. Concentrations of Mo and W indicate particulary low values, less than the detection limit for nearly whole samples.

In order to clarify relationships between the elements, correlation coefficients were also calculated. The results show following pairs of element to be comparatively good (correlation coefficient: more than 0.700) correlations.

Ba-K, Ba-Mg, Ba-Na, Ba-Sr, Co-Cu, Co-Mn, Co-Ni, Co-Zn, Co-Ni, Cu-K, Cu-Mg, Cu-Mn, Cu-Zn, K-Mg, K-Na, K-Zn, Mg-Na, Mg-Sr, Mg-Zn, Mn-Ni, Na-Ni, Na-Sr, Sr-Zn

The elements including Ba, Co, Cu, Na, Mg, Ni, Sr and Zn show good correlations each other.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 3) using the values obtained by EDA method. Distribution of each element is summarized as follows;

As: High value samples are scattered over the area along Sungai Mirali and no clear tendency of distribution pattern is observed due to low concentration.

Au: Samples of relatively higher values are scattered, however, all the samples show low absolute values.

Ba: Anomalous zones are distributed along Sungai Mirali.

Co: Zones of high value and anomaly are distributed in south of the area along Sungai Mirali. Absolute value is low.

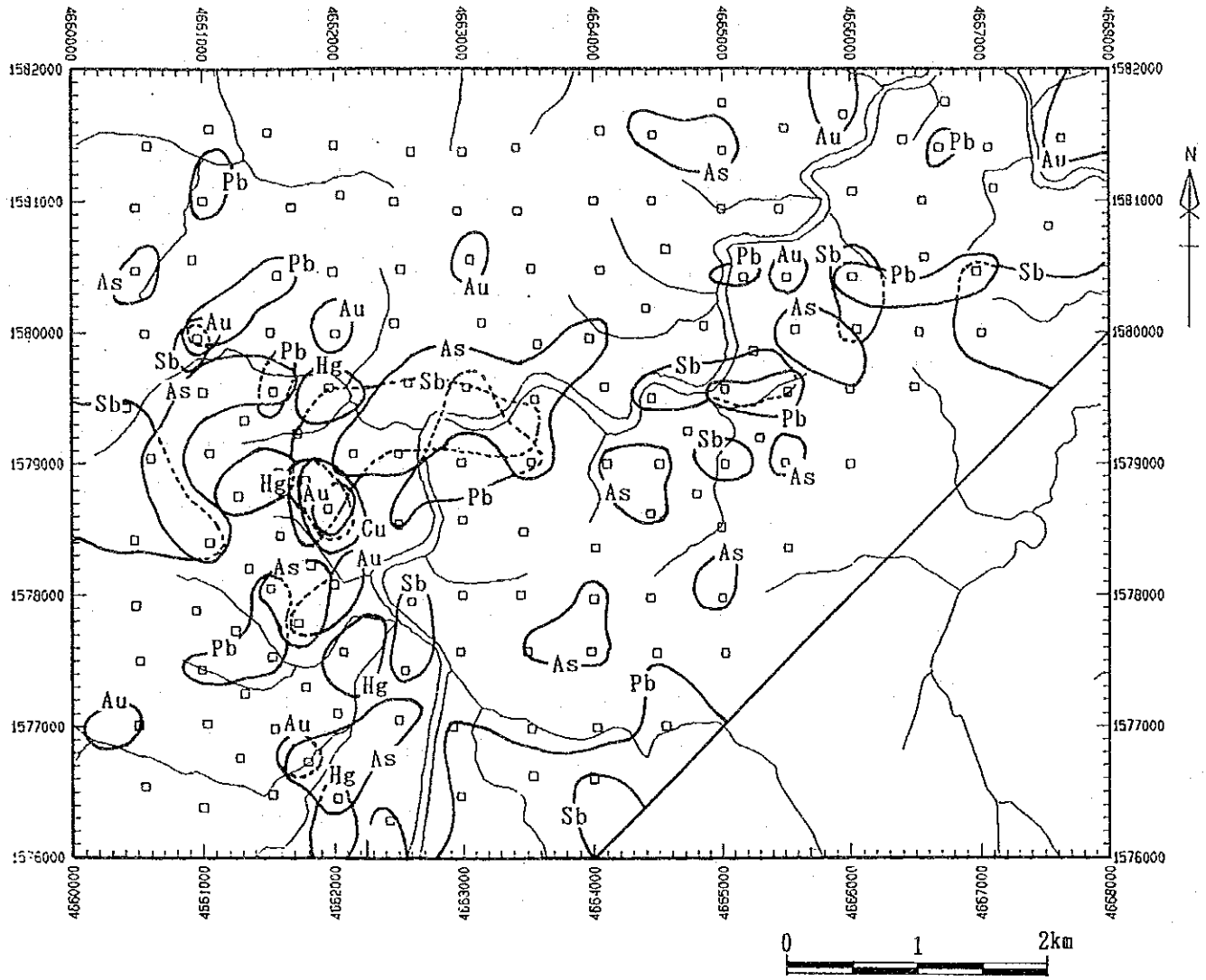
Cr: High value and anomalous zones are distributed along Sungai Mirali and Sungai Kapuakan. Absolute value is low.

Cu: Distribution of high value and anomalous zones are restricted in the area along Sungai Mirali.

Table II-1-5 Statistics of soil geochemical survey in Area J

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	36.7	13	< 1	1.9	0.503	—	2.0	7.0	—
Au (ppb)	76.0	4	< 1	0.6	0.199	1.6	0.5	1.0	0.5
Ba (ppm)	—	325	26	125.6	0.176	282.2	117.0	180.0	—
Co (ppm)	18.7	85	< 1	3.4	0.514	35.8	4.0	9.0	45.8
Cr (ppm)	—	401	19	54.5	0.247	170.1	47.0	78.0	162.8
Cu (ppm)	—	133	3	11.1	0.240	33.5	11.0	17.0	38.5
Hg (ppb)	—	194	37	71.1	0.110	117.8	70.5	86.0	123.9
K (%)	—	2.31	0.08	0.580	0.233	1.693	0.580	0.920	2.249
Mg (%)	—	2.11	0.08	0.369	0.219	1.014	0.355	0.570	1.138
Mn (ppm)	—	2,925	22	142.8	0.492	1,374.0	115.5	444.0	—
Mo (ppm)	86.7	5	< 1	0.6	0.165	1.2	0.5	0.5	0.5
Na (%)	—	1.62	0.01	0.129	0.394	0.789	0.105	0.320	—
Ni (ppm)	—	324	5	17.9	0.380	103.0	15.0	33.0	109.0
Pb (ppm)	1.3	30	< 2	12.5	0.208	—	14.0	18.0	—
S (%)	—	0.025	0.007	0.015	0.104	0.025	0.015	0.019	—
Sb (ppm)	40.0	13.9	< 0.2	0.64	0.727	—	0.90	4.10	—
Sr (ppm)	—	73	10	28.5	0.176	64.1	27.0	43.0	—
Ti (%)	—	1.37	0.16	0.286	0.104	0.461	0.280	0.320	0.428
U (ppm)	—	3.2	0.2	1.97	0.116	—	2.00	2.20	2.97
W (ppm)	99.3	2	< 2	1.0	0.025	1.1	1.0	1.0	1.0
Zn (ppm)	—	238	9	35.5	0.200	88.9	35.0	49.0	102.3

*1: geometric mean *2: shown in logarithm *3: background value + 2 x standard deviation
*4: Exploratory Data Analysis (Kurzl H.,1988)



As > 7 ppm	Hg > 124 ppb
Au > 1.5 ppb	Pb > 18.0 ppm
Cu > 39 ppm	Sb > 4.1 ppm

Fig. II-1-4 Distribution of geochemical anomalous zones in Area J

Hg: High value and anomalous zones are found in the northeastern and southwestern parts of the area along Sungai Mirali.

K : Zones of relatively high value are found mainly in the area west of Sungai Mirali.

Mg: A tendency of distribution is similar to Co, Cr and Ni. Zones of relatively high value occur in the area along Sungai Mirali.

Mn: High value zones are found in the southern part of the area, west of Sungai Mirali. The rest of the high value samples are scattered over the area

Mo: No clear distribution tendency is observed due to low concentration.

Na: High value and anomalous zones occupy the flat area, west of Sungai Mirali.

Ni: Zones of high value and anomaly are found along Sungai Mirali, however, Ni concentration is low.

Pb: High value and anomalous zones are scattered over the area and no clear distribution tendency is observed.

S : High value zones are scattered over the area and no clear distribution tendency is found.

Sb: High value and anomalous zones occur in the central part of the area trending E-W direction, however, concentration of Sb is low in Area J.

Sr: Anomalous zones occur along Sungai Mirali in the western part of the area.

Ti: High value and anomalous zones occur along Sungai Mirali in the southern, central and noutheastern parts of the area.

U : High value and anomalous zones are scattered over the area and no characteristic feature of distribution is found.

W : Only one sample gives a value above the detection limit.

Zn: High value and anomalous zones mainly occur in the west of Sungai Mirali.

Considering the distribution maps and geological environment of the area, the elements, which are possibly useful for investigating the area, were choosen and an anomaly map for these elements was prepared (Fig. II-1-4). All the anomalies are scatterd over the area except in the central part of the area, near the west bank of Sugai Mirali where anomalies of Au, Cu, Hg and Sb overlap each other.

(4) Multi element analysis

Factor analysis was examined as the multi element analysis in this survey. The results of facter analysis are given in Table II-1-6. Following relationships between elements and factors extracted by the factor analysis.

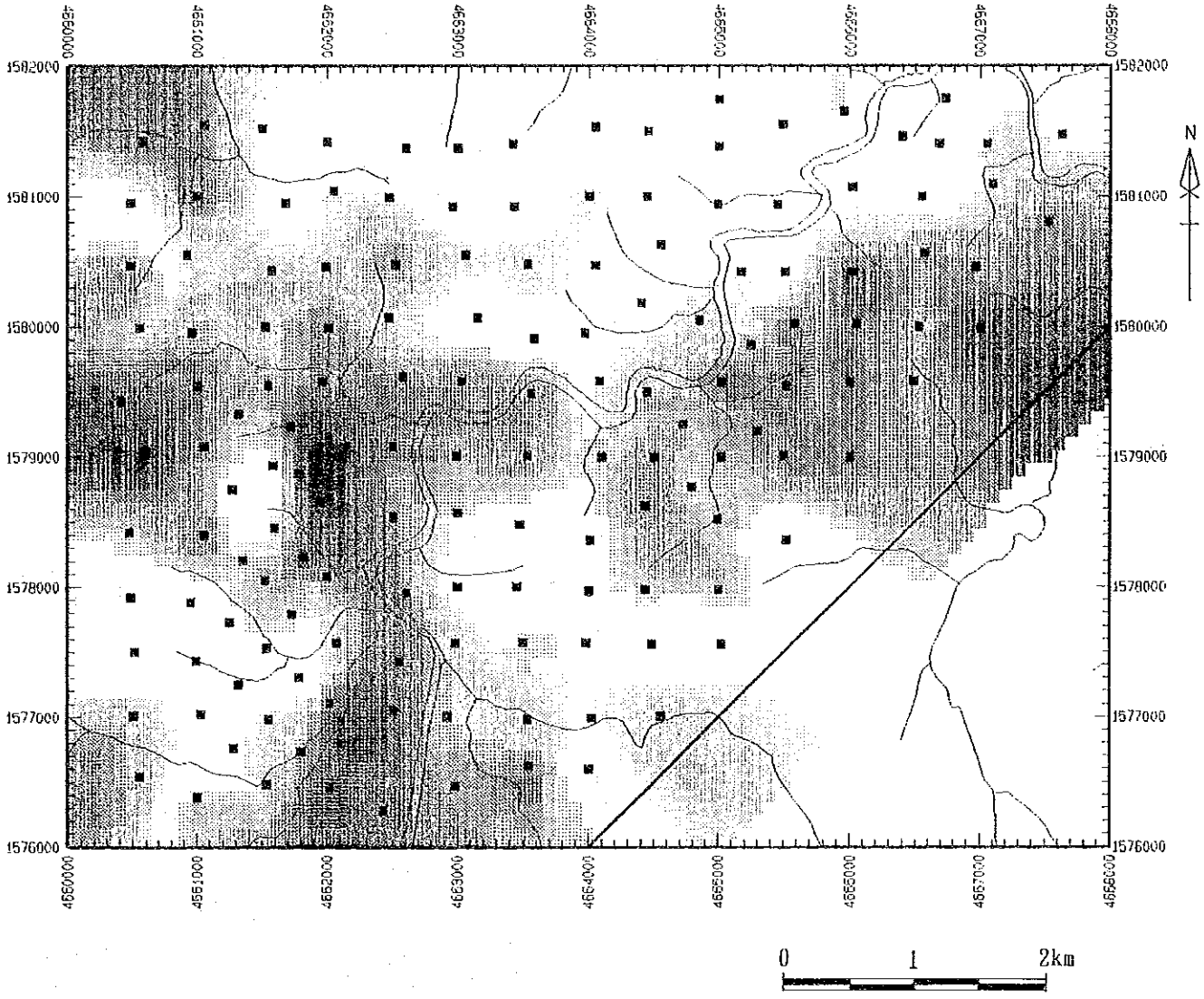
Factor 1 : Ba-Co-Cu-K-Mg-Mn-Na-Ni-Sr-Zn

Factor 2 : Pb-U

Table II-1-6 Results of factor analyses for soil samples in Area J

Element	Factor loading (Varimax rotation)							Commu-nality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	
As	0.005	0.072	-0.583	0.052	-0.012	-0.012	0.095	0.3575
Au	0.060	-0.080	0.084	0.047	0.033	0.256	0.000	0.0858
Ba	0.704	0.422	-0.032	0.047	0.155	0.387	-0.093	0.8634
Co	0.868	-0.095	-0.239	-0.046	0.160	-0.062	0.032	0.8514
Cr	0.438	-0.164	-0.018	0.070	0.796	0.149	-0.125	0.8959
Cu	0.788	-0.082	-0.089	0.417	0.187	0.074	-0.218	0.8977
Hg	0.025	-0.366	-0.173	0.047	0.294	0.207	-0.350	0.4187
K	0.631	0.459	-0.100	0.383	0.061	0.326	-0.178	0.9072
Mg	0.782	0.113	-0.107	0.373	0.205	0.245	-0.127	0.8490
Mn	0.901	-0.127	-0.018	-0.054	0.061	-0.007	0.077	0.8414
Mo	0.141	-0.290	-0.162	0.517	0.029	0.054	-0.082	0.4080
Na	0.718	-0.025	-0.072	0.121	0.248	0.510	0.027	0.8589
Ni	0.703	-0.045	-0.001	0.029	0.649	0.058	0.050	0.9492
Pb	0.147	0.733	-0.105	-0.154	-0.080	-0.224	-0.045	0.6514
S	0.401	0.032	-0.033	-0.167	0.051	0.494	-0.327	0.5447
Sb	0.346	-0.102	-0.570	0.154	0.080	-0.172	-0.046	0.5166
Sr	0.743	0.145	-0.039	0.068	0.097	0.376	-0.065	0.7339
Ti	0.286	-0.349	-0.111	0.461	0.029	-0.016	-0.370	0.5662
U	-0.069	0.804	0.007	-0.115	-0.056	0.054	0.049	0.6735
W	0.000	-0.007	-0.047	-0.042	-0.009	-0.011	0.238	0.0607
Zn	0.808	0.000	-0.042	0.377	0.123	0.130	-0.139	0.8485
F.C.*1	47.1 %	14.7 %	6.2 %	8.8 %	10.0 %	8.8 %	4.4 %	—

*1: Factor contribution



Factor 1 factor score : Blue
Factor 2 factor score : Yellow
Factor 3 factor score : Red

Fig. II-1-5 Distribution of factor scores in Area J

Factor 3 : As-Sb
Factor 4 : Mo
Factor 5 : Cr-Ni
Factor 6 : Na-(S)
Factor 7 : (Hg)-(S)-(Ti)

Factor 1, to which a group of many elements are related, is probably reflecting a nature of provenance of the sedimentary rock. Factor 2 is possibly attributed to chemical nature of sedimentary rock. Factor 3, 4 and 5 are not clearly related to any paticular aspect. Among these factors, three factors, Factor 1, 2 and 3, were selected and a distribution map of factor score was prepared allocating three different colors for each factor (Fig. II-1-5). Three factors are shown by following colors.

Factor 1 : blue Factor 2 : yellow Factor 3 : red

Distribution tendencies of these factors are summarized as follows;

Factor 1: A distribution of high factor score, found in the south along Sungai Mirali and in the northwest along Sungai Kapuakan, coincides well with the distribution of alluvium. Consequently, Factor 1 can be attributed to chemical nature of the alluvium deposits.

Factor 2: Zones of slightly high factor score are scattered over the area.

Factor 3: High factor score zones occur in the center of the area trending in E-W directon.

Although Factor 1 was most clearly extracted by factor analysis, this factor seems to be related to chemical feature of the alluvium deposites.

1-4 Area K

1-4-1 Geology and mineralization

(1) Survey area

The soil geochemical survey conducted over the various areas of utramafic rock distribution during Phase III suggested Area K to be one of potential area for nickel laterite. A semi-detail soil geochemical survey was, subsequently, conducted in the area.

The Area K is located at east of Ranau in the central part of Kinabalu Area. The main road connecting Ranau and Telupid runs in the middle of the area and Sungai Luhan flows eastward in the northern part of the area. The area has a slightly steep mountainous topography, especially in the area of ultra-basic rock. The highest peak reaches 1,300 m at the northwest corner of the area and a ridge of

approximately 700 m high runs E-W direction in the central part of the area. Flat plains occur in the northeastern part of the area along Sugai Luhan and in the southwestern part of the area. The area is mainly covered by secondary Jungle.

(2) Geology

Geology of Area K consists of ultra-basic rocks (Pr and Dn) of Cretaceous to Tertiary age, Crocker formation (P_2Cr) of Eocene to Oligocene and Terrace deposits. Geological map is shown in Fig. II-1-6.

The ultra-basic rocks, consisting of harzburgite (Pr) with intercalated layers of dunite (Dn), occur occupying central to western part of the area. The Crocker formation occurs in the southeastern part and southwestern corner of the area separated from ultra-basic rocks by faults. It consists of sandstone, mudstone and intercalation layers of both of them. The terrace deposits consisting of sand and gravel occupy the area along Sungai Luhan and southwestern part of the area.

(2) Mineralization

The area is covered by thick lateritic soil of dark brown to brown color and thickness of soil reaches more than a few meter. The lateritic soil mainly occur over the area of ultra-basic rock and the area of Crocker formation at the vicinity of ultra-basic rocks is partly covered by yellowish brown lateritic soil. The occurrences of saprolite, strongly weathered ultra-basic rocks, were recognized at two locations, center of the area and south of the area, and three samples were colected for assaying (Table II-1-4). The sample collected at southern part of area (N701) shows slightly low content of Ni 0.5 %. While, two samples collected at central part of the area (N715 and N716) show relatively high Ni contents of 1.50 % and 1.44 %.

1-4-2 Soil geochemical survey

(1) Sampling

A soil geochemical survey was conducetd in the Area K collecting 240 samples at 120 locations. Sample locations and sample list are, respectively, given in Fig. II-1-7 and Appendix 4. As a rule, two samples, at 50 cm deep and 150 cm, were collected at one location using hand auger. As shown in soil profiles of the sample list, B horizen, generally, develops to the depth much deeper than 150 cm. However, in rare cases C horizon was encountered at the depth shallower than 150 cm. In that

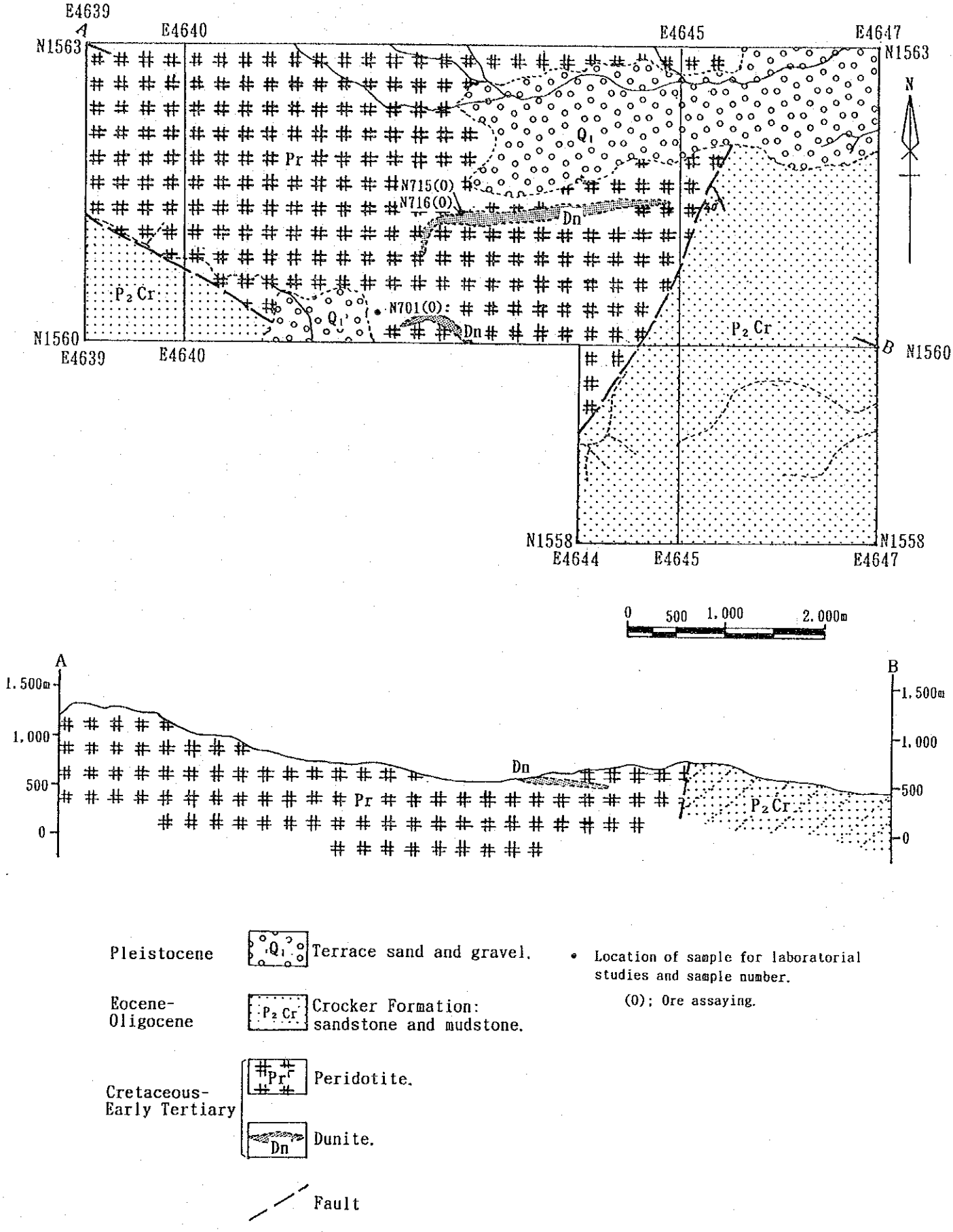
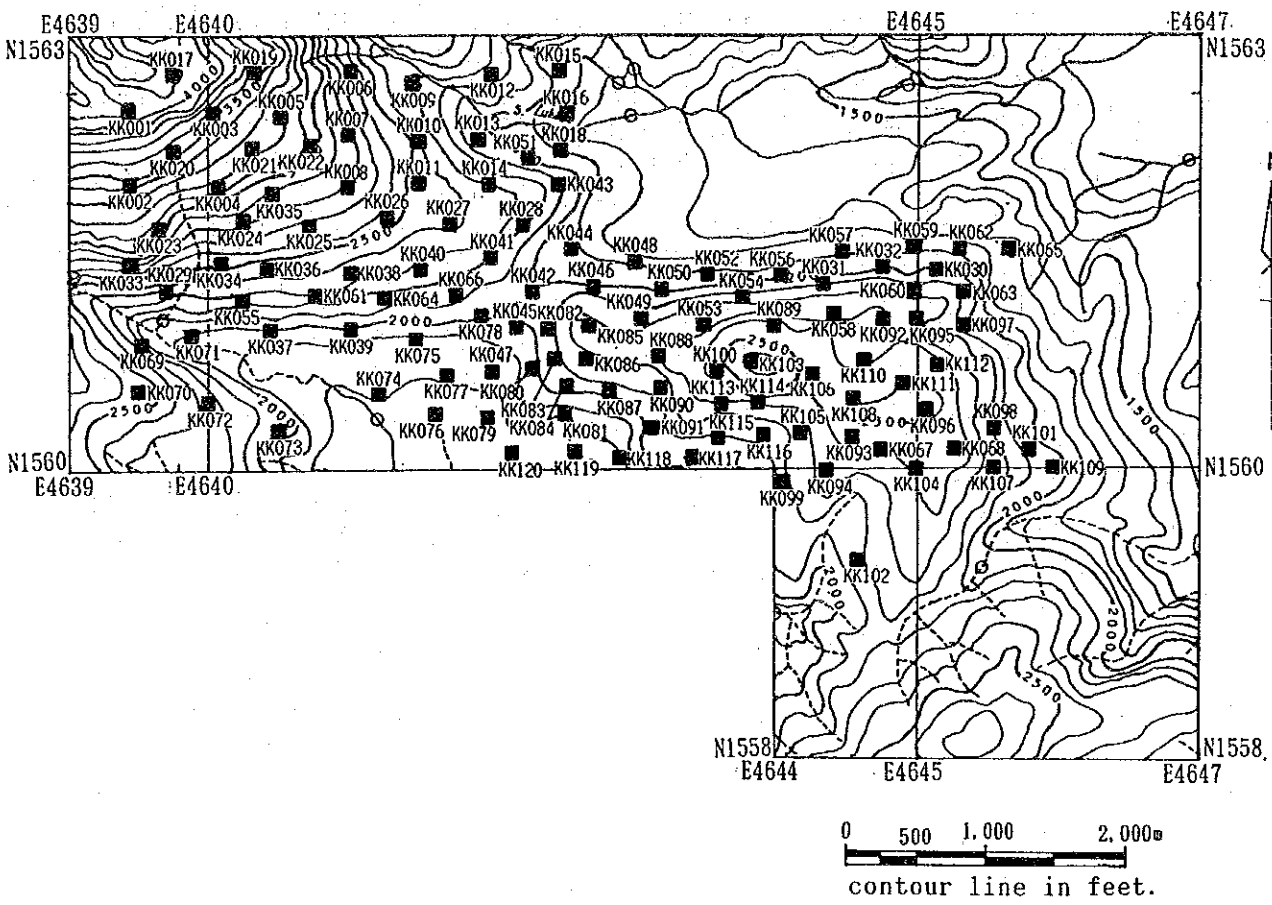


Fig. II-1-6 Geologic map and cross sections of Area K



■ Location of augering site and soil sample number at depth of 0.5 m, KK001 soil sample number at depth of 1.5 m is not shown.

○ Location of stream sediment samples collected in phase III.

Fig. II-1-7 Location map of geochemical samples in Area K

case, a sample was collected at the bottom of B horizon. After drying up these samples, -80 mesh fraction were prepared for chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 5. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-7.

Followings are chemical characteristics of the soil samples of Area K.

Al:The maximum values and averages of 50 cm deep samples and 150 cm deep samples are, respectively, 12.60 %, 7.49 % and 13.49 %, 6.73 %. The average Al of 150 cm deep samples is slightly lower than that of 50 cm. Al values tend to show a reverse relation with Ni. As Al increases, Ni decreases.

Co:Compared to the common Co values of ultra-basic rocks (approximately 100 ppm), the soil samples seem to be slightly enriched. The maximum values and averages of 50 cm deep samples and 150 cm deep samples are, respectively, 816 ppm, 216 ppm and 1,543 ppm, 225 ppm. A proportional relatoin is observed between Co and Ni values.

Cr:Compared to the common Cr values of ultrabasic rocks (approximately 3,000 ppm), the soil samples seem to be slightly enriched. The maximum values and averages of 50 cm deep samples and 150 cm deep samples are, respectively, 12,196 ppm, 5,481 ppm and 11,315 ppm, 4,842 ppm. The 150 cm deep samples tend to show lower values.

Fe:Both samples of 50 cm deep and 150 cm deep show a similar concentration. Compared to common ultra-basic rock, they show high concentration with maximum value and average of 47 % and 25 %.

Ni:Samples of 150 cm deep show higher concentration than those of 50 cm deep. The maximum values and averages are, respectively, 8,636 ppm and 2,564 ppm for 50 cm deep samples, 10,136 ppm and 2,627 ppm for 150 cm deep samples. Considering that normal content of Ni in olivine is commonly 3,000 to 4,000 ppm, the soil samples of Ni content more than 5,000 ppm were probably produced by Ni enrichment process through weathering. 12 samples of 50 cm deep samples and 20 samples of 150 cm deep samples show Ni content more than 5,000 ppm.

Typical cases of nickel laterite deposits show a vertical zonation consiting of residual lateritic soil on top, intermediate zone of altered peridotite with saprolite and garnierite, zone of fresh peridotite (Guilbert and Charles, 1985).

Table II-1-7 Statistics of soil geochemical survey in Area K

(50 Cm)

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
Al (%)	—	12.60	1.61	7.487	0.172	—	8.460	10.000	—
Co (ppm)	0.8	810	< 1	216.3	0.488	—	251.5	477.0	—
Cr (ppm)	—	12,196	43	5,480.9	0.476	—	7,645.0	9,180.0	—
Fe (%)	—	47.01	2.74	25.697	0.233	—	30.530	36.520	—
Ni (ppm)	—	8,636	10	2,564.0	0.484	—	3,346.5	4,429.0	—

*1: geometric mean *2: shown in logarithm *3: background value + 2 x standard deviation
*4: Exploratory Data Analysis (Kurzl H.,1988)

(150 Cm)

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
Al (%)	—	13.49	1.72	6.726	0.198	—	7.875	9.600	—
Co (ppm)	—	1,543	3	225.3	0.450	—	257.0	466.0	—
Cr (ppm)	—	11,315	25	4,842.1	0.493	—	7,098.5	8,515.0	—
Fe (%)	—	47.29	2.58	24.324	0.245	—	30.630	34.940	—
Ni (ppm)	—	10,136	7	2,627.4	0.504	—	3,534.5	4,565.0	—

*1: geometric mean *2: shown in logarithm *3: background value + 2 x standard deviation
*4: Exploratory Data Analysis (Kurzl H.,1988)

Ni, together with Co, concentrates at the intermediate zone, while Cr, Al and Fe concentrate in the upper zone of lateritic soil. Coinside with the typical case, Ni and Co are more enriched in 150 cm deep samples and Al and Cr are more enriched in 50 cm deep samples.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 6) using the values obtained by EDA method. Both samples of 50 cm deep and 150 cm deep show a similar distribution patterns for each element and they are summarized as follows.

Al: High value and anomalous zones occur over the area of ultra-basic rocks in the northwestern part and the area of Crocker formation in the east.

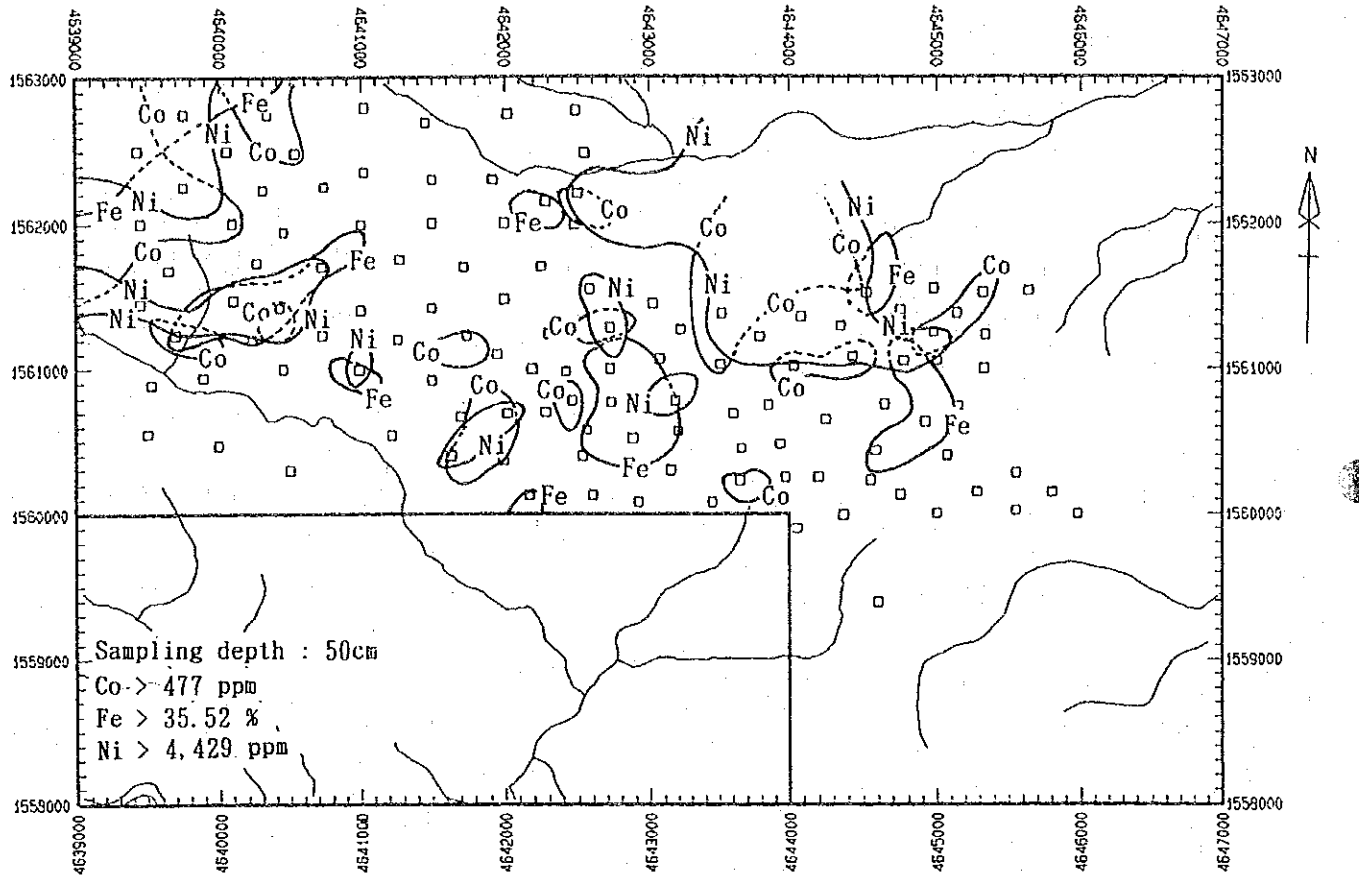
Co: Samples of anomalous value are scattered over the area of ultra-basic rocks and it does not show a clear distribution pattern.

Cr: A anomalous zone occurs at the center of ultra-basic rocks and samples of anomalous value occur western part and eastern edge of ultra-basic rocks.

Fe: Fe shows similar distribution pattern to Cr. High value and anomalous zones occur over the area of ultra-basic rock at the center, in northwestern part and eastern edge.

Ni: High value and anomalous zones cover the eastern half and western part of the ultra-basic rocks.

Anomaly maps of three elements, Co, Fe and Ni, were drawn for 50 cm deep samples and 150 cm deep samples(Fig. II-1-8). Both of the maps show a similar distribution pattern of anomalies. Co, Fe and Ni anomalies overlap each other at northeastern end of the ultra-basic rocks, close to terrace deposits, central part and western part of the area.



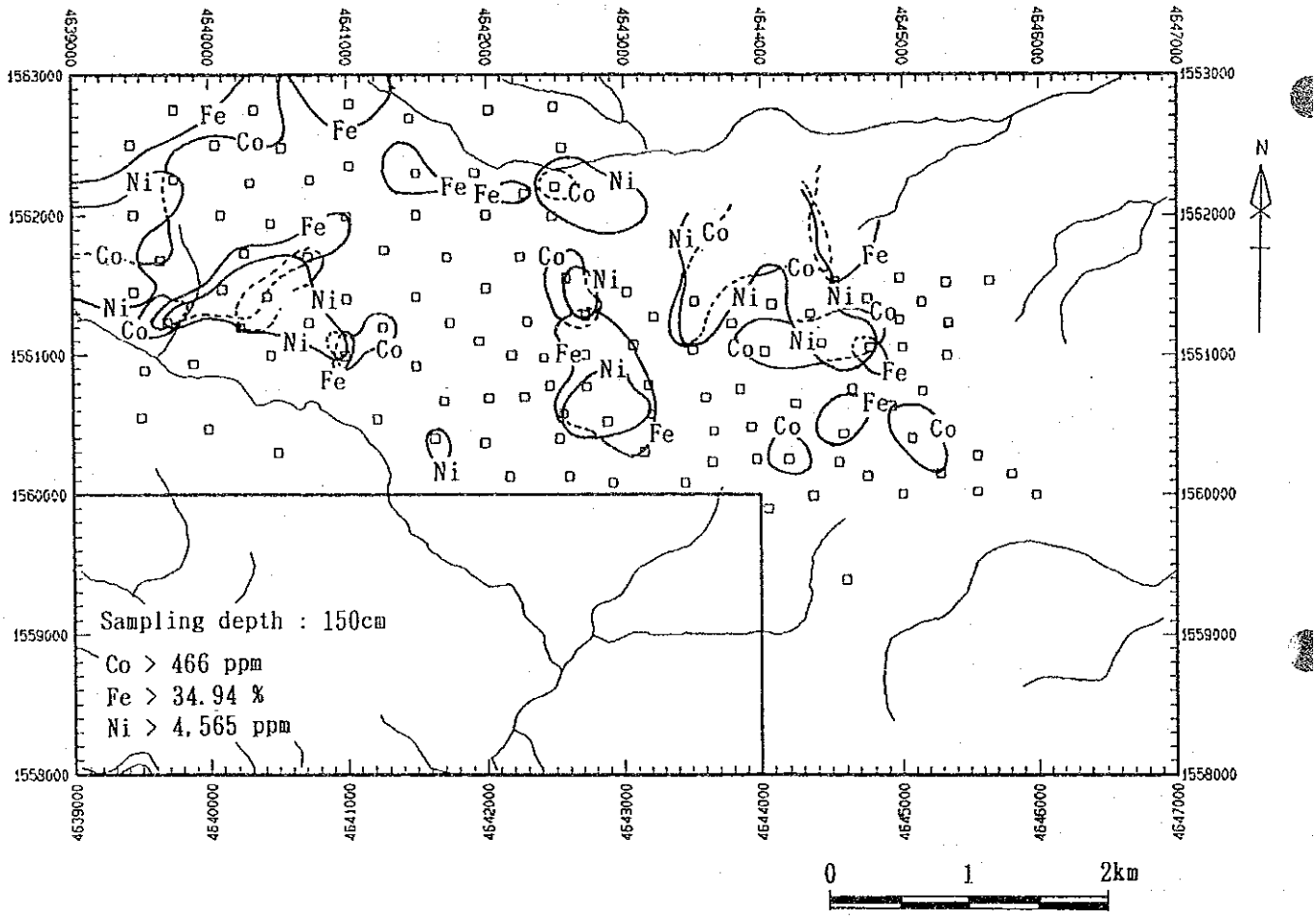


Fig. II-1-8 Distribution of geochemical anomalous zones in Area K

1-5 Area L

1-5-1 Geology and mineralization

(1) Survey area

Area L was selected as a potential area of titanium deposits by the finding of very high Ti samples at the upper stream of Sungai Karamuak during the regional geochemical survey in Phase III. A semi-detailed geochemical survey of stream sediments was conducted for Area L in this phase.

The area is located in the upper stream of Sungai Karamuak, at southern end of the Kinabalu area. A topography in the area is generally steep mountainous with a maximum altitude of approximately 700 m. Sungai Karamuak drains from west to east in the center of the area, and stream sediment samples were collected from the main stream of Sungai Karamuak and both its south and north tributaries. The survey was conducted establishing camp in the area.

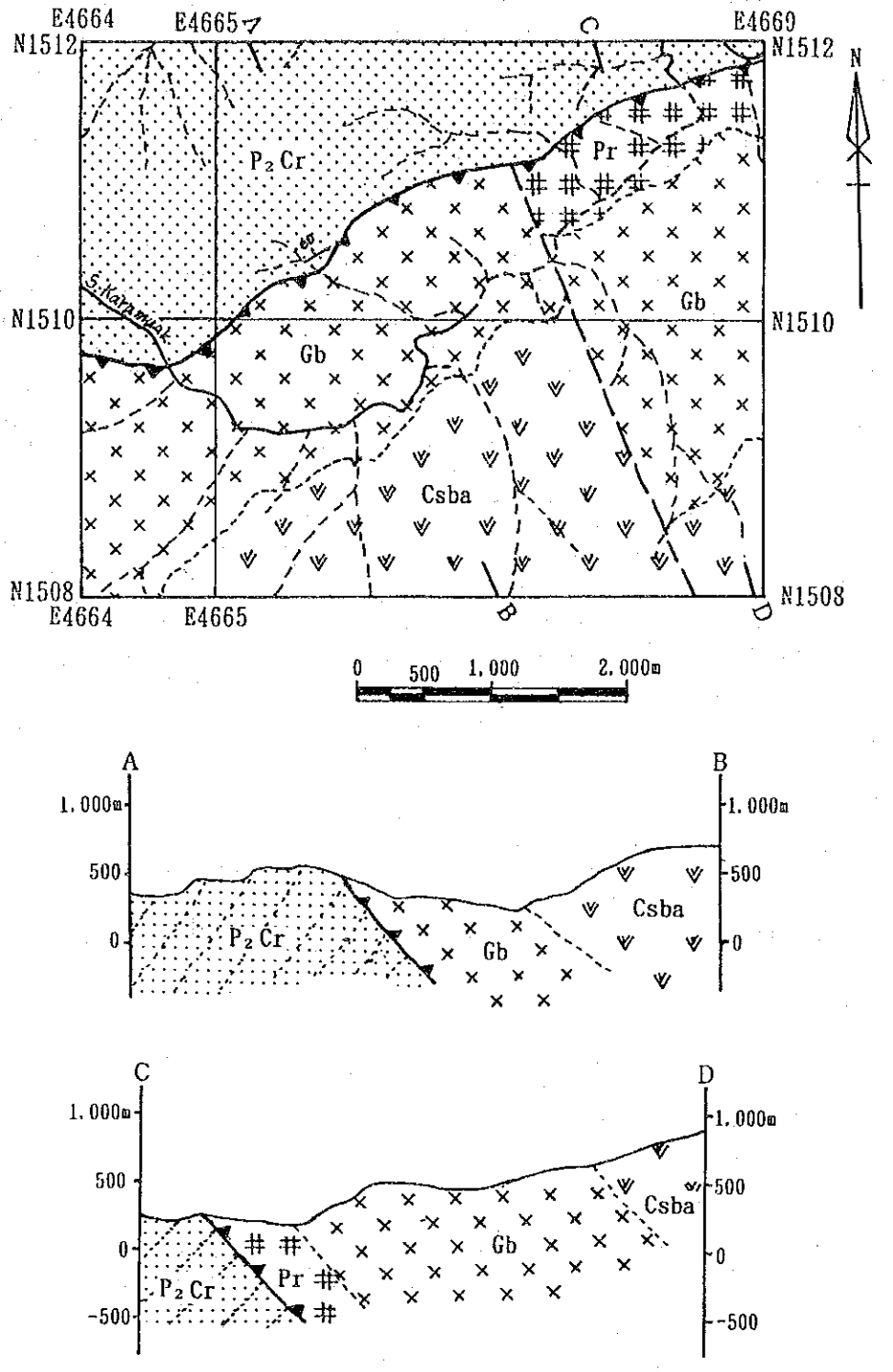
(2) Geology

Geology of Area L consists of peridotite (Pr) and gabbro (Gb) of Cretaceous to Tertiary age, basalt (Csba:Chert-spilite formation) of Cretaceous to Eocene and Crocker formation (P_2Cr) of Eocene to Oligocene age. The southern block consisting of peridotite, gabbro and basalt thrust up northward onto the Crocker formation. Geological map is shown in Fig. II-1-9.

Peridotite, gabbro and basalt, in ascending order, are constituents of the block south of thrust fault. Partly serpentinized, dark gray to dark greenish gray peridotite (Pr) occur along Sungai Karamuak in the northwestern part of the area. The gabbro (Gb), dark color, medium grain rock, is distributed on north facing slop in the eastern part of the area and along Sungai Karamuak in the center to western part of the area. It occationaly shows a layered structure. The basalt (CsBa) with around 50 cm across pillow structure occurs at relatively higher elevation on the slop south of Sungai Karamuak. It is a dark green rock with fine plagioclase and pyroxene phenocrysts. The Crocker formation (P_2Cr), consisting of sandstone and mudstone, occupies the northern and northwestern part of the area.

(2) Mineralization

No significant mineralization and alteration was found in the area except weak pyrite disseminations and chloritization in the basalt,



Eocene-Oligocene — P_2Cr — Crocker Formation: sandstone and mudstone.

Cretaceous-Eocene — Csba — Chert-Spilite Formation: basalt.

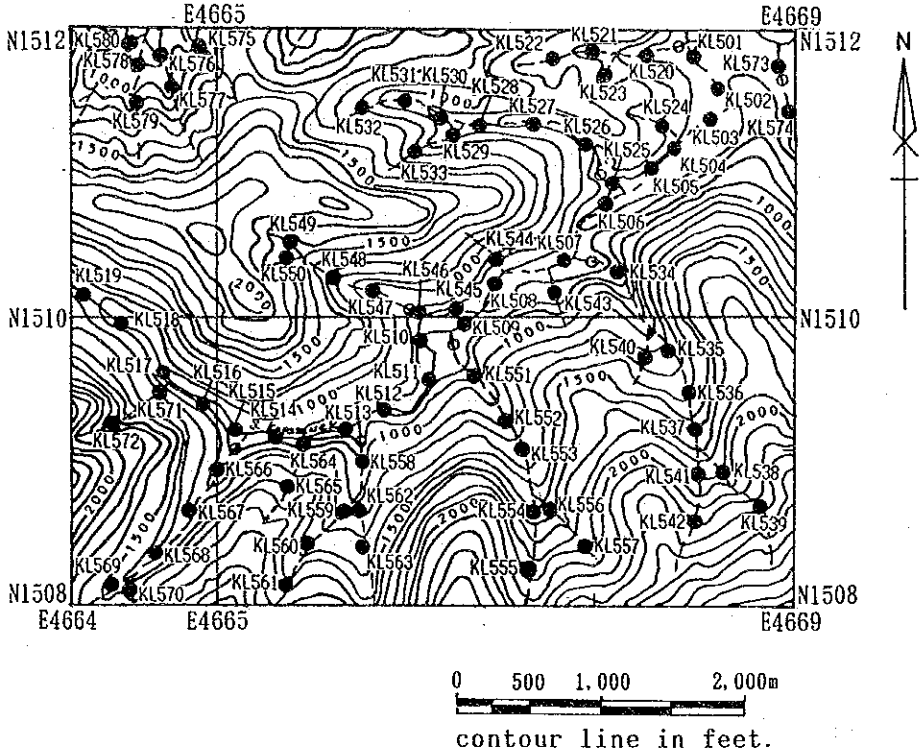
Cretaceous-Early Tertiary — Gb — Gabbro.

Cretaceous-Early Tertiary — Pr — Peridotite.

Thrust fault

Fault

Fig. II-1-9 Geologic map and cross sections of Area L



KL501 Location of stream sediment samples and sample number

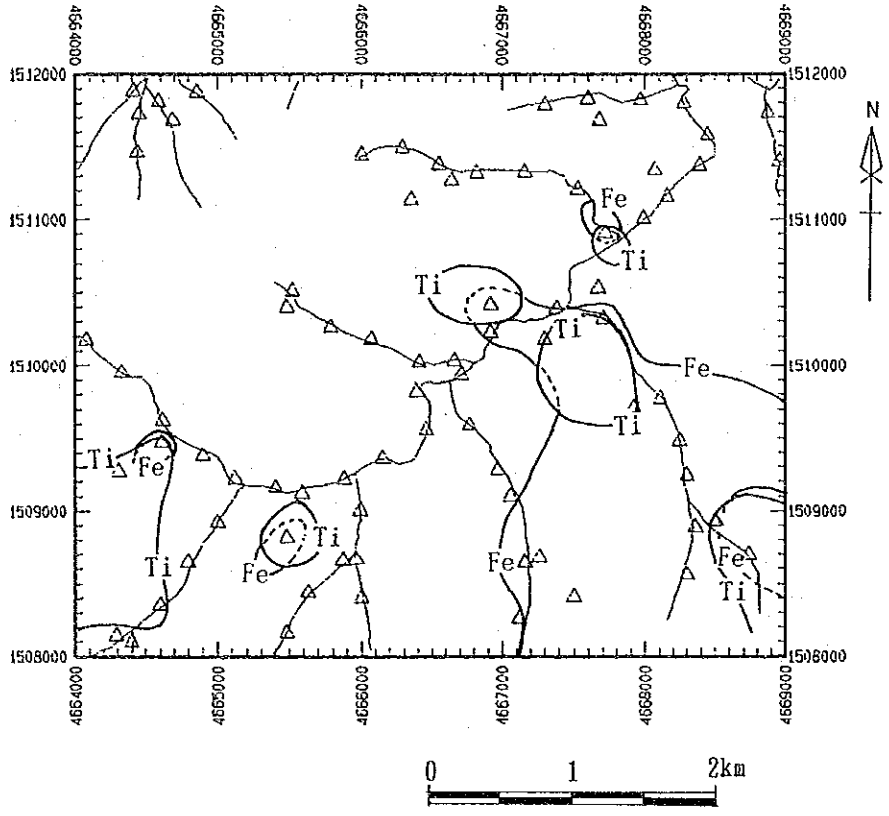
○ Location of stream sediment samples collected in phase III.

Fig. II-1-10 Location map of geochemical samples in Area L

Table II-1-8 Statistics of stream sediments geochemical survey in Area L

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
Fe (%)	—	17.13	0.84	4.377	0.344	—	4.359	10.210	—
Ti (%)	—	12.40	0.19	0.825	0.404	5.310	0.890	1.930	—

*1: geometric mean *2: shown in logarithm *3: background value + 2 x standard deviation
*4: Exploratory Data Analysis (Kurzl H.,1988)



Fe > 10.21 %

Ti > 1.93 %

Fig. II-1-11 Distribution of geochemical anomalous zones in area L

1-5-2 Stream sediment geochemical survey

(1) Sampling

A stream sediment geochemical survey was conducted in the Area L. Locations of collected samples and their list are, respectively, shown in Fig. II-1-10 and Appendix 7. After drying up, the samples were sent to chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 8. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-8.

Fe shows relatively high concentration with maximum value of 17.13 % and average 4.38 %. Although Ti concentration is high with maximum of 12.40 % and average 0.83 %, abnormally high values shown by the samples collected during the regional geochemical survey was not obtained. The samples collected in the area of the Crocker formation give low concentration of Fe and Ti. Disregarding these samples, Fe and Ti values of Area L are much higher than common values of mafic rocks. Fe and Ti show a good correlation with correlation coefficient of 0.829.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 9) using the values obtained by EDA method. Distribution of each element is summarized as follows;

Fe: The samples of anomalous value (more than Fe 10.21 %) are distributed in the area of gabbro and basalt in southeastern of the area and along Sungai Karamuak.

Ti: Distributions of the samples with anomalous value (more than Ti 1.93 %) are restricted in the area of gabbro.

An anomaly map of Fe and Ti shown in Fig. II-1-11. Anomalies of Fe and Ti overlap well and they occur in the area of gabbro along Sungai Karamuak and its southern tributaries.

High Fe and Ti in the area of gabbro and good correlation between Fe and Ti suggest a occurrence of ilmenite concentration within the gabbro of Area L.

1-6 Area M

1-6-1 Geology and mineralization

(1) Survey area

Considering the results of regional geochemical survey of Phase III and geological environment of the area, this area was selected as a potential area for porphyry copper deposits. A soil geochemical survey was conducted in this area.

Area M, occupying eastern part of the Kinabalu area and northern part of the Labuk area, is located in the lower stream area of Sungai Sugut. The Sungai Sugut flows meanderingly from southwest to northeast in the center of the area and many small tributaries flow into it from both sides. The topography in the area is generally gentle hill. The northeastern part of the area and both sides of Sungai Sugut are occupied by flat low lands with altitudes of 30 m to 100 m. While, western part of the area is occupied by a slightly steep topography of hilly to mountainous and the altitude reaches 500 m at the northwestern corner of the area. Small villages are scattered along Sungai Sugut and cultivation activities are found near the villages. The area is mostly covered by secondary forest.

(2) Geology

The area is covered by widespread Crocker formation (P_2Cr) of Eocene to Oligocene age and alluvium (Q_2) occurs along the main rivers. Geological map is given in Fig. II-1-12.

The Crocker formation (P_2Cr), consisting of mainly yellowish brown, massive sandstone and subordinate, laminated mudstone, covers a whole area except along the main streams. The formation generally stricks NW-SE and dips steeply toward southwest at 70° to 80°. Anticlines and synclines with NW-SE to E-W axes occur in the northern part of the area. The alluvium, consisting of sand and gravels, is distributed along Sungai Sugut and a part of its tributaries.

(2) Mineralization

No significant mineralization and alteration was found in Area M.

1-6-2 Soil geochemical survey

(1) Sampling

A soil geochemical survey was conducted in Area M. Locations of collected samples and their list are, respectively, shown in Fig. II-1-13 and Appendix 10. After drying up these samples, -80 mesh fractions were prepared for chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 11. These analytical results were

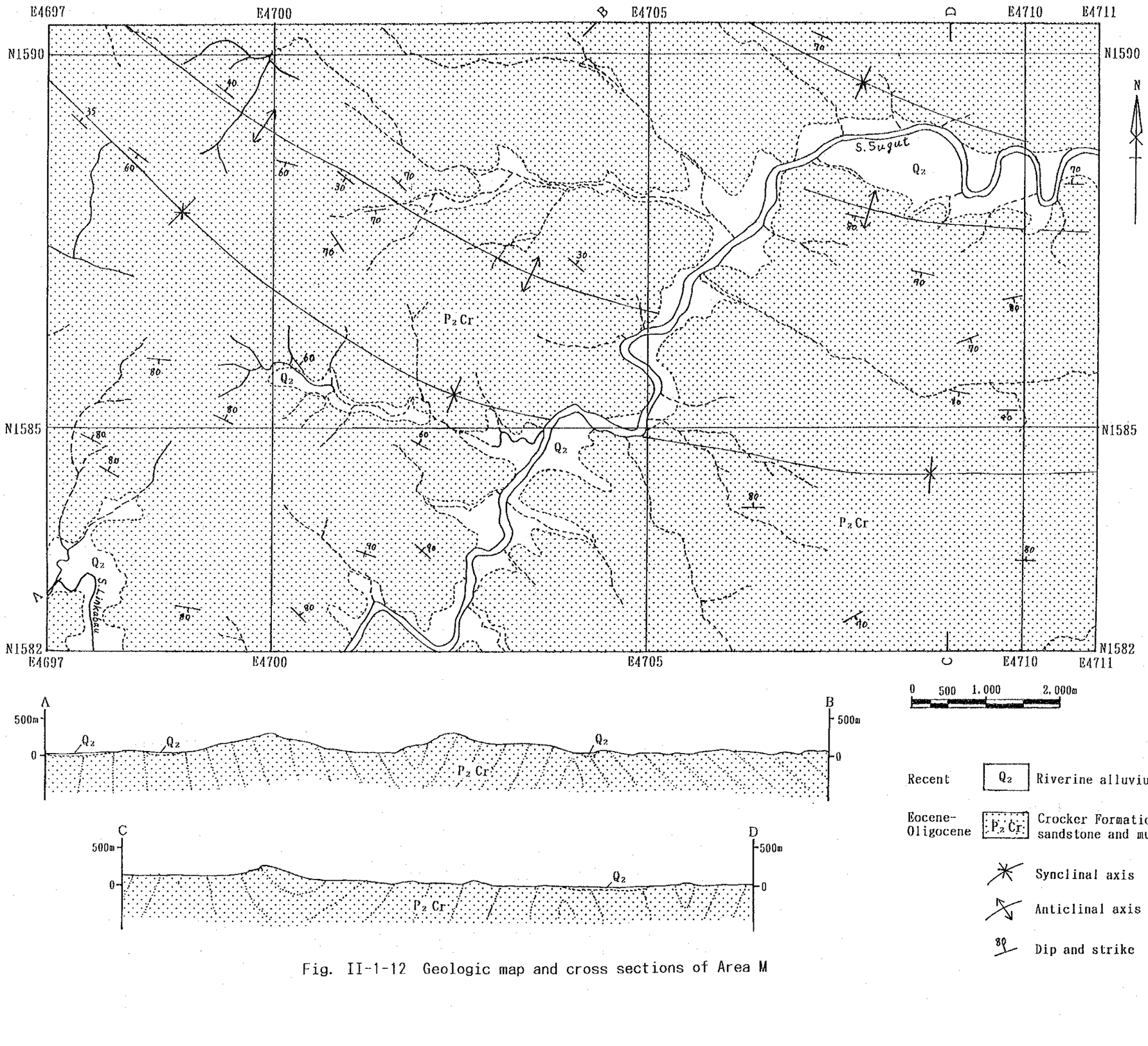
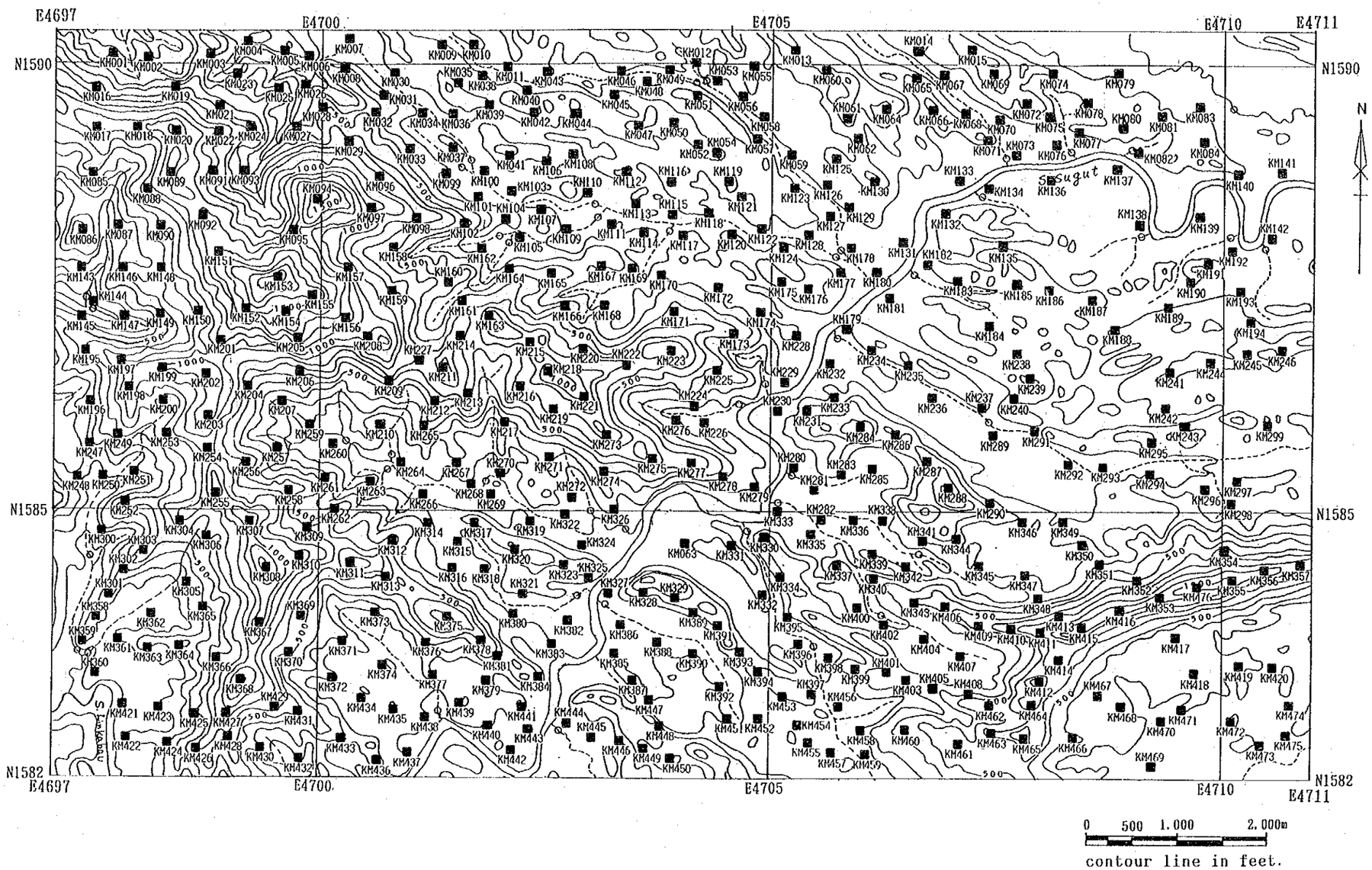


Fig. II-1-12 Geologic map and cross sections of Area M



KM001 Location of soil samples and sample number.

○ Location of stream sediment samples collected in phase III.

Fig. II-1-13 Location map of geochemical samples in Area M

input to a computer and statistical figures were obtained. The results of these are given in Table II-1-9.

The statistical figures of Area M show following tendencies comparing with other areas of similar giological environment.

Element indicating higher value: Ba.

Element indicating lower value : As, Co, Cr, Cu, Hg, Mg, Ni.

The above tendencies coincides with facts that sandstone and mudstone cover the entire area and no significant alteration and mineralization zone exists in the area. The maximum values of Au and Cu, respectively, 57 ppb and 498 ppm, are high. Concentration of W is low showing values lower than detection limit for nearly whole samples. In order to clarify relationships between the elements, correlation coefficients were also calculated. The results show following pairs of elements to be comparatively good (correlation coefficient: more than 0.600) correlations.

Ba-K, Ba-Na, Ba-Sr, Co-Mg, Co-Mn, Co-Ni, Co-Zn, Cr-Ni, Cu-Mg, Cu-Mn, Cu-Ni, Cu-Zn, K-Mg, K-Na, K-Sr, K-Zn, Mg-Mn, Mg-Na, Mg-Ni, Mg-Sr, Mg-Zn, Mn-Na, Mn-Ni, Mn-Zn, Na-Sr, Na-Zn, Ni-Zn, Sr-Zn

The elements such as Co, Cu, K, Mn, Na, Ni and Zn show good correlations each other. Au and Cu show a fairly good correlation with correlation coefficient of 0.517.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 12) using the values obtained by EDA method. Distributions of each element are summarized as follows;

As: Characteristic distribution pattern is not clearly observed. High value zones tend to align in E-W trend in the central area.

Au: A high value zone is distributed over the lower stream of Sungai Karamuak in the northeastern part of the area. Other than this, samples of high value are scattered in the western and eastern part of the area.

Ba: High value and anomalous zones are distributed both side of Sungai Sugut in the eastern and western parts of the area.

Co: Characteristic distribution pattern is not clearly observed. Samples of high and anomalous values tend to be distributed along Sungai Sugut, especially in its lower stream area.

Cr: Samples of high and anomalous values are distributed in the eastern part of the area, along Sungai Sugut and its tributaries of eastern side.

Cu: An anomalous zone occurs covering the area of Alluvium along the lower stream of

Table II-1-9 Statistics of soil geochemical survey in Area M

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	27.1	43	< 1	2.9	0.548	36.1	4.0	9.0	—
Au (ppb)	85.3	57	< 1	0.6	0.298	2.5	0.5	0.5	0.5
Ba (ppm)	—	1,469	35	158.2	0.285	588.8	140.5	259.0	762.4
Co (ppm)	20.0	27	< 1	2.3	0.425	16.1	2.0	5.0	—
Cr (ppm)	—	447	20	52.7	0.234	154.9	47.0	74.0	163.8
Cu (ppm)	—	498	2	10.7	0.341	51.4	10.0	16.0	47.1
Hg (ppb)	—	400	15	59.0	0.198	146.6	59.0	82.0	172.5
K (%)	—	2.13	0.10	0.519	0.244	1.598	0.525	0.870	—
Mg (%)	—	3.01	0.06	0.249	0.253	0.799	0.240	0.380	0.893
Mn (ppm)	—	1,651	12	53.4	0.396	330.5	41.5	102.0	281.7
Mo (ppm)	59.7	6	< 1	0.8	0.259	2.5	0.5	1.0	2.8
Na (%)	—	1.27	0.02	0.100	0.277	0.358	0.100	0.170	0.499
Ni (ppm)	—	269	5	17.0	0.327	76.5	14.0	30.0	89.2
Pb (ppm)	2.3	173	< 2	10.9	0.284	40.4	12.0	18.0	45.3
S (%)	—	0.105	0.007	0.013	0.148	0.026	0.013	0.017	0.028
Sb (ppm)	32.1	14.3	< 0.2	0.75	0.667	—	1.40	3.00	—
Sr (ppm)	—	114	8	26.6	0.165	56.9	27.0	36.0	75.4
Ti (%)	—	0.52	0.17	0.290	0.074	0.408	0.290	0.330	0.437
U (ppm)	—	3.0	1.4	2.14	0.059	2.82	2.20	2.40	—
W (ppm)	97.3	5	< 2	1.0	0.068	1.4	1.0	1.0	1.0
Zn (ppm)	—	114	8	27.0	0.201	68.2	26.0	40.0	93.1

*1: geometric mean *2: shown in logarithm *3: background value + 2 x standard deviation
*4: Exploratory Data Analysis (Kurzl H.,1988)

Sungai Sugut. Other than this, samples of high and anomalous values are scattered over the tributary of Sungai Sugut in the northeastern part of the area.

Hg: High value and anomalous zones are distributed along the lower stream of Sungai Sugut. Other than this, small high value zones are scattered over the area.

K : High value and anomalous zones are scattered over the area and no characteristic distribution feature is observed.

Mg: High value and anomalous zones are distributed along the lower stream of Sungai Sugut. Other than this, small high value zones are scattered over the area.

Mn: Similar to Hg and Mg, high value and anomalous zones occur covering the alluvium along the lower stream of Sungai Sugut. Other than this, small high value and anomalous zones scattred in the area.

Mo: Samples of anomalous value occur along the lower stream of Sungai Sugut. The absolute value is low.

Na: High value and anomalous zones are distributed along the lower stream of Sungai Sugut and western part of the area.

Ni: Zones of high value and anomaly cover the area of the alluvium along the lower stream of Sungai Sugut. Along the both sides of its tributaries, small high value zones are scattered.

Pb: High value and anomalous zones are mainly distributed in the southern part of the area aligned in E-W trend. A high value zone occurs along the lower strem of Sungai Sugut.

S : Similar to Ni, zones of high value and anomaly cover the area of the alluvium along the lower stream of Sungai Sugut. Samples of high value and anomaly are distributed along the tributary areas.

Sb: Samples of high value and anomaly mainly occur along the Sungai Sugut and the rest of them are scattered over the area. Concentration of Sb in Area M is low.

Sr: High concentration zones are distributed in the western and northeastern parts of the area.

Ti: Samples of high value and anomaly are scattered over the area and it does not show a characteristic distribution feature.

U : Although it is not clear, high value and anomalous zones tend to occur in the southern part of the area.

W : Maximum value is 5 ppm and almost all samples show values below the detection limit.

Zn: High value zones are scattered over the area and no characteristic distribution pattern is observed.

Considering the distribution maps and geological environment of the area, the

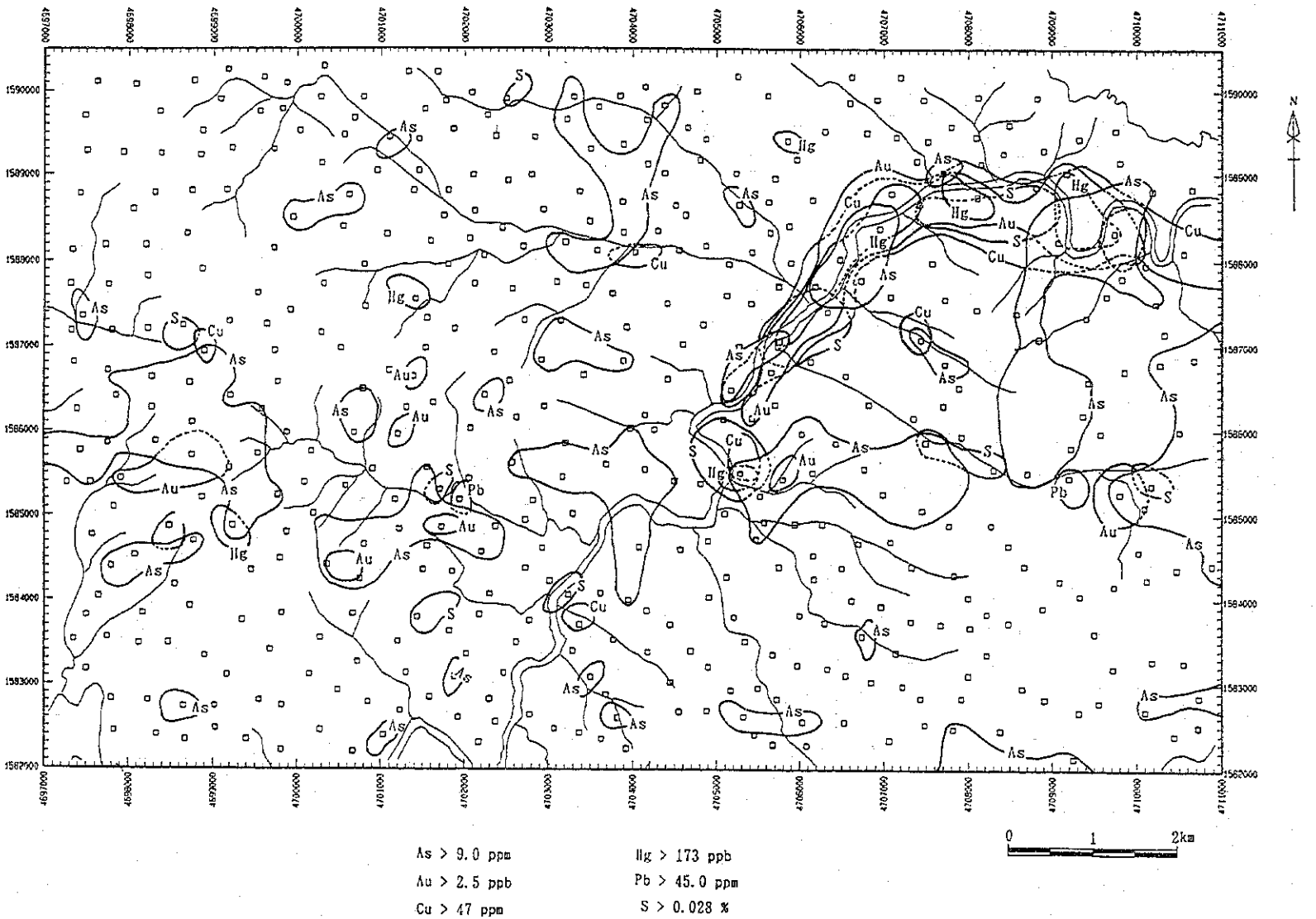


Fig. II-1-14 Distribution of geochemical anomalous zones in Area M

elements, which are possibly useful for investigating the area, were choosen and an anomaly map for these elements was prepared (Fig. II-1-14). The area of alluvium along the lower stream of Sungai Sugut is clarely covered by anomalies of As, Au, Cu, Hg, Pb, S, and small scale anomalies are scattered over Area M.

(4) Multi element analysis

Factor analysis was examined as a multi element analysis in this survey. The results of facter analysis are given in Table II-1-10. Following relationships between elements and factors were extracted by the factor analysis.

Factor 1 : Ba-Co-K-Mg-Mn-Na-Sr-Zn
Factor 2 : Cr-Ni
Factor 3 : Ti-U
Factor 4 : As
Factor 5 : Cu-Mo
Factor 6 : Hg-S
Factor 7 : (Pb)
Factor 8 : Au

Factor 1, showing relations with many elements, is probably reflecting a nature of provenance of the sedimentary rock. All the elements related to Factor 2, 4 and 8 show low concentration in Area M. Factor 7 is not clear the relationship. Among these factors, three factors, Factor 1, 5 and 6, were selected and a distribution map of factor scores was prepared allocating three different colors for each factor (Fig. II-1-15). Three factors are shown by following colors.

Factor 1 : yellow Factor 5 : blue Factor 6 : red

Distribution tendencies of these factors are summarized as follows;

Factor 1: Zones of high factor score are scattered over western part of the area and no characteristic distribution feature is observed.

Factor 5: High factor score zones clearly cover the alluvium along the lower stream of Sungai Sugut.

Factor 6: Similar to Factor 5, high factor score zones occur covering the alluvium along the lower stream of Sungai Sugut. In addition to them, samples of slightly high factor score are scattered in the southern part of the area.

Although Factor 5 and Factor 6 are related to the elements reflecting mineralization, such as Cu-Mo and Hg-S, zones of high factor score occur covering the alluvium along the lower stream of Sungai Sugut. These factors seem to reflect chemical nature of alluvium deposits.

Table II-1-10 Results of factor analyses for soil samples in Area M

Element	Factor loading (Varimax rotation)								Commu-nality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Factor 8	
As	0.084	-0.127	0.014	-0.510	-0.030	-0.041	0.017	-0.074	0.2919
Au	0.156	-0.194	-0.009	-0.149	-0.161	-0.273	0.086	-0.560	0.5054
Ba	0.721	-0.004	0.140	-0.383	0.186	-0.083	-0.122	0.009	0.7429
Co	0.597	-0.390	-0.020	0.231	-0.176	-0.161	0.306	-0.050	0.7155
Cr	0.156	-0.793	0.185	-0.332	-0.129	-0.234	0.037	-0.116	0.8843
Cu	0.458	-0.406	0.045	-0.136	-0.542	-0.135	0.129	-0.391	0.8764
Hg	0.107	-0.221	-0.151	0.004	-0.067	-0.542	-0.078	-0.246	0.4481
K	0.838	-0.112	0.314	0.009	-0.108	0.005	0.098	-0.114	0.8476
Mg	0.646	-0.288	0.225	-0.042	-0.465	-0.157	0.146	-0.294	0.9016
Mn	0.622	-0.374	-0.126	0.140	-0.176	-0.320	0.257	-0.116	0.7754
Mo	0.060	-0.092	0.025	-0.063	-0.543	-0.279	0.057	-0.079	0.3988
Na	0.795	-0.236	0.241	-0.120	0.048	-0.208	0.008	-0.062	0.8100
Ni	0.358	-0.787	0.055	-0.139	-0.145	-0.211	0.178	-0.180	0.8990
Pb	0.164	-0.297	0.314	-0.192	-0.123	-0.020	0.460	-0.138	0.4966
S	0.144	-0.334	-0.089	-0.094	0.002	-0.586	0.138	-0.079	0.5172
Sb	0.139	-0.105	0.022	-0.379	-0.185	-0.312	0.239	-0.020	0.3634
Sr	0.813	-0.056	0.094	-0.247	-0.184	0.044	0.033	-0.066	0.7749
Ti	0.368	-0.067	0.600	0.052	-0.249	-0.001	-0.082	0.061	0.5749
U	0.165	-0.041	0.678	-0.059	0.078	0.066	0.122	-0.013	0.5168
W	-0.005	0.018	0.052	-0.041	-0.130	-0.349	0.001	-0.009	0.1436
Zn	0.649	-0.313	0.345	-0.114	-0.275	-0.099	0.313	-0.160	0.8607
F.C.*1	35.5 %	17.2 %	10.2 %	7.0 %	9.2 %	10.1 %	5.1 %	5.7 %	—

*1: Factor contribution

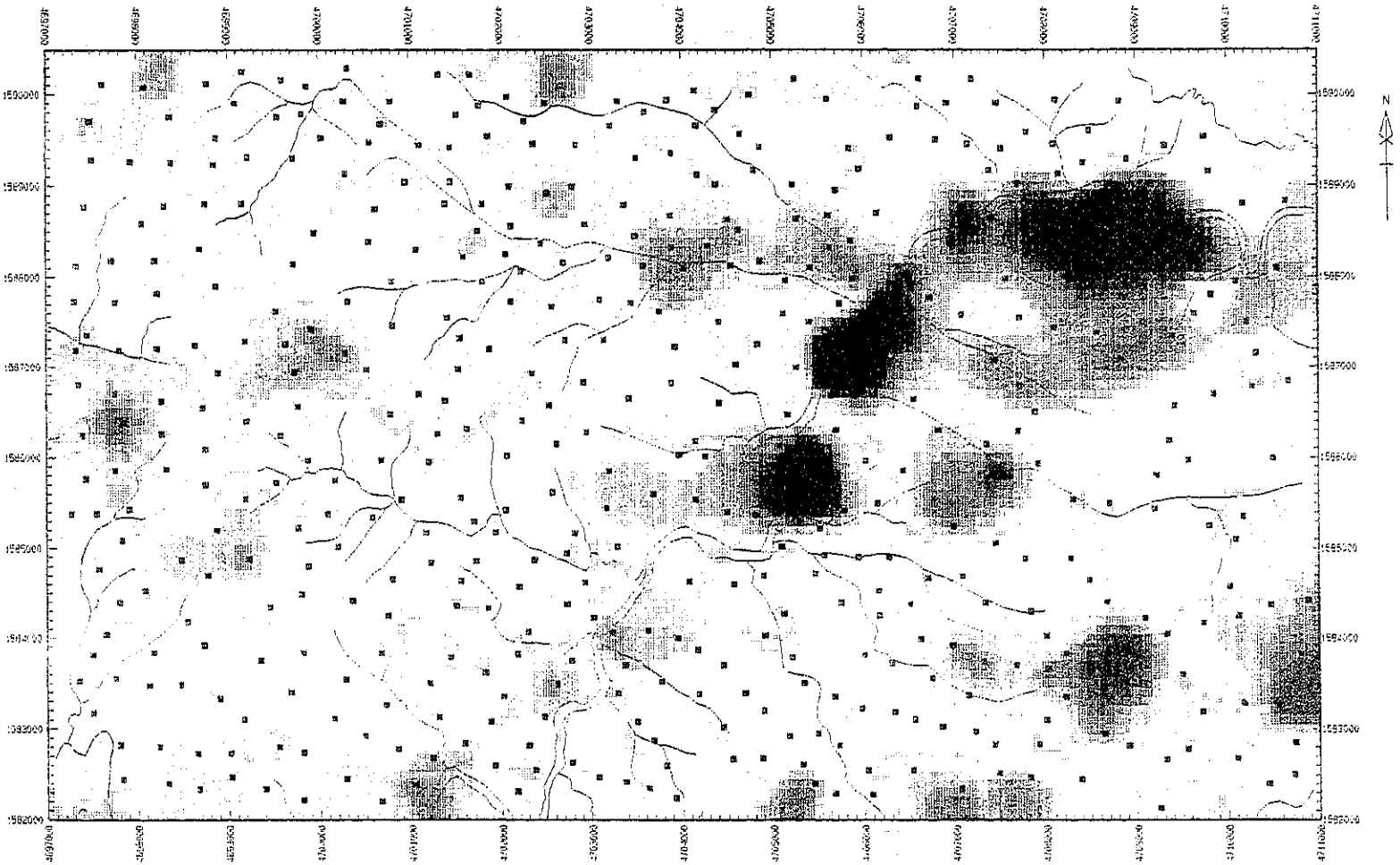


Fig. II-1-15 Distribution of factor scores in Area M

1-7 Area N

1-7-1 Geology and mineralization

(1) Survey area

The soil geochemical survey conducted over the areas of utra-basic rocks during Phase III suggested Area N to be one of potential area for nickel laterite. A semi-detailed soil geochemical survey was, subsequently, conducted in the area.

Area N is located at west of Telupid in the central part of the Labuk area. The area, generally, is occupied by a gentle hilly topography with an altitude approximately 100m. Two mountain ridges consisting of ultra-basic rocks, one in the central part of the area and the other in the southeastern part of the area, run in a NE-SW directin and the maximum elevation reaches upto 450 m. Three river systems, Sungai Tapang, Sungai Telupid and Sungai Mailo, flow from southwest to northeast in the area. All of them are tributaries of Sungai Labuk. The main road connecting Ranau and Telupid runs along Sungai Telupid in the western part of the area. The area is, generally, covered by secondary forest.

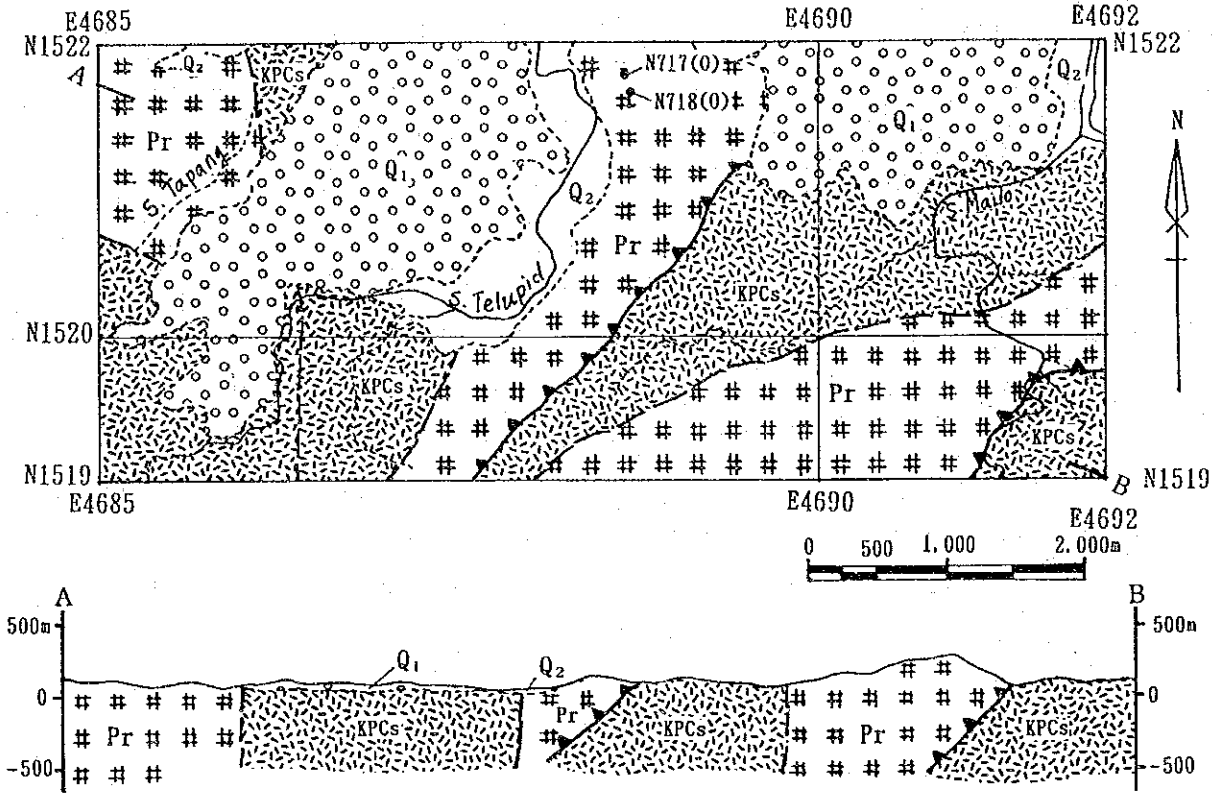
(2) Geology

Geology of Area N consists of Peridotite (Pr) of Cretaceous to Tertiary age, Chert-Spilite formation (PKCs) of Cretaceous to Eocene, Terrace deposits (Q_1) and Alluvium (Q_2). Geological map is shown in Fig. II-1-16.

Three separete bodies of Peridotite (Pr) in the northwestern, central and southeastern parts of the area occur in the area and they consist of harzburgite and serpentinite. The Chert-spilite formation (PKCs) occupies the flat lowland separated from Peridotite by fault and thrust fault. The formation includes closely associated chert, basalt and dolerite. Because of a poor exposure of these rocks in the area, they are included in one unit. The flat areas in the northwestern and northeastern parts of the area is covered by Terrace deposits (Q_1) consisting of sand and gravels. The Alluvium (Q_2) is distributed along Sungai Telupid.

(2) Mineralization

The area is covered by thick lateritic soil of dark brown to brown color and thickness of soil reaches more than several meters. The lateritic soil mainly occurs over the area of Peridotite and it partly extents to the area of Chert-Spilite formation. Two samples of strongly weathered peridotite were collected in the northern part of the area for assaying. The assay results show relatively high



Recent — Q_2 — Riverine alluvium.

Pleistocene — Q_1 — Terrace sand and gravel.

Cretaceous-Eocene — KPCs — Chert-Spilite Formation: chert, basalt and dolerite.

Cretaceous-Early Tertiary — Pr — Peridotite.

Thrust fault

Fault

• Location of sample for laboratorial studies and sample number.

(0); Ore assaying.

Fig. II-1-16 Geologic map and cross sections of Area N

Ni contents of 0.80 % and 1.32 % (Table II-1-4).

1-7-2 Soil geochemical survey

(1) Sampling

A soil geochemical survey was conducetd in the Area N collecting 170 samples at 85 locations. Sample locations and sample list are, respectively, given in Fig. II-1-17 and Appendix 13. As a rule, two samples, at 50 cm deep and 150 cm, were collected at one location using hand auger. As shown in soil profiles of the sample list, B horizen, generally, develops to the depth much deeper than 150 cm. However, in rare cases C horizon was encountered at the depth shallower than 150 cm. In that case, a sample was collected at the bottom of B horizon. After drying up these samples, -80 mesh fractions were prepared for the chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 14. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-11.

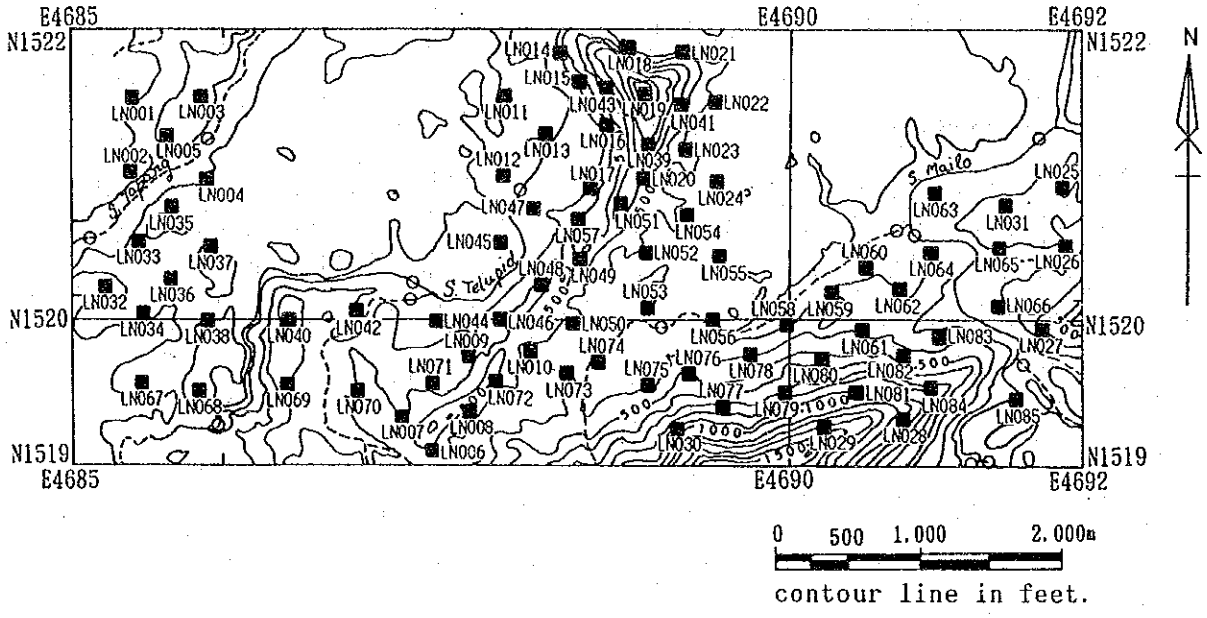
The chemical characteristics of the soil samples in Area N area summarized as follows.

Al: The maximum values and averages of 50 cm deep samples and 150 cm deep samples are, respectively, 17.27 %, 6.92 % and 18.72 %, 7.13 %. The Al content of 150 cm deep samples is slightly higher than that of 50 cm. Al is significantly depleted in the samples with high Ni content. Al contents of the samples with Ni more than 5,000 ppm range from 1.00 % to 4.00 %.

Co: Compared to the common Co values of ultra-basic rocks (approximately 100 ppm), the soil samples of Area N are enriched in Co. The maximum values and averages of 50 cm deep samples and 150 cm deep samples are, respectively, 1,046 ppm, 114 ppm and 997 ppm, 133 ppm. A proportional relatoin is observed between Co and Ni values.

Cr: Compared to the common Cr values of ultrabasic rocks (approximately 3,000 ppm), some of the soil samples of Area N are enriched in Cr. The maximum values and averages of 50 cm deep samples and 150 cm deep samples are, respectively, 13,357 ppm, 2,110 ppm and 11,876 ppm, 1,981 ppm. The 150 cm deep samples tend to show lower values.

Fe: Both samples of 50 cm deep and 150 cm deep show a similar concentration tendencies. Compared to common ultra-basic rock, they show higher concentration. The maximum values and averages of 50 cm deep samples and



LN001 Location of augering site and soil sample number at depth of 0.5 m, soil sample number at depth of 1.5 m is not shown.

° Location of stream sediment samples collected in phase III.

Fig. II-1-17 Location map of geochemical samples in Area N

Table II-1-11 Statistics of soil geochemical survey in Area N

(50 Cm)

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
Al (%)	—	17.27	0.84	6.916	0.289	—	7.970	12.900	—
Co (ppm)	—	1,046	5	113.5	0.608	—	131.0	477.0	—
Cr (ppm)	—	13,357	50	2,110.2	0.673	—	3,677.0	8,280.0	—
Fe (%)	—	46.17	2.70	19.020	0.274	—	18.730	38.270	—
Ni (ppm)	—	13,114	11	885.9	0.823	—	1,709.0	5,835.0	—

*1: geometric mean *2: shown in logarithm *3: background value + 2 x standard deviation
*4: Exploratory Data Analysis (Kurzl H.,1988)

(150 Cm)

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
Al (%)	—	18.72	1.07	7.125	0.299	—	8.600	13.520	—
Co (ppm)	—	997	6	133.4	0.588	—	200.0	515.0	—
Cr (ppm)	—	11,876	40	1,980.9	0.692	—	3,861.0	8,097.0	—
Fe (%)	—	43.29	3.07	19.266	0.252	—	19.700	35.730	—
Ni (ppm)	—	14,497	14	1,035.1	0.838	—	2,178.0	6,120.0	—

*1: geometric mean *2: shown in logarithm *3: background value + 2 x standard deviation
*4: Exploratory Data Analysis (Kurzl H.,1988)

150 cm deep samples are, respectively, 46.17 %, 19.02 % and 43.29 % and 19.27 %.

Ni:Samples of 150 cm deep show slightly higher concentration than those of 50 cm deep. The maximum values and averages are, respectively, 13,114 ppm and 886 ppm for 50 cm deep samples, 14,497 ppm and 1,035 ppm for 150 cm deep samples. Considering that normal content of Ni in olivine is commonly 3,000 to 4,000 ppm, the soil samples of Ni content more than 5,000 ppm are probably produced by Ni enrichment process through weathering. 17 samples of 50 cm deep samples and 21 samples of 150 cm deep samples show Ni content more than 5,000 ppm. These numbers higher than those of Area K.

Typical cases of nickel laterite deposits show a vertical zonation consiting of residual lateritic soil on top, intermediate zone of altered peridotite with saprolite and garnierite, zone of fresh peridotite (Guilbert and Charles, 1985). Ni, together with Co, concentrates at the intermediate zone, while Cr, Al and Fe concentrate in the upper zone of lateritic soil. Coinside with this, Ni and Co are more enriched in 150 cm deep samples and Cr is more enriched in 50 cm deep samples.

Compared with the results of Area K, the maximum values of Cr and Ni are higher and averages of those are lower in Area N. The samples collected in the area of Chert-Spilite formation show lower values of Cr, Fe, Ni, even if they show dark brown color similar to the soil samples of the Peridotite area. These samples lower the average value of Cr, Fe and Ni in Area N.

(3) Single element analysis

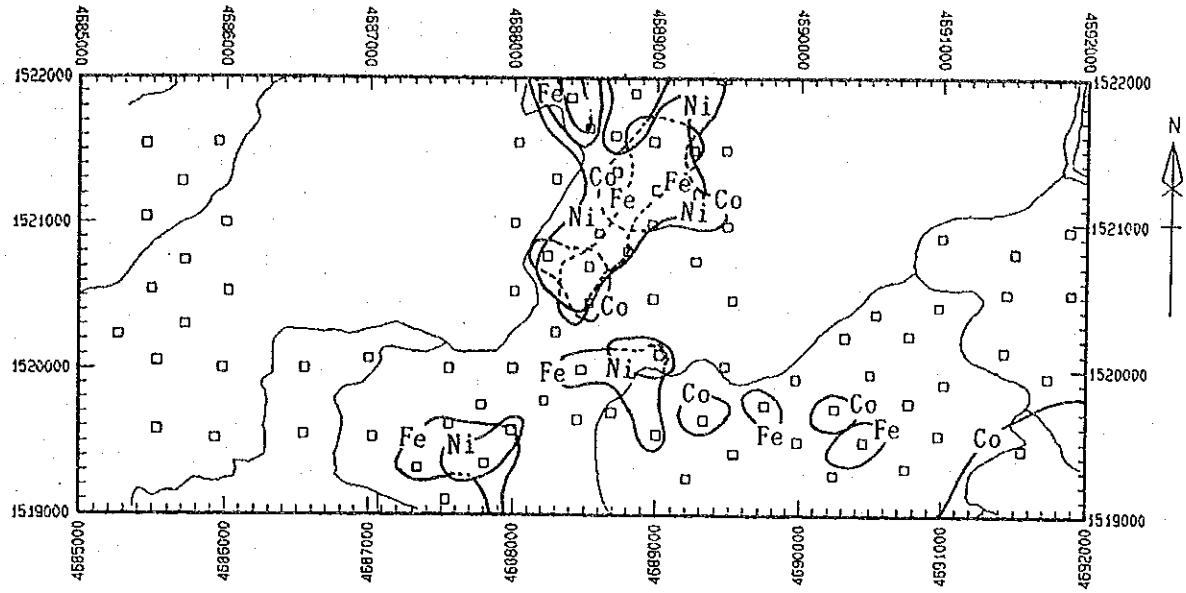
Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 15) using the values obtained by EDA method. Both samples of 50 cm deep and 150 cm deep show a similar distribution patterns for each element and they are summarized as follows.

Al: High value and anomalous zones occur over the area of Chert-Spilite formation in the southern part of the area.

Co: High value and anomalous zones occur at the north end of the Peridotite body in the center of the area. Samples of high and anomalous values are scattered over the Peridotite body in the southwest of the area.

Cr: High value and anomalous zones cover the Peridotite bodies in the center and southwest of the area.

Fe: Similar to Cr distribution, high value and anomalous zones are distrubuted over the Peridotite bodies in the center and southwest of the area.

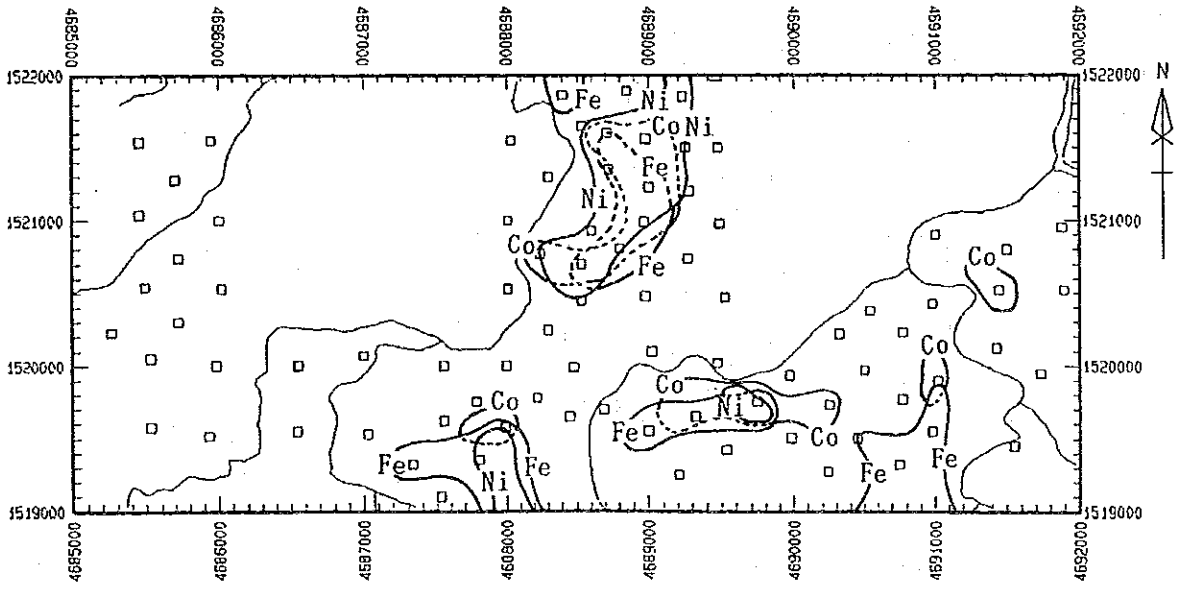


Sampling depth : 50cm

Co > 477 ppm

Fe > 38.27 %

Ni > 5,835 ppm



Sampling depth : 150cm

Co > 515 ppm

Fe > 35.73 %

Ni > 6,120 ppm

Fig. II-1-18 Distribution of geochemical anomalous zones in Area N

Ni: An anomalous zone occurs at the north end of the Peridotite body in the center of the area. High value samples are distributed over the center body and southeast body of Peridotite.

Anomaly maps of three elements, Co, Fe and Ni, were drawn for 50 cm deep samples and 150 cm deep samples (Fig. II-1-18). Both of the maps show a similar distribution pattern of anomalies. Co, Fe and Ni anomalies overlap each other at the north end of the Peridotite boby in the center of the area. Other than this, small zones of anomaly are scattered over the center and southeast bodies of Peridotite.

The most potential area for nickel laterite deposits in Area N is, therefore, the northern part of the Peridotite body in center of the area.

1-8 Area P

1-8-1 Geology and mineralization

(1) Survey area

During the regional geochemical survey in PhaseIII, high Cr (maximum 117,538 ppm) samples were found in the area upper stresm of Sungai Mailo and Area P was selected as a potential area for chromite deposits. A stream sediment geochemical survey was conducted in the area.

The Area P is located at the south of Telupid, in the central part of the Labuk area. Sungai Mailo, a tributary of Sungai Labuk, flows from southwest to northeast in the center of the area. A steep mountainous topography occupies the area. High ridges run surrounding Sungai Mailo and the maximum altitude reaches 1,200 m in the southern part of the area. The survey was conducted by flying camp and samples were collected mainly from Sugai Mailo and its tributaries.

(2) Geology

Geology of Area P consists of Peridotite (Pr), Gabbro (Gb) and Dolerite (Do) of Cretaceous to Tertiary age, and Chert-Spilite formation (CsCh) of Cretaceous to Eocene age. The geological map is shown in Fig. II-1-19.

The Peridotite (Pr) widespreads in the whole area along Sungai Mailo and it consists of mainly serpentinized harzburgite with rare occurrences of dunite. The Gabbro (Gb), a equigranular rock consisting of pyroxene, hornblende and plagioclase, is distributed in northwestern part of the area separated from Peridotite by a fault. A small body of dolerite intrudes into the Gabbro at the western edge of the