No. 23

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

(PHASE II)

(Geochemical and Heliborne Geophysical Surveys)

FEBRUARY, 1992

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 decided 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. Takehiko Nagamatsu from 16th July 1991 to 23rd January 1992.

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 geochemical and heliborne geophysical surveys in Phase II.

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

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

February, 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

Gen-ichi Fukuhara
President
Metal Mining Agency of Japan

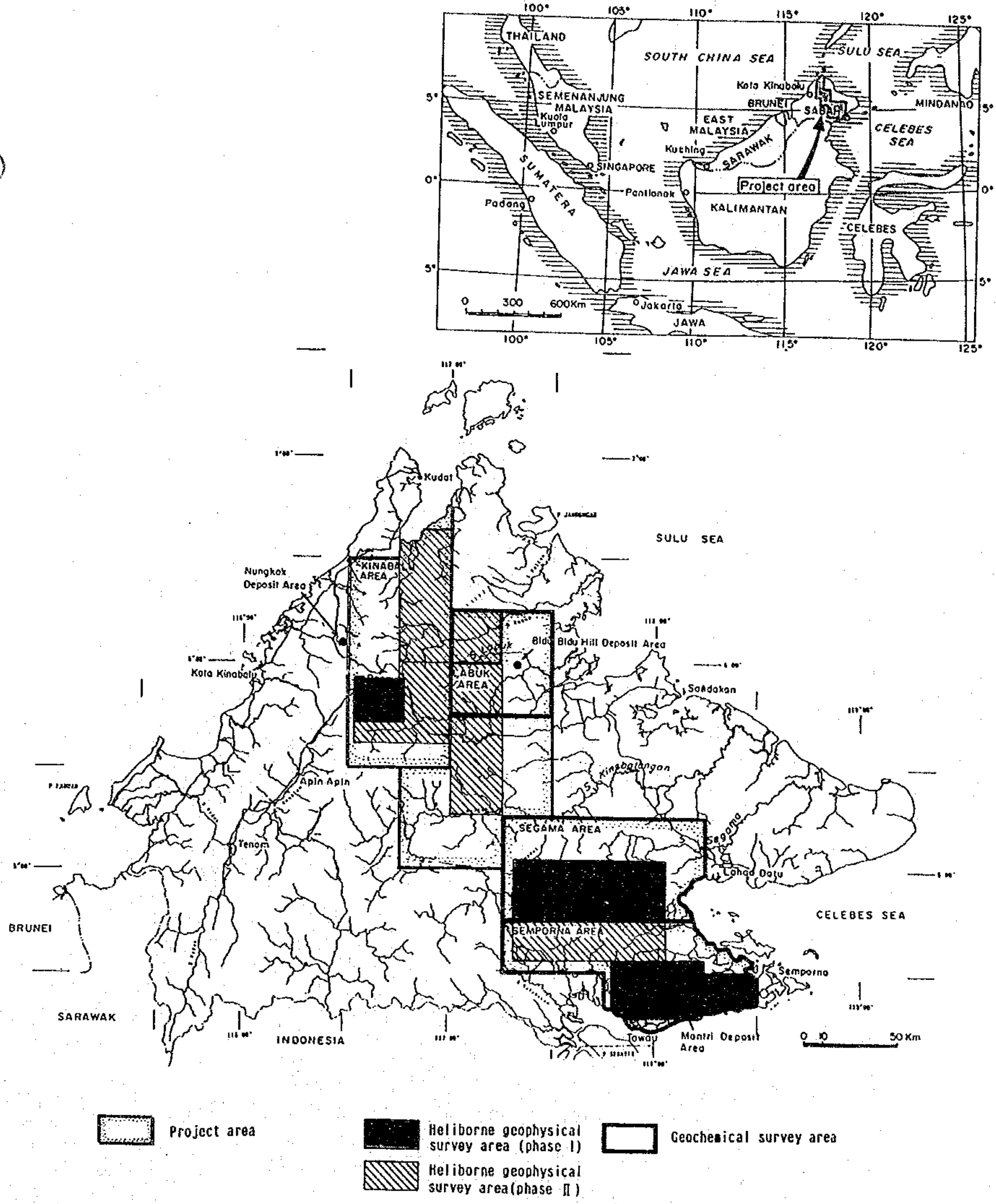

Fig. 1 Location map of the project area

ABSTRACT

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

The regional geochemical survey and heliborne geophysical survey were adopted in this phase survey. The regional geochemical survey was carried out in the Segama area, Semporna area and a part of Kinabalu and Labuk areas using the optimum survey methods selected in the orientation survey of Phase I. The heliborne survey of magnetic and radiometric methods was conducted over the areas of Northern Kinabalu, Southern Kinabalu, Labuk, Segama, Northern Semporna and Southern Semporna.

Results of the regional geochemical survey delineated many mineral potential areas including known mineral showing zones. This results suggest that the survey methods applied are quite useful for the survey in this project area. The results of this survey delineated the following areas as the potential area of mineral resources in the Segama and Semporna areas:

Segama area: the area between Sungai Sabahan and Sungai Diwata, upper stream of Sungai Segama, upper stream of Sungai Danum, surroundings of Silam.

Semporna area: the area between Sungai Balung and Sungai Kalumpang, Nagos area, upper stream of Sungai Sipit, upper most stream of Sungai Kalumpang, Sungai Apas area and the surroundings of Tawau Hill.

Among these area, the areas in the Segama area, except the surroundings of Silam, have potentiality of copper ore deposits. The potentiality of the surroundings of Silam is chromite ore deposits. The promising areas in the Semporna area have potentiality of gold-silver ore deposits.

Sampling work and chemical analyses were carried out in the Kinabalu/Labuk area. The data analyses for these analytical results will be carried out in the next phase together with the data in the Kinabalu and Labuk areas.

The results of the heliborne survey clearly reflect the geology of the survey areas. A direction of N-S delineated in this survey is interpreted to be the latest structure because this direction cuts other trending structures. The small magnetic anomalous zones in the southern part of the Southern Kinabalu area

are interpreted to be comparatively highly magnetized blind intrusive bodies of 1 to 2 km in depth from the surface. Ultra-basic rock bodies near surface are expected in the southwestern part of the Segama area due to the magnetic anomalous zones. The ultra-basic rock bodies at shallow depth are also expected in the northern part of the Semporna area. Low magnetic anomalous zones of small and irregularly shaped are found within high magnetic anomalous zones in the area of volcanic rocks in the southern part of the Semporna area. These low magnetic anomalous zones are thought to be hydrothermally altered zone. These low magnetic anomalous zones are well correspond to the high count anomalous zones of uranium.

As the results of overall interpretation for the regional geochemical and heliborne geophysical surveys, the below-mentioned areas are delineated as the promising areas of mineral resources in the Segama and Semporna areas. These area exclude the areas where intense exploration work has been carried out.

Segama area: the area between Sungai Sabahan and Sungai Diwata, upper stream of Sungai Segama and upper stream of Sungai Danum.

Semporna area: upper stream of Sungai Sipit, upper most stream of Sungai Kalumpang, Sungai Apas area and surroundings of Tawau Hill.

The target for the areas in the Segama area is copper ore deposits and the target for the areas in the Semporna area is gold-silver deposits. Each area deliniated in this survey covers comparatively wider area. Further exploration work should be carried out for these promissing areas in order to select exact target zones within these areas.

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Part I General

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. This project is four years project starting from 1990 and this report includes the survey results of Phase II.

Objectives of this survey are to clarify the mineral potentiality in this area for the future mineral development of mineral resources in this area. The area selected for this survey (Fig. 1) is thought to have higher mineral potentiality in the State of Sabah, because many known mineral occurrences are distributed in this area. In order to execute this purpose, regional geochemical survey and heliborne magnetic and radiometric surveys were carried out in this phase.

1-2 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 processing and preliminary data analyses were completed in this project. The results of these survey are conclusively summarized as follows;

(1) Satellite image analysis

① The ring structure deliniated in and around Ranau and N-S trending fault zone in the Kinabalu area shows close relationship with intrusives. Because mineralization is recognized in these intrusives, the ring structure is thought to be important for future mineral exploration in this area.

② The ring structure is also scattered other than Ranau area. These ring structures are also important for the mineral exploration in the project area.

③ During the ground truth survey of the satellite image analysis, lateritic soil samples were collected and analyzed. These sample shows comparatively high values of Ni (maximum; 0.86 %). Potentiality of lateritic nickel deposit is thought to be high.

(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.

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.

1-3 Coverage and outline of Phase II

The regional geochemical survey was carried out in both areas of Segama, Semporna and a part of Kinabalu and Labuk areas. The heliborne survey was conducted in the Northern Kinabalu, Southern Kinabalu, Labuk, Segama, Northern Semporna and Southern Semporna areas. Fieldwork, data processing and data analyses were carried out for five areas excluding the Northern Kinabalu area. The data analyses for the survey of the Northern Kinabalu area will be conducted 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 are shown in Table I-2.

Each survey method emphasizes the followings;

① Regional geochemical survey

Examine the relation between geology and mineralization and delineate mineral potential areas in the Segama and Semporna areas. The data analyses for the samples collected from Kinabalu/Labuk area will be carried out in Phase III.

② Heliborne geophysical survey

Examine aeromagnetic and aero-radiometric distribution, and delineates magnetic and radiometric bodies related to sulfide mineralization and hydrothermal alteration.

Data processing and analyses for the geochemical survey were completed in Japan. The base camps are established at Lahad Datu for the Segama area and Tawau for Semporna area. Base camp was established at the down stream of Sungai Meliau for the survey in the Kinabalu/ Labuk area. The field survey was mainly conducted by flying camp along streams.

Table I-1 Summary of work amounts

Work item	Work amounts	
Regional geochemical survey	Coverage 11,300 km^2	Stream sediments: 6,328 samples Pan concentrates: 387 samples Soil : 113 samples Rock : 122 samples
Heliborne geophysical survey	Field survey	7,700 km^2 16,659.4 line-km
	Data analyses	10,650 km^2 21,923.4 line-km
	(From Phase I	5,650 km^2 10,919.0 line-km)
	(To Phase III	2,700 km^2 5,655.0 line-km)

Table I-2 Work amounts of laboratorial studies

Study item	Work amounts	
Geochemical survey		
Thin section	22	samples
Polished section	10	samples
X-ray diffraction analyses	10	samples
QME*[1] of pan concentrates	387	samples
Physical properties measurement		
Field measurement	106	points
Laboratory measurement	102	samples
Chemical analyses		
Stream sediments	6,328 132,888	samples elements
Soil	113 678	samples elements
Rock	122 2,561	samples elements
Ore	10 70	samples elements

The base camps for the heliborne survey were at Kota Marudu in the Northern Kinabalu area, Kundasang in the Southern Kinabalu area, Luasong in the Northern Semporna area and Kota Kinabalu. The data processing and analyses of the heliborne survey were conducted in Canada and Japan.

1-4 Survey member

The members of the project planning and prior negotiation and field survey are as the following;

(1) Project planning and prior negotiation

Japanese counterpart		Malaysian counterpart	
Kenzo Masuta	MMAJ	David Lee Tain Choi	Geological Survey of Malaysia
		Lim Peng Siong	Geological Survey of Malaysia
		Alexander Yan	Geological Survey of Malaysia

MMAJ; Metal Mining Agency of Japan

(2) Field survey

Japanese counterpart			Malaysian counterpart		
Takehiko Nagamatsu	Team leader	BEC	Lim Peng Siong	Coordinator	GSM
Masahiko Nono	Geochemical	BEC	Alexander Yan	Senior geologist	GSM
Masatsugu Okazaki	Geochemical	BEC	Joanes Muda	Geologist	GSM
Jun-ichi Yamagata	Geochemical	BEC	Paulus Godwin	Geologist	GSM
Hirosi Hyodo	Geochemical	BEC	Allagu Balaguru	Geologist	GSM
Kazutoshi Sugiyama	Geochemical	BEC	Cleafos Totu	Geologist	GSM
			Salleh Adanan	Geologic Assist.	GSM
			Japili Samin	Geologic Assist.	GSM
			Rojer Totu	Geologic Assist.	GSM
			Kamil Kamaruddin	Geologic Assist.	GSM

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

The data analyses of the heliborne geophysical survey was carried out by Mr. Susumu Sasaki (Bishimetal Exploration Co., Ltd.) in Japan.

1-5 Survey period

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

Geochemical Sampling ; 16th July 1991 to 25 November 1991.

Geochemical field analysis ; 11th November 1991 to 31st December 1991.

Heliborne geophysical survey; 24th September 1991 to 20th January 1992.

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 Malaya and Eastern Malaysia situated in northern and southwestern Borneo. Population of Western and Eastern Malaysia in total is 16.5 millions. The area of the country is approximately 330,000 km^2.

Eastern Malaysia comprizes the State of Sabah and State of Sarawak. The project area is situated in the Sabah, from its northwestern part to its southeastern part and the coverage is 26,500 km^2. The area is subdivided into four areas. 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 island. In Kota Kinabalu, international airline services are available. Regular flight lines 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 from 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 run out from Ranau. In the Labuk area, there are some roads for log transportation. However, vehicles can not be used at the southern and northern part of the area. In the Segama and Semporna areas, there are some roads used for plantation and log transportation on the east coast area. In the western part of the Segama area, rivers are mainly used for transportation. In the eastern to southern part of the Semporna area, roads for plantation 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 coast. Heights occupy the eastern area and volcanic mountains are found in the southern part. Flat plain is along rivers and their down streams. Mt. Kinabalu which is the highest mountain in the southeast Asia, rise up to 13,455 ft in western end of the Kinabalu area which is occupied by steep topography. Highland dominates in the Labuk and Segama areas. Swamp extends at the end of main rivers and the rivers are extremely meandering there. Highland dominates in the Semporna area except the young volcanics region with volcanic topography.

The main drainage system 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 to South China Sea, Sungai Kalumpang and Kinabatangan flows down to Celebes Sea and other river systems are to Sulu Sea at the east. These river systems form deep valley at the upper stream and extremely meandering at the down stream in general. The river also forms swamp area at the mouth of the river.

2-3 Climate and vegitation

The survey area is situated in the tropical monsoon region. From spring to summer it is a season with less rain, from autumn to winter it is rainy season. Precipitation in the less rain 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 jungle except the area used 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 wide area in the northwest to southeast 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 flysh 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, which was ealier 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 realized in middle Miocene through Pliocene.

Cretaceous ultra-basic intrusives, syn- and post-orogenic plutonic intrusives and effusive rocks such as dacite, andesite and basalt in Pliocene through Holocene and recognized as the result of the igneous activities.

Geologic 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 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 can be seen in the Kinabalu, Labuk and Segama areas, which distribution is closely related with that of the sedimentary rocks accompanied with spilite effusion. Plutonic intrusions such as adamellite and granodiorite are characteristic in the Kinabalu area. Volcanic rocks such as dacite, andesite and basalt are characteristic in the Semporna area. This volcanic belt extends northeast until the southern part of 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 effusion and hydrothermal gold-silver deposits closely related with volcanic rocks. Chromium or platinum deposits related with ultra-basic rocks, lateritic aluminum and nickel deposits and manganese deposits in sedimentary rocks are known as well. The distribution map of main metallic ore deposits and mineral showings in the project area (after K.M. Leong, 1976) are shown in Fig. I-2.

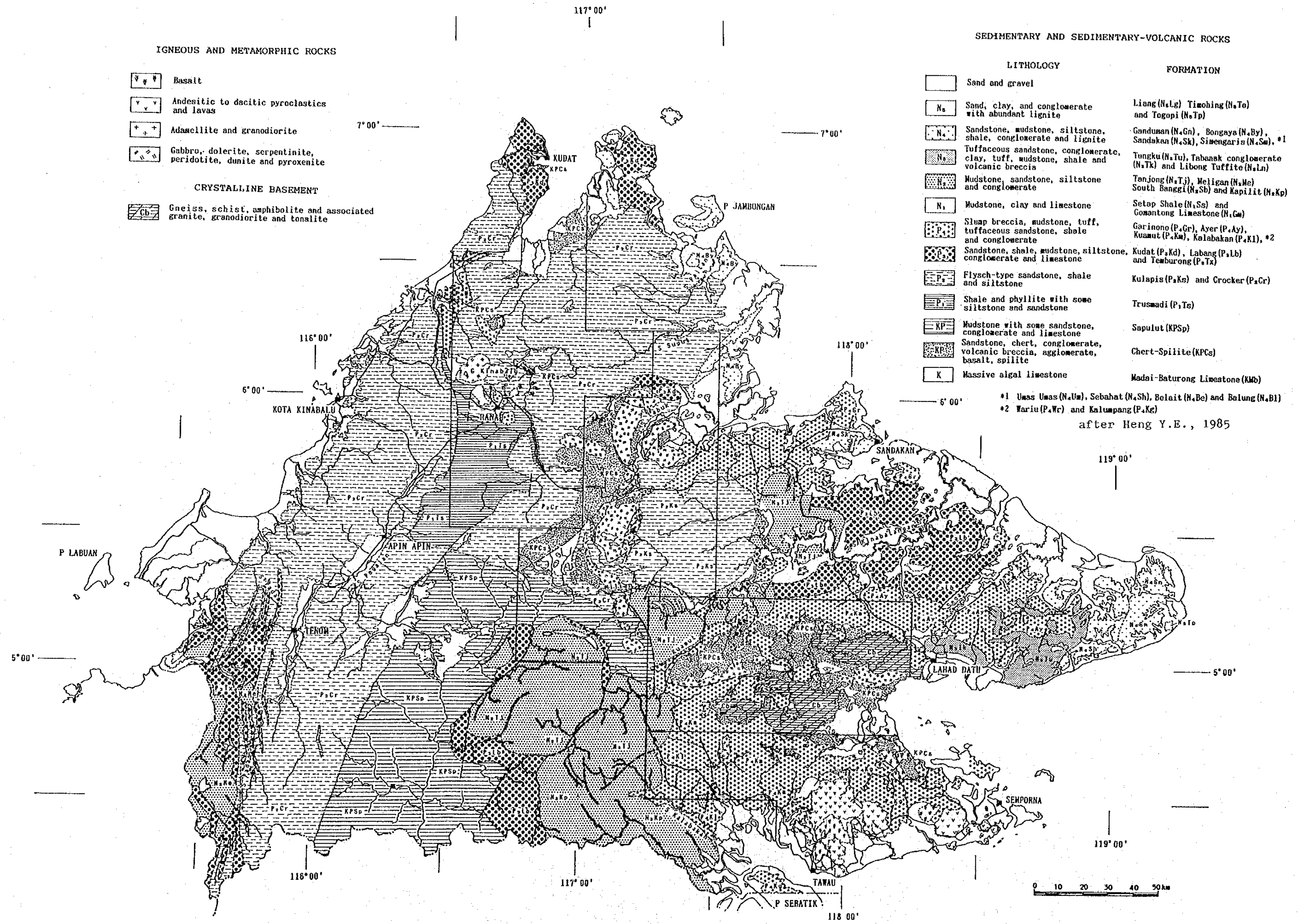

Fig. I-1 Geologic map of Sabah, Malaysia

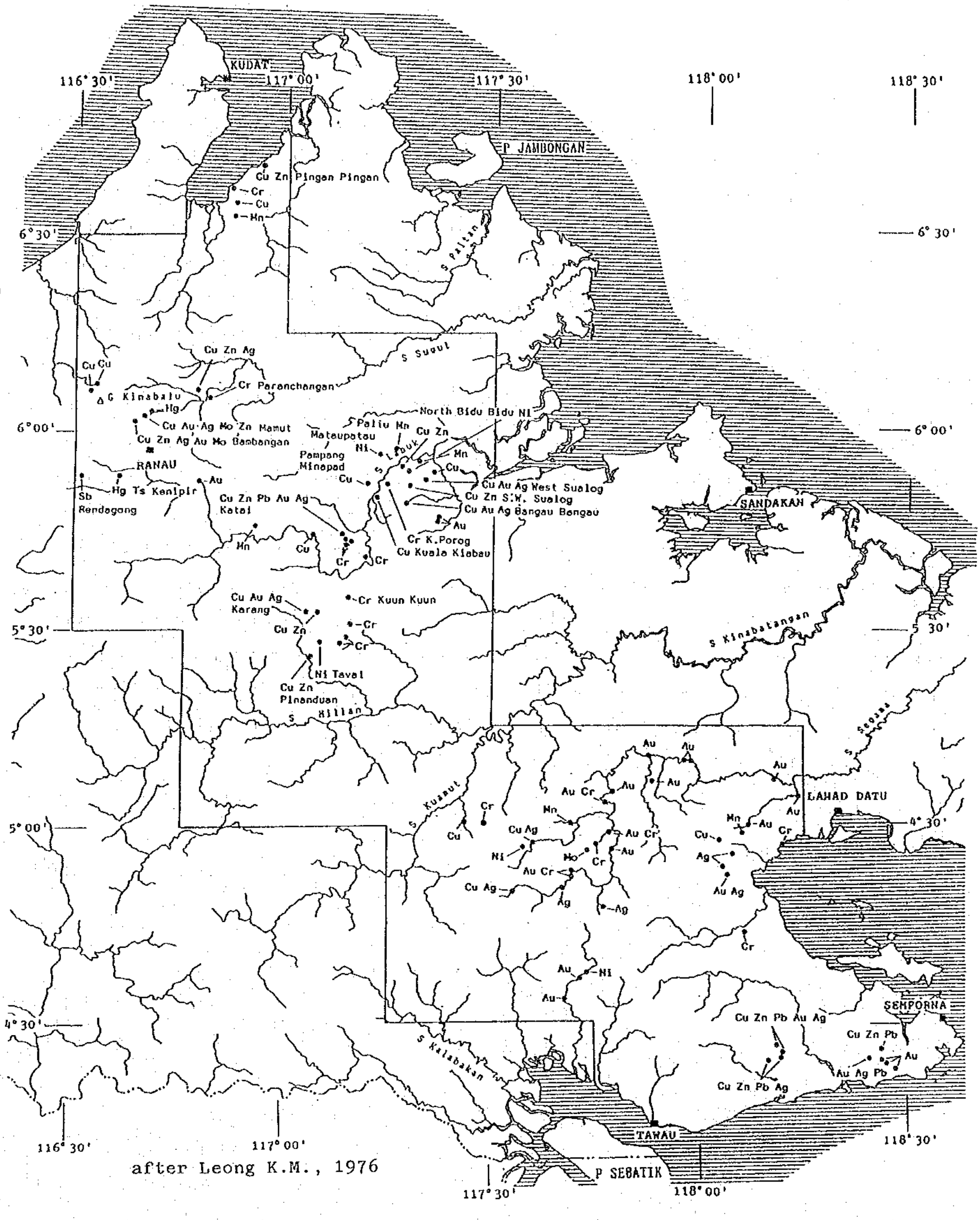

Fig. I-2 Distribution map of mineral occurences in the project area

The Mamut mine is the only active mine in the project area. The Mamut deposit 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 United Nations. The Overseas Mineral Resources Development Co., Ltd., Japan, obtained the exploration right on the Mamut area through international tender in 1968, and carried out exploration work from 1968 to 1972, then began development work in 1973. The mine has been operated 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 near future. This ore deposit is Cyprus-type massive sulfide deposits situated in spilitic effusive rocks. Exploration work for this ore deposit has been 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 drill work (approximately 40,000 m) for this deposit.

Exploration work for gold-silver deposits occured in volcanic rocks in the Semporna area has been carried out by Zamia SDN. BHD. The survey area by this company covers wide area from 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 as well.

Chapter 4 Survey results

4-1 Regional geochemical survey

Regional geochemical survey, which are composed of stream sediments and pan concentrates as the sample media, was carried out in the Segama and Semporna areas. The survey methods used were selected based on the results of the orientation geochemical survey coducted in Phase I. Representative rock samples were also collected and were analyzed to clarify the geochemical nature of the rocks in the survey area. In addition, soil geochemical reconnaissance survey was carried out in the area of ultra-basic rocks to clarify a potentiality of residual laterite deposits. Regional geochemical sampling was also conducted in a part of the Kinabalu and Labuk areas.

(1) Pathfinder element

The following 21 elements were adopted for the pathfinder elements in this survey, based on the results of the orientation geochemical survey in the Phase I.

Stream sediment sample (21 elements).
As, Au, Ba, Co, Cr, Cu, Hg, K, Mg, Mn, Mo, Na, Ni, Pb, S, Sb, Sr, Ti, U, W, Zn.

Soil sample (6 elements).
Al, Co, Fe, Cr, Ni, Pt.

Qualitative Mineral Examination (QME) was also carried out for the pan concentrates to clarify the qualitative mineral composition of the pan concentrates.

In addition to above geochemical survey, the representative rock samples were analized for 21 elements which are same elements for the stream sediment samples to clarify the geochemical nature of the background rocks in the survey area.

(2) Data analyses

The distribution maps of elements (Appendix 5 and 15) were prepared to clarify the distribution tendencies of each element. Data analyses were made using single element analysis and multi-element analysis. Exploratory Data Analysis (EDA) (Kurzl,H., 1988) method was adopted as the single element analysis to deliniate the threshold values. Cluster and factor analyses were applied as the multi element analysis in this survey.

Exploratory Data Analysis (EDA) method delineates threshold value by means of statistics data processing, and distribution pattern of each element is not affected in this method. The cluster analysis is grouping method of elements which have close relationship among them. Factor analysis is the method to delineate factors which form the relationship among the elements.

The data analyses were separately conducted for the Segama area and the Semporna area because of the different geology between the survey areas. Computer was used for these data processing and analyses.

(3) Survey results in the Segama area

Geologic reconnaissance survey was simultaneously carried out in the regional geochemical survey. Geologic map was prepared using the previous geologic data and the data obtained from the present survey. The geologic map is shown in Fig.II-1-1. Sampling work for the most part of the area was completed by flying camp. The following results were obtained for each survey method.

<u>Stream sediment geochemical survey</u>

Stream sediment samples collected in the Segama area are listed in Appendix 1 and the analytical results are shown in Appendix 2. Locations of the samples are shown in Fig. II-1-2 and Plate II-1-1.

Distribution maps of each element and distribution map of anomalous samples are shown in Appendix 5 and in Fig.II-1-4, respectively. These maps give the following results:

① Among the analyzed elements, the maximun value of Au (2,500 ppb) and Cr (18,532 ppm) are relatively high. The maximum values such as 12,390 ppm Mn, 3,605 ppm Ni, 6.53 % Na and 4.95 % K are higher than those values in the Semporna area. These maximum values of each element may reflect the geology in the survey area.

② Correlation coefficient among the elements including Cr, Co, Mg, Mn and Ni are higher than that of other elements. These pairs of elements reflect the existence of ultra-basic rocks and Chert-Spilite formation in this area.

③ The distribution maps of Co, Cr, Mg and Ni indicate that these elements have close relation with ultra-basic rocks. The highly concentrated zones of Au are mostly located in the areas of crystalline basement rocks.

④ The samples with anomalous and high values of Cu and S are concentrated in the area between Sungai Diwata and Sungai Sabahan. Because the Chert-Spilite formation occrs in this area, potentiality of Cyprus type copper deposits is expected.

⑤ Pyrite disseminations are found in the upper stream of Sungai Segama in the central part of this survey area. Anomalous Ba and S, and high Cu value samples were also detected in this area. Because of the distribution of Chert-Spilite formation, a potentiality of Cyprus type copper deposits is expected in this area.

⑥ Anomalous and high value samples of Cu and S are found in the upper stream of Sungai Danum which is ocuppied by basic rocks and Chert-Spilite formation in the north. The assay results of float sample (Sample No. J055) collected in the lower stream of Sungai Danum give the grades of 1.2 g/t Au, 42.6 g/t Ag, 0.93 % Cu and 3.99 % Zn. Potentiality of mineral deposits is thought to be high in this area.

⑦ Anomalous samples of Ba and S are found in the area between Sungai Latangang and Sungai Belang where ocuppied by sedimentary rocks. Because this area is surrounded by Chert-Spilite formation, this area is interesting area for the mineral exploration.

⑧ Anomlous and high value samples of Cr show close relationship with the distribution of ultra-basic rocks and the significant anomalous zone is found in and around Silam village. A potentiality of chromium deposits is restricted in the surroundings of Silam village in the eastern part of the survey area.

Cluster and factor analyses were applied as the multi element analysis. The obtained dendrogram (Fig.II-1-5) indicates that the common elements with high contents in ultra-basic and basic rocks give clear clusters. The results of factor analyses indicate that the factor 1 is closely related with the elements including Co, Cu, Mg, Na, S, Sr and Zn and factor 3 is closely related with the elements such as Cr and Ni. Because of the related pathfinder elements, the zones of the higher factor score of factor 1 (Fig.II-1-6) seem to be related with both the geology and copper mineralization. The areas of the above mentioned ④, ⑤ and ⑥ are selected as the zones of higher factor score. The factor 3 is interpreted to be related with ultra-basic rocks. The distribution of Factoe 3 factor score is coincident with the geology. The remaining other factors are not able to clarify their relationship.

Pan concentrate survey

The samples collected in the survey area is shown in Appendix 6 and their locations are shown in Fig.II-1-3. The results of QME are shown in Appendix 7. The amounts of sample is different depend on the geology at the sampling point. Large amounts of samples were collected around the zone of ultra-basic rocks and remarkably small amounts of sample (less than 1 gram) were collected in the area of sedimentary rocks. The collected minerals is composed mainly of rock forming minerals, and reflect the geology at the sampling point (Fig.II-1-8). Very small amount of native gold was recognized in five samples which are scattered in the area.

Rock geochemical survey

The representative rock samples were collected to clarify the geochemical nature of the background geology in the survey area. The location of rock samples are shown in Fig.II-1-3 and analytical results are shown in Appendix 8. The contents of the elements including Co, Cr, Mg, Ni and Zn tend to show higher values in the ultra-basic rocks and the elements including Cu, Sb, Zn and Ti give higher values in the basic rocks. The elements including As, Hg, Pb and U are closely related with the sedimentary rocks such as sandstone and shale. The relationship between elements and rocks show the same geochemical nature observed for the typical rocks.

Soil geochemical survey

The soil geochemical reconnaissance survey was carried out in the area of ultra-basic rocks to clarify a potentiality of residual laterite deposits. The location of soil samples are shown in Fig.II-1-3 and the descriptions of samples are shown in Appendix 9. The analytical results are shown in Appendix 10. The analytical results show that the maximum value of Ni is 5,313 ppm and 11 samples contain more than 3,000 ppm Ni which is relatively low content. The lateritization in the Segama area is weaker than that in the Labuk area.

(4) Survey results in the Semporna area

Geologic reconnaissance survey was simultaneously carried out in the regional geochemical survey. Geologic map compiled from previous geologic data and the data obtained from the present survey is shown in Fig.II-1-9. Sampling work for the central to eastern part of the survey area was completed using the agriculutural road. Sampling work from cental to western part of the survey area was mostly completed by flying camp. The following results in each survey method were obtained.

Stream sediment geochemical survey

Stream sediment samples collected in the Semporna area are listed in Appendix 11 and the analytical results are shown in Appendix 12. The locations of the samples are shown in Fig. II-1-10 and Plate II-1-2.

The distribution maps of each element obtained from the statistical data processing are given in Appendix 15 and the distribution map of anomalous samples are shown Fig.II-1-12. The data processing and the distribution maps give the following results.

① Among the elements, the maximun value of Au (9,320 ppb), S (5.526 %), Pb (789 ppm) and Ba (1,230 ppm) give relatively higher values.

② The correlation coefficient among the elements including Cr, Mg and Ni are high. These pairs of elements reflect the geology. Au is closely related with Pb among the elememts.

③ According to the distribution maps of each element and of anomalous samples, the anomalous and high content samples of As, Au, Ba, Cu, Hg, Pb, S and Zn are concentrated in the area between Sungai Balung and Sungai Kalumpang where known mineral showings are distributed.

④ The samples with the high contents of As, Au and S are concentrated in the area of the north side of the highway between Tawau and Semporna. The known mineralized zones are also situated in this area.

⑤ The anomalous and high content samples of Au, Pb and S are distributed in the upper stream of Sungai Sipit in the eastern part of the survey area. Altered zones are also observed in this area.

⑥ The anomalous and high content samples of As, Cu, Hg and Pb are concentrated in the upper most stream of Sungai Kalumpang.

⑦ The anomalous samples of As and Au are widely distributed along Sungai Apas in the southern part of the survey area.

⑧ The zone of relatively high contents of As and Pb is found in the north slope of the Tawau Hill at the northwest of Tawau.

⑨ The anomalous and high content samples of U are distributed around Tawau. The contents of U in this zone are the highest contents in the Segama and Semporna areas.

Cluster and factor analyses were applied as the multi element analysis. The results of the cluster analyses (Fig.II-1-13) indicate that Mn-Ti, Na-Sr, Mg-Co-Zn, Cr-Ni and Au-Pb form clusters. These related elements show similar distribution tendencies on the distribution maps.

Results of the factor analysis delineated five factors. Among these factors, factor 1 seems to be weakly related with copper mineralization according to the related elements to this factor. Factor 4 being closely related with Au and Pb seems to be related with gold mineralization. The high factor score of factor 1 are mainly distributed (Fig.II-1-14) in the area of sedimentary rocks and are not found in the area of Chert-Spilite formation. This fact suggests that the potentiality of copper deposits is low in this area. The high factor score zones of factor 4 (Fig.II-1-15) delineated the areas of above-mentioned③, ④, ⑤, ⑥ and ⑦ some gold mineralized zones are known within these area.

Pan concentrate survey

List of samples collected in this survey is shown in Appendix 16 and their locations are shown in Fig.II-1-11. The results of QME analysis are shown in Appendix 17. The results of the QME analysis (Fig.II-1-16) indicate that mineral composition reflects the geology at each sampling point. The samples collected in the area of sedimentary rocks in the western part of the area contain a relatively large amount of zircon. Little amounts of native gold was recognized in the four samples which are found in the area between Sungai Balung and Sungai Kalumpang.

Rock geochemical survey

List of the rock samples is given in Table II-1-12. Locations of rock samples are shown in Fig.II-1-11 and analytical results are shown in Appendix 18. The results is similar to that of the Segama area. Strongly altered two rock samples characteristically contain high values of Hg (2,905 ppb and 1,126 ppb) and S (4.307 % and 7.944 %). There is a close relationship between alteration and high contents of Hg and S.

Soil geochemical survey

List of samples and the analytical results are shown in Appendix 19. The maximum value of Ni is 3,506 ppm which is lower than the value obtained in the Segama area. It might be stated that the lateritic soil is not widely developed in the survey area because of strong volcanism and the smaller ultra-basic rock bodies compare to those in the Segama area.

(5) Survey results in the Kinabalu/labuk area

Regional geochemical survey composed of stream sediments, pan concentrates, rock and soil as sample media was carried out in the part of the Kinabalu and Labuk areas.

Geologic map prepared based on the previous geologic data and the data obtained from the present survey is shown in Fig.II-1-17. The locations of stream sediment samples are shown in Plate II-1-3. The location of the samples of pan concentrate, rock and soil are shown in Fig.II-1-18. The list of stream sediment samples is shown in Appendix 20 and their analytical results are shown in Appendix 21. The list of pan concentrate is given in Appendix 22 and the results of Qualitative Mineral Examination (QME) are shown in Appendix 23. The list of rock and soil samples and their analytical results are given in Appendix 24 and 25 respectively.

Data analyses for the analytical results obtained from the present survey in this area will be carried out together with the results of the regional geochemical survey for the Kinabalu and Labuk areas in the next phase.

4-2 Heliborne geophysical survey

Helicopter-borne magnetic and radiometric data acquisition and processing were done at six areas including Northern Kinabalu, Southern Kinabalu, Labuk, Segama, Northern Semporna and Southern Semporna. Data analysis for five areas except the Northern Kinabalu area was carried out. The results of the analysis are as follows:

(1) Southern Kinabalu and Labuk area

In this area, both anomaly distributions of magnetics(Figs.II-2-5 and II-2-6 and II-2-7) and radiometrics(Figs.II-2-8 and II-2-9 and II-2-12) show remarkable difference between the Southern Kinabalu and Labuk areas. That is, large-scale high-magnetic anomalies and high-count radiometrics are distributed broadly in the Southern Kinabalu area, while small-scale low-magnetic anomalies and low-count radiometrics are dominated in the Labuk area.

These differences between both areas reflect geology of each area;

non-magnetic and high-radiometric sediment rocks(sandstone, P_2Cr) are distributed wholly in the Southern Kinabalu area, while highly-magnetized and low-radiometric chert-spilite (KpCs) and ultra-basic rocks(Ub) are dominated in the Labuk area.

<u>Southern Kinabalu area</u>

N-S trending magnetic discontinuity lineaments dominated in the high magnetic anomalous zone are correspond to the strikes of the faults prefered by the satellite image analysis, so these lineaments seem to reflect main geological structure. The northern extensions of these lineaments shall be examined using the magnetic data of the Northern Kinabalu area.

And there are magnetic discontinuity lineaments in the directions of NE-SW in the whole area, NW-SE at the western part, NS to NNW-SSE at the central-to-northern part, and EW directions at the western and central-to-southern parts.

Magnetic anomalies of relatively long wave-length and small amplitude show alignments in NW-SE, N-S and E-W directions at the western, central-to-south-eastern and southern parts. These magnetic anomalies are caused by highly magnetized dacite and/or gabbro of the depths of 1 - 2 km below ground level and the magnetic susceptibilities of $0.2 - 0.7 \times 10^{-3}$ CGSemu. As mentioned above, these anomalies are located in high-count radiometric zone so that these are not caused by the shallower source.

As potassium(K) high count zones coincide almost with a high total count zone, the total count radiometrics in this zone are contributed by potassium mainly. While, there are small-scale uranium(U) high count anomalies in the central to southwestern part, where uranium also contribute to total count.

<u>Labuk area</u>

Short wave-length magnetic anomalies are distributed predominantly in this area, showing characteristic alignments of NNW-SSE to NW-SE, NE-SW, NE-SW to ENE-WSW, and NW-SE to WNW-ESE directions in the northern, northeastern, central, and southern parts, respectively. These anomalies are caused by chert-spilite and ultra-basic rocks of high magnetization at the ground surface and/or at the shallower part, which are divided into small blocks by N-S trending magnetic discontinuity lineaments.

As mentioned above, the Labuk area is occupied by low count radiometrics. However high radiometrics are found broadly at the northeastern, southeastern, southwestern and southern parts, and sparsely at the central part, and align in N-S and E-W directions excepting the southern part. N-S direction is the latest main structure in the Southern Kinabalu and Labuk area, because it is the one of the main geological structure in the Southern Kinabalu area, corresponding to the one of magnetic discontinuity lineaments to block highly magnetized rocks, and can be seen on the radiometric map reflecting the surface geology.

Potassium(K) contribute total count wholly. Uranium(U) shows low count wholly in the this area, but there are small-scale uranium high count points in the central part.

(2) Segama and Semporna area

Both anomaly distributions of magnetics(Figs.II-2-13, II-2-14, II-2-15 and II-2-16) and radiometrics(Figs.II-2-17, II-2-18, II-2-19 and II-2-23) show the characteristic pattern at each part.

That is, predominant large low-magnetic anomalies of E-W directions and predominant low-radiometrics with isolated high-radiometrics in the northern part (Segama area), large high-magnetic and high-radiometric anomalous zone in the western and central part (Northern Semporna area), low-magnetic and high-radiometric anomalies of small scale in the southwestern part (Southern Semporna area) and E-W trending low-magnetic anomalies and high-radiometric anomalies in the southeastern part (Southern Semporna area).

These features reflect geology of each part, that is, ultra-basic rocks of high magnetization and low radiometrics, sedimentary rocks of weak magnetization and high radiometrics, andesite of high magnetization and relatively high radiometrics are dominated at the northern, western and central, and southern parts, respectively.

Northern part(Segama area)

E-W trending magnetic anomalies of large amplitudes at the northern part and a lot of small-scale magnetic anomalies at the western and eastern parts are due to highly magnetized bodies at the ground surface. These highly magnetized bodies are divided into a lot of small blocks by magnetic discontinuity lineaments trending in E-W and NE-SW directions, and correspond to ultra-basic rocks because of low radiometrics.

At the western to southwestern part, there are found high magnetic anomalous zone of large scale and high radiometric anomalies, which suggest sedimentary rocks of weak magnetization and high radiometrics are distributed predominantly. Uranium high count anomalies are distributed at the same locations of high total count anomalies, where the contribution of uranium to total count occupies very large part. These uranium high count anomalies extend to the western side of the central part(Northern Semporna area).

And in the southwestern part, small magnetic anomalies are distributed, which suggest the existence of highly magnetized bodies such as ultra-basic rocks at the shallower part(0 - 500m below ground level).

Central part(Northern Semporna area)

This part is occupied by high magnetic and high-count radiometric zone wholly, which suggests non-magnetic sediment rocks are dominated. Magnetic discontinuity lineaments reflecting the geologic structure are found as follows; N-S trending lineaments in the whole part, NW-SE trending ones at the western part and NE-SW to ENE-WSW trending ones at the central-to-eastern part.

At the central-to-eastern part, there are found a lot of small magnetic anomalies, suggesting the existence of highly magnetized ultra-basic rocks intruded into the sedimentary rocks at the shallower part.

Southwestern part(Southern Semporna)

Magnetic discontinuity lineaments trending in N-S, NW-SE and NE-SW directions are distributed in this area.

The north end of the circular pattern is limited by NW-SE and NE-SW trending magnetic discontinuity lineaments, and at its southern side, there are distributed a lot of low magnetic anomalies due to highly magnetized andesite at the ground surface.

While, high-count radiometric rocks are distributed at the north of the circular pattern and broadly overlapping partially the distributions of the highly magnetized bodies at the south of the circular pattern. And the latter are limited by N-S, NW-SE and NE-SW trending radiometric discontinuity lineaments.

According to a geologic map, andesite are distributed in this whole part, but highly magnetized andesite are spotted by non-magnetic bodies, where high radiometrics are found. This suggests the existence of alteration and/or mineralization which cause demagnetization and high radiometrics.

Southeastern part (Southern Semporna)

Low magnetic anomalies of large-scale extending in E-W directions, overlapping partially high-count radiometric anomalies, are due to highly magnetized andesite at the ground surface.

4-3 Overall discussion

(1) Regional geochemical survey

As the results of this survey, distributions of each element well correspond to the geology, and delineated the known mineral showings in the Segama and Semporna areas. These facts indicate that the survey method applied in this survey are adequate for the regional survey in this area. The survey results are interpreted as following;

① High value and anomalous samples of As and Cu are recognized in the area between Sungai Sabahan and Sungai Diwata, upper stream of Sungai Danum and upper stream of Sungai Segama. Chert-Spilite formation (KPCs) is found in and nearby these areas, and pyrite disseminations are also found in these areas. These areas are interpreted to have potentiality of Cyprus-type sulfide deposits based on the above-mentioned facts.

② High value zones of pathfinder elements including As, Au, Pb and S which possibly indicate gold-silver mineralization, are concentrated in the areas of the Nagos area, upper stream of Sungai Sipit, the area between Sungai Balung and Sungai Kalumpang, upper most stream of Sungai Kalumpang and surroundings of Sungai Apas in the Semporna area. Known mineral showings of gold-silver mineralization are also situated within these areas. These promising areas are in the area of volcanic rocks. Consequently, the gold-silver mineralization has close relationship with the volcanic activity and the potential area is thought to be limited in the volcanic zones.

③ Strong hydrothermally altered zones are found in many places in the volcanic zone of the Semporna area. High value zones of Hg show close relationship with these altered zones, as the results of the geochemical survey. The volcanic zone in the Semporna area is also known as a geothermal field, and therefore the relationship between the alteration and gold-silver mineralization is not clear.

④ Distribution of high value zones of Cr show close relation with the distribution of ultra-basic rocks. These high value zones are concentrated surrounding Silam village in the eastern part of the Segama area. Potentiality of chromium ore deposits is thought to be limited within this area. Known chromium showings are also known in this area.

⑤ High value zone of U are concentrated near Tawau in the southern part of the Semporna area. Only this area is thought to have the potentiality of uranium in the Segama and Semporna areas.

(2) Heliborne geophysical survey

The survey results are interpreted as follows;

① Non-magnetized and high radiometric zones are widely distributed in the area of sedimentary rocks (mainly sandstone) in the Southern Kinabalu area. On the other hand, high magnetized and low radiometric zones are found in the area of the Chert-Spilite formation (KPCs) and ultra-basic rocks (Ub). The survey results correspond to the geology of both the areas.

② Magnetic anomalies of relatively long wave-length and small amplitude align in the directions of NW-SE at the western part, N-S at the central to southeastern part, and E-W at the southern part of the Southern Kinablu area, which are caused by dacite and/or gabbro of magnetic susceptibility of 0.2 to 0.7×10^{-3} CGSemu and the depth of 1 to 2 km below ground level. These parts show high total counts on the radiometrics total count map, so these magnetic anomalies are due to deeper sources undoubtedly.

③ N-S trending magnetic discontinuity lineaments in the Labuk area cut main lineaments of different directions and block the high magnetic bodies. Radiometric discontinuity lineaments also indicate a N-S direction. The N-S system in the Southern Kinabalu and Labuk area is interpreted to be the latest structure in both the areas.

④ Distributions of magnetic and radiometric anomalous zones well correspond to the geology in the Segama area, and Northern and Southern Semporna areas. These distributions suggest that highly magnetized and low radiometric ultra-basic rocks occupy the Segama area, low magnetic and high radiometric sedimentary rocks crop out in the Northern Semporna area, and high magnetic and comparatively low radiometric volcanic rocks are distributed in the Southern Semporna area.

⑤ Many magnetic anomalies of small amplitude and relatively long wave-length are distributed in the high magnetic zone at the southwestern part of the Segama area, and those are caused by intrusive rocks such as ultra-basic rocks at the shallower part(surface to 500m below ground level).

⑥ Many magnetic anomalies of small amplitude and relatively long wave-length are found at the central to eastern part of the Northern Semporna area, and those are due to shallower intrusive rocks such as ultra-basic rocks, because low radiometric count anomalies spot in high count zone at the same locations.

⑦ According to a geologic map, andesite is distributed broadly in the circular zone of the Southern Semporna area, but highly magnetized bodies corresponding to andesite are spotted by low and/or non magnetized bodies and radiometrics total count anomalies are found at the spotted locations. Then, the existence of alterations losing magnetization are suggested at the spotted locations.

(3) Discussion

Considering the survey results of regional geochemical and heliborne geophysical surveys, following can be pointed out for the Segama and Semporna areas;

① Distribution of the discontinuity lineaments indicate that the significant structure is N-S and NE-SW systems in both the areas. Results of the satellite image analyses in Phase I and heliborne survey show that the N-S trending structure is the latest structure in these areas. The NE-SW trending system is the main structure which is parallel to the distribution of volcanic rocks.

② The area between Sungai Sabahan and Sungai Diwata is interpreted to have potentiality of copper ore deposits on the basis of the results of geologic and geochemical surveys in this area. This area is outside of the heliborne survey area.

③ Anomalous Cr samples are concentrated in the surroundings of Silam village in the Segama area. This area is interpreted to have potentiality of chromium ore deposit. This potential area is situated outside of the heliborne survey area.

④ Results of the geochemical survey indicate potentiality of copper ore deposits in the area of upper stream of Sungai Segama. Low magnetic anomalous zone with high radiometric count which may indicates alteration is also observed in this area. The low magnetic anomalous zones with high uranium radiometric count are well correspond to the hydrothermally altered zone in the Segama and Semporna areas.

⑤ Geochemical anomalous samples are concentrated in the upper stream of Sungai Danum. Potentiality of copper ore deposits may exist in this area. Low magnetic anomalies and high uranium count are also observed in this area.

⑥ Significant geochemical anomalous zones are concentrated in the area between Sungai Balung and Sungai Kalumpang. The potentiality of mineral deposits is thought to be high. Small low magnetic anomalies and high count zone of uranium are also found in this area. This area is characterized with magnetic discontinuity lineaments trending three directions of NE-SW, NW-SE and N-S.

⑦ The Nagos area in the Semporna area is interpreted to have potentiality of gold-silver ore deposits. Low magnetic anomalies and high count zone of uranium are also occur in this area.

⑧ Upper stream of Sungai Sipit situated north of the Nagos area is also interpreted to be the potential area of gold-silver deposits. This area is outside of the heliborne survey area.

⑨ In the central part of the Semporna area, upper most stream of Sungai Kalumpang also indicates possibility of gold-silver ore deposits by the results of the geochemical survey. Low magnetic anomalous zones with high count of uranium which possively indicate altered zone, are found nearby this area.

⑩ The geochemical survey results delineated the Sungai Apas area as the potential area of gold-silver deposits. This area is situated outside of the heliborne survey area.

⑪ The results of geochemical survey also suggest potentiality of gold-silver deposit at the north of Tawau Hill. The heliborne survey gives no significant result for this area.

⑫ The geochemical survey delineates the surroundings of Tawau as an uranium concentrated zone. But the heliborne survey gives negative result. The potentiality of uranium deposit in this area is thought to be low.

Chapter 5 Conclusions and recommendations

5-1 Conclusions

The results of regional geochemical survey for the Segama and Semporna areas clearly delineated the known mineralized zones in these areas. Consequently, the survey methods applied are usefull geochemical survey method in this project area.

The results of the stream sediment geochemical survey delineated promising areas of mineral resources in the Segama and Semporna areas. These potential areas are the following;

<u>Segama area</u> : between Sungai Sabahan and Sungai Diwata, upper stream of Sungai Segama, upper stream of Sungai Danum and the surroundings of Silam village.

<u>Semporna area</u>: between Sungai Balung and Sungai Kalumpang, the surroundings of Nagos, upper stream of Sungai Sipit, Sungai Apas area, Tawau hill and the surroundings of Tawau.

In accordance to the geology and the distribution of pathfinder elements, the promising areas delineated in the Segama area have potentiality of Cyprus type massive sulfide deposits except the sorroundings of Silam village. The silam area has potentiality of chromium ore deposits. The mineral potentiality in the Semporna area is gold-silver deposits considering the geology, distributions of pathfinder elements and known mineral showings. The potentiality in the surroundings of Tawau is uranium, of concentration of uranium is observed in the geochemical survey results.

Mineral composition of the pan concentrate sample well reflects the geology of the sampled area. Native gold was observed in some samples. These samples are scattered in the Segama area, but are gathered nearby Mantri area in the Semporna area.

Results of chemical analyses for the rock samples indicate common composition of elements for each kind of rock. Strongly altered volcanic rocks are characterized with high contents of Hg.

The analytical results of soil samples show low contents of Ni compare to the samples collected in the Labuk area. This fact may indicate that some factors which obstruct the development of lateritic soil, such as volcanic activity, are existed in this area.

Data analyses for the geochemical samples collected in the Kinabalu/Labuk area will be made in the next phase.

Heliborne geophysical survey was conducted over six selected areas of Northern

Kinabalu, Southern Kinabalu, Labuk, Segama, Northern Semporna and Southern Semporna. Data analyses for these areas, except the Northern Kinabalu area, were completed in this survey. Fieldwork and data processing were completed for the Northern Kinabalu area. The data analyses for the Northern Kinabalu area will be made in next phase.

The survey results of the heliborne geophysical survey are conclusively summarized as following;

① The Southern Kinabalu area is mostly covered with low magnetic and high radiometric zones. On the other hand, the Labuk area is mostly high magnetic and low radiometric zones. These facts may reflect the difference of geology in these two areas.

② The small magnetic anomalous zones which are found in the south of the Southern Kinabalu area, are interpreted to reflect comparatively highly magnetized intrusive bodies situated 1 - 2 km in depth from the surface.

③ Magnetic discontinuity lineaments trending a N-S direction in the Segama area block the highly magnetized zones. This fact suggests that the direction of N-S is the latest geologic structure in this area.

④ Distribution of magnetic anomalous zones in the southwest of the Segama area indicate existence of ultra-basic rock bodies near surface (0 - 500 m in depth).

⑤ Distribution of magnetic and radiometric anomalous zones also indicate existence of ultra-basic bodies at shallow depth in the central to eastern part of the Northern Semporna area.

⑥ Irregularly shaped low magnetic anomalous zones are found within the high magnetic zones in the Southern Semporna area. These low magnetic zones are interpreted to be hydrothermally altered zones of volcanic rocks.

As the results of the regional geochemical and heliborne geophysical surveys, the following areas are delineated as the promising area of mineral resources in the Segama and Semporna areas;

<u>Segama area</u>

① Area between Sungai Sabahan and Sungai Diwata.
② Upper stream of Sungai Segama.
③ Upper stream of Sungai Danum.
④ Surroundings of Silam village.

<u>Semporna area</u>

① Area between Sungai Balung and Sungai Kalumpang.
② Nagos area.
③ Upper stream of Sungai Sipit.
④ Upper most of Sungai Kalumpang.
⑤ Sungai Apas area.
⑥ Surroundings of Tawau Hill.

Among these areas,①, ② and ③ in the Segama area are the promising areas of copper ore deposits. The target for ④ in the Segama area is chromium ore deposits. The all areas delineated in this survey in the Semporna area have potentiality of gold-silver ore deposits.

Investigation has been carried out for the surroundings of Silam village and intense exploration work has also been carried out for the area between Sungai Balung and Sungai Kalumpang of the Semporna area by private firm.

The highly concentrated zone of uranium was delineated by the geochemical survey near Tawau in the Semporna area. However, the results of aero-radiometric survey indicate negative results. The potentiality of uranium in this area is thought to be low.

5-2 Recommendations

The following survey method are recommendable for the survey in Phase III on the bases of the survey results of Phase II;

1) Results of the regional geochemical survey delineated potential areas of mineral resources including known mineral showings. Therefore, this survey method should be used for the regional geochemical survey in the Kinabalu and Labuk areas.

2) The promising areas delineated in this survey cover comparatively wide area and therefore, further exploration work should be carried out in order to delineate exact target zones. Locations of these promising areas are shown in Fig. II-3-1. The following survy method should be applied for these areas.

<u>Segama area</u>

① Area between Sungai Sabahan and Sungai Diwata: soil geochemical survey
② Upper stream of Sungai Segama. : rock geochemical survey
③ Upper stream of Sungai Danum. : rock geochemical survey

<u>Semporna area</u>

① Upper stream of Sungai Sipit. : soil geochemical survey
② Upper most of Sungai Kalumpang. : soil geochemical survey
③ Sungai Apas area. : soil geochemical survey
④ Surroundings of Tawau Hill. : soil geochemical survey

A preliminary geologic survey also should be carried out for these selected areas. The areas where exploration work have been carried out exclude for the areas of further exploration work in the Segama and Semporna areas.

Part II Survey results

Chapter 1 Regional geochemical survey

1-1 Survey methods and work amounts

1-1-1 Methodology

Based on the results of the orientation geochemical survey in Phase I, a regional geochemical survey was carried out in the Segama and Semporna areas, and a part of the Kinabalu and Labuk areas in order to clarify the mineral potentiality in these areas. The sample medias used in the regional survey are stream sediments and pan concentrates. In addition, a rock geochemical survey using representative rock samples in these area was conducted to examine the geochemical nature of the background geology. Soil samples were also collected to examine the mineral potentiality of lateritic soil in the areas of ultra-basic rocks. A reconnaissance geologic survey and sampling work for laboratorial studies were simultaneously carried out along the geochemical sampling routes.

The stream sediment samples were collected from the entire areas. At each sampling site the sample was collected from the edge of stream flow which is the optimum samplimg point delineated in the survey results of Phase I. The sample is minus 60 mesh fraction sample. Sample density applied is 2 km^2/sample except flat area and the density in the flat area is 4 km^2/sample. The sampling work could not conducted in the areas of a northern part of the Segama area, eastern and southern parts of the Semporna area and an east to northeast part of the Labuk area where is widely ocupied with swamp. Deep vallys are found at the upper stream of Sungai Segama and the sampling work could not be condacted in these parts because it was quite dangerous to walk inside the vally. At the each sampling site, the scale of stream, color and grain size of sediment etc. were discribed and sample list was prepared. More than 150 grams of -6 mesh fraction sample were collected at each sampling site. After drying up the sample, the sample was divided into to two samples. One is for chemical analyses and other is for storage in the Geological Survey ofMalaysia, Sabah office. The samples for the chemical analyses were send to the laboratories in Japan and Canada.

Sampling work for pan concentrates was also carried out along the streams where sampling of stream sediments were conducted. The sample is collected by pannninng of five pan (approximately 25 liters). The sample density of the pan concentrate sample is 34 km^2/sample. The sample was dryed up and measured the weight. If the weight of the sample is more than 10 grams, 10 grams was studied and remaining sample was stored in the office of Geological Survey of Malaysia. Qualitative Mineral Examination (QME) was conducted for these samples in Japan.

During the survey, representative rock samples were collected and chemically analyzed. The elements analysez are 21 elements same as the stream sediment samples. About 100 grams of each sample was used for the chemical analyses and remaining sample was stored in Geological Survey of Malaysia.

Soil samples were collected in the area of ultra-basic rocks. The each sample was collected at the top of B horizon. The sampling density is 3 km^2/sample. The sample collected are dryed up then sieved and -80 mesh fraction sample was collected for the chemical analyses.

The fieldwork was condacted by nine Malaysian and six Japaneses geologists. The work was mainly conducted by flighing camp along the streams.

1-1-2 Coverage of work

The work amount completed for each area is the following:

	Segama area	Semporna area	Kinabalu/Labuk	Total
Geochemical survey				
Stream sediments	2,740 spls.	2,580 spls.	1,008 spls.	6,328 spls.
Pan concentrates	175 spls.	160 spls.	51 spls.	386 spls.
Rock	51 spls.	50 spls.	21 spls.	122 spls.
Soil	74 spls.	17 spls.	22 spls.	113 spls.
Laboratorial studies				
Thin section	12 spls.	10 spls.	—	22 spls.
Polished section	5 spls.	5 spls.	—	10 spls.
X-ray diffraction analysis	5 spls.	5 spls.	—	10 spls.
Ore assaying	5 spls.	5 spls.	—	10 spls.

Elements chemically analyzed (21 elements) for stream sediment and rock samples and their ditection limit are the following:

Element	Ditection limit	Element	Ditection limit	Element	Ditection 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

The elements (6 elements) and their ditection limit for the soil samples are as follows:

Element	Ditection limit	Element	Ditection limit	Element	Ditection limit
Al	0.01 %	Cr	2 ppm	Ni	1 ppm
Co	1 ppm	Fe	0.01 %	Pt	5 ppb

The elements assayed for the ore samples and their ditection limits are as the following:

Element	Ditection limit	Element	Ditection limit	Element	Ditection limit
Au	0.1 g/t	Pb	1 ppm	S	0.001 %
Ag	0.1 g/t	Zn	1 ppm		
Cu	1 ppm	Mo	1 ppm		

The elements applied in this survey was selected based on the results of the orientation geochemical survey in Phase I.

1-1-3 Data processing and analyses

The analytical results of the stream sediment samples were input in computer. Statistical data teratment, singl element and multi element analyses were made using these input data.

In order to carried out the singl element analyses, histograms and cumulaive frequency graphs were prepared and statistics for each element were calculated. A half value of the ditection limit was used for the sample indicating less than the ditection limit of the element in this calculation. The mean values calculated are geometric means. Based on this calculated results, distribution map of each element was drawn by computer. The contents of each element were divided into following four ranks:

Less than background (B) value.

More than background value, less than B + standerd deviation(SD).

More than B + Standerd 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 elment.

As the multi element analyses, cluster and factor analyses were utilized in this survey. The cluster analysis is a grouping method of the elements using coorelations among the elements. The factor analysis is the method to delineate the factor which forms the reletionship among the samples.

For the pan concentrate samples, magnetite and ilmenite were sepalated using magnet and the remaining samples were observed under a microscope to ditect the minearals and their volune percentage. Then weight percentage was calculated using the specific gravity for each mineral.

The number of sample for rock and soil samples is not enough to treat statistically. Therefore, studies were made for the results of the chemical analyses. The data analyses and interpretation were made using newly prepared geologic maps for the survey area.

1-2 Survey results of the Segama area

1-2-1 Geology and mineralization

The Segama area is underlain by pre-Triassic crystalline rocks, Cretaceous to Tertiary ultra-basic to basic rocks and Tertiary to Quaternary sedimentary rocks according to S.K. Chung; 1971 and Y.E. Heng; 1985. A geologic map is shown in Fig.II-1-1 compiled using the previous geologic data and the data obtained from the present survey.

The crystalline rocks (Cb) are widely found as the basement rocks in the eastern and southern parts of the area. These rocks are composed mainly of gneiss, amphibolite and schist. Some intrusive rocks of granodiorite and granite are exposed in the crystalline rocks.

Cretaceous to Tertiary ultra-basic to basic rocks (Ub) are found in the surrounding zones of the crystalline rocks. The ultra-basic rocks are composed mainly of serpentinite and serpentinized peridotite. The basic rocks are composed of dolerite and gabbro.

Chert-Spilite formation (KPCs) is found in the surrounding zones of the ultra-basic to basic rocks and is composed of sedimentary rocks accompanied by basaltic lavas. The Chert-Spilite formation consists of sandstone, chert, basaltic pillow lavas and pyroclastic rocks deposited during Cretaceous to Eocene in age.

In the western part of the area, Sapulut formation (KPSp) is found and mainly consists of mudstone deposited during Cretaceous to Eocene time. During Eocene to Miocene, Kulapis formation (P_2Ks), Labang formation (P_3Lb), Ayer formation (P_4Ay) and Kuamut formation (P_4Km) characterized by flish type sediments are widely distributed in the area. The Kulapis formation is composed of sandstone and shale and is limitedly found in the northeastern part of the area. The Labang formation is composed of sandstone, shale, mudstone, conglomerate and limestone and is limitedly found in the western part of the area. The Ayer formation is composed of tuff, slump breccia, mudstone, sandstone and some limestone and is widely found in the eastern part of the area. The Kuamut formation is composed of slump breccia, conglomerate, sandstone and siltstone and is widely found in the area. The Tanjong formation (N_2Tj) is composed of sandstone and mudstone deposited in Miocene time is found in the western part of the area. Tabanak Conglomerate (N_3Tk) composed mainly of conglomerate is found in the eastern part of the area.

Pleistocene terrace deposits (Q1) are found along the rivers and alluvium sediments (Q2) are found along the coast and rivers.

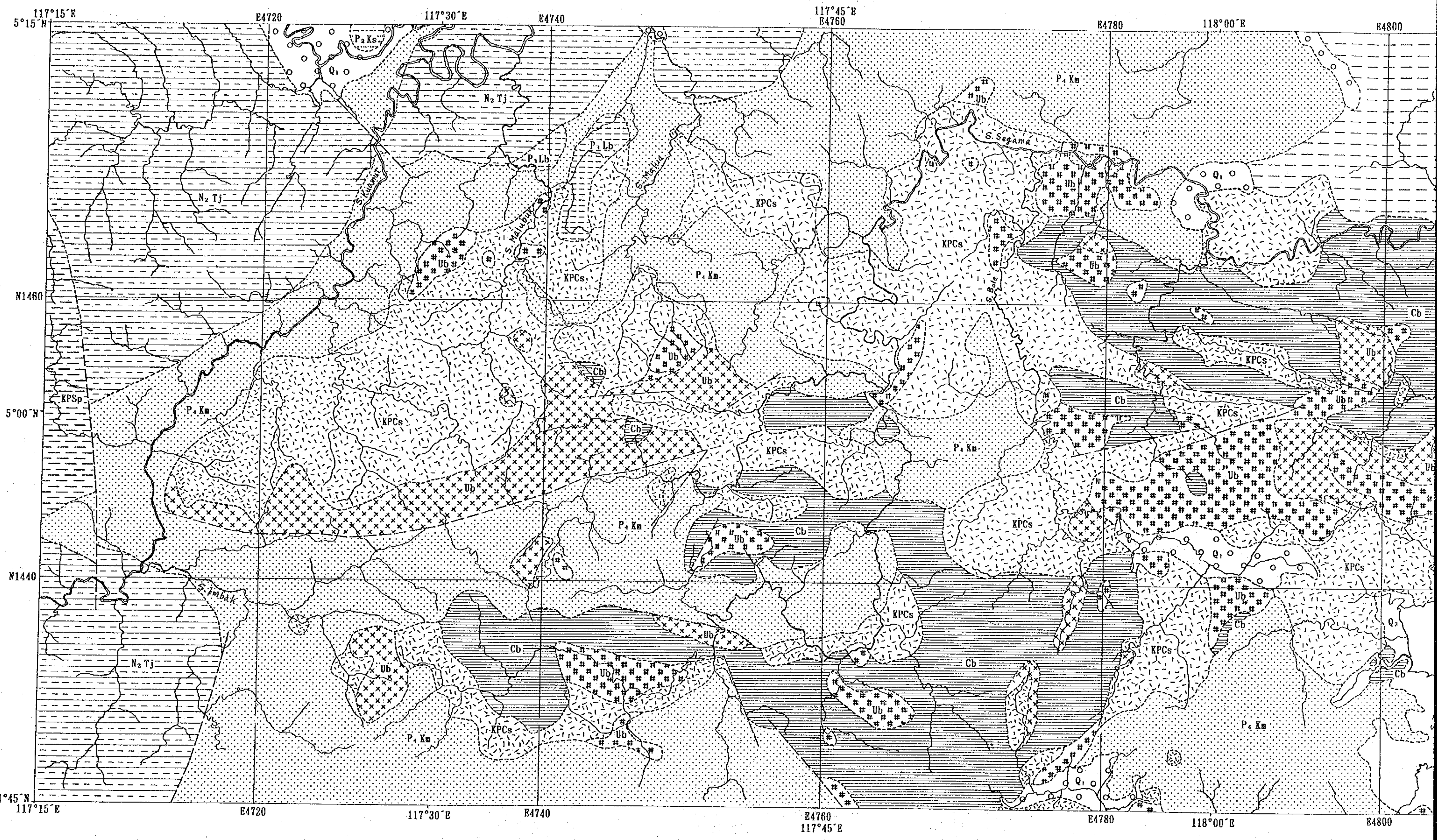

Fig. II-1-1 Geologic map of the Segama area

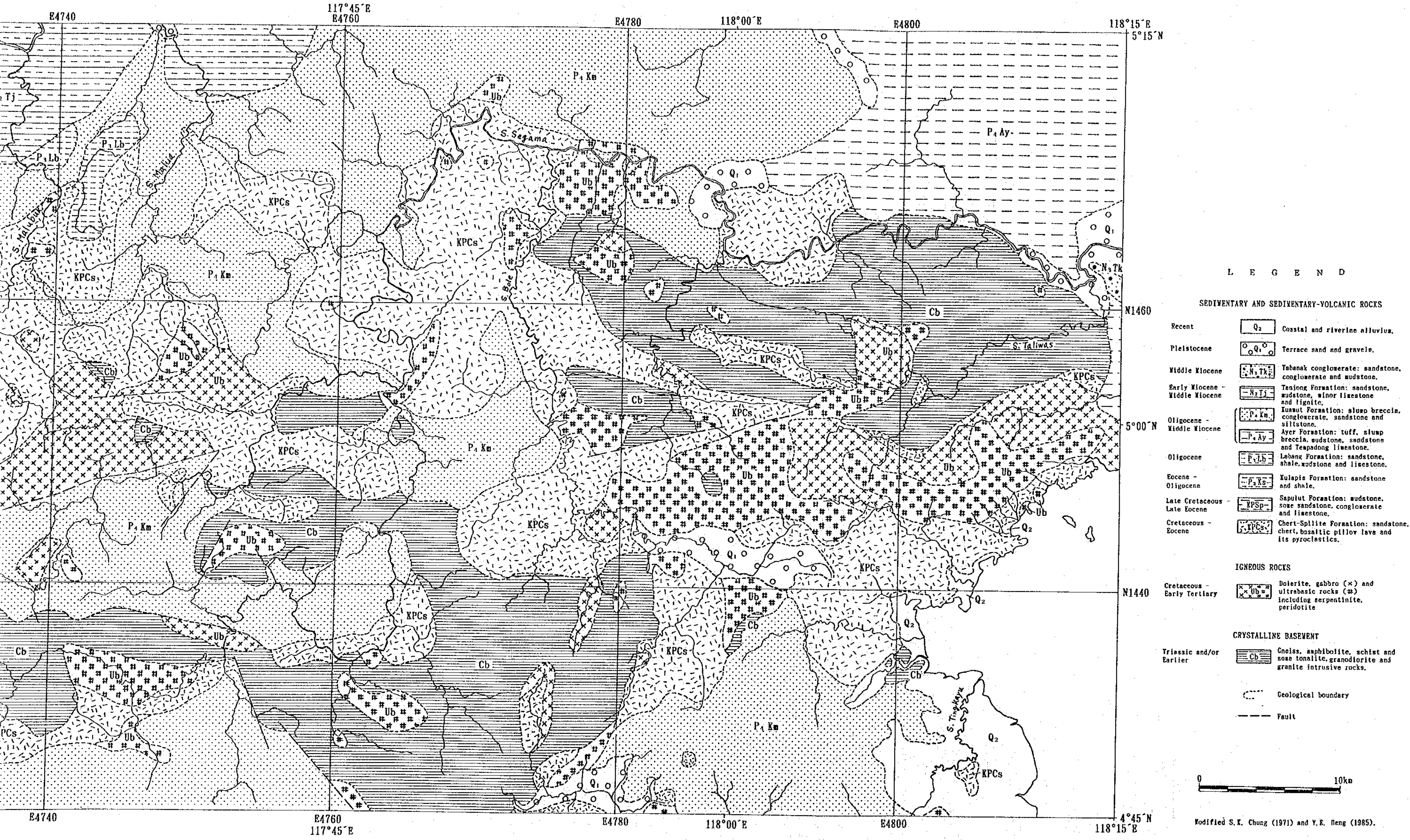

Fig. II-1-1 Geologic map of the Segama area

Distribution of the ultra-basic to basic rocks and the Chert-Spilite formation show close relationship among them. These ultra-basic, basic rocks and the Chert-Spilite formation are regarded as a part of ophiolite. The wide zones of ultra-basic to basic rocks are found in the eastern part of the area, while the narrow zones are sporadicaly found in the central to western part of the area.

Fault systems are composed of ENE-WSW, NE-SW, NW-SE and NNW-SSE systems (Y.E. Heng; 1985). Because the distribution of ultra-basic rocks, basic rocks and Chert-Spilite formation suggest that these units form a succession of ophiolite, the geologcal structure in the survey area may be complicated.

The mineralization in the survey area recognized are mineral showings of chromium, copper and gold.

The mineral showings of chromium are found around the ultra-basic rocks facing the Darvel bay and disseminations of chromite occur in peridotite.

The mineral occurrence of copper is found in the upper stream of the Sungai Segama and Sungai Danum. The mineral occurrence in the upper stream of the Sungai Segama is composed of the massive and disseminated pyrite and chalcopyrite occuring in schist and the Chert-Spilite formation. A mineralized float composed of disseminations of pyrite and chalcopyrite was collected in the main stream of the Sungai Danum, and mineralized floats with the disseminations of chalcopyrite and pyrite in quartz vein were collected in the tributary of the upper stream of Sungai Danum. The origin of these mineralized floats have been not confirmed.

The mineral occurrences of gold are recognized as placer gold in the zone between the middle stream of Sungai Segama and Sungai Sabahan. The gold contents are relatively high in the conglomeratic bed along the middle stream of Sungai Segama (J. Muda; 1988).

1-2-2 Sampling

Samples of stream sediments and pan concentrates were collected along the rivers. Samples of rock and soil were collected along the river and road. Sampling in the eastern part of the area was carried out from the base camp established in the town of Lahad Datu because of better living environment. But the sampling in the area from central to western part was mostly carried out by flying camp because of no road.

Descriptions of stream sediment at the sampling sites such as geology, scale of the stream, color and size of sediments, etc. were conducted and were listed in Appendix 1. The location of samples are shown in Fig. II-1-2 and Plate II-1-1.

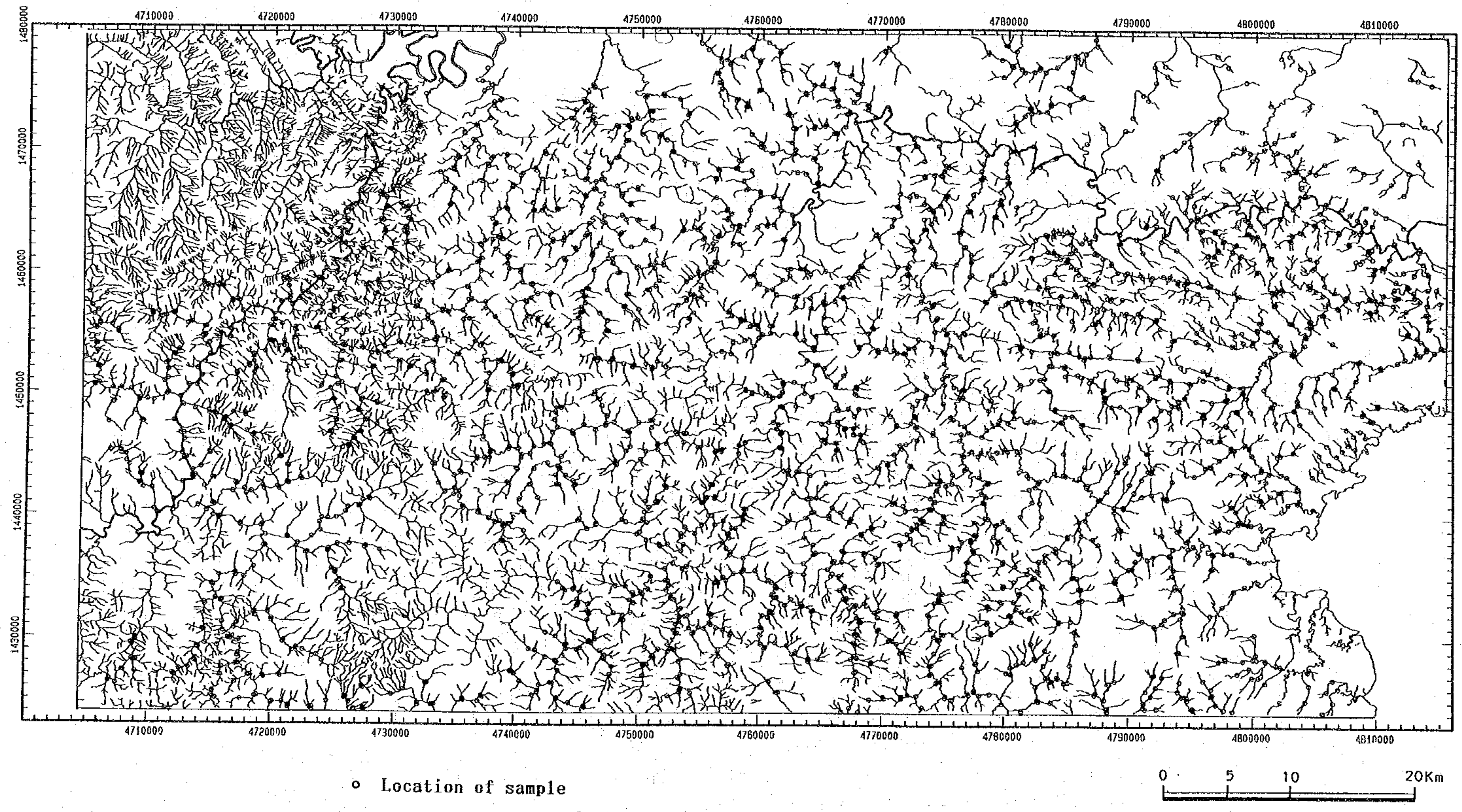

Fig. II-1-2 Location map of stream sediment samples in the segama area

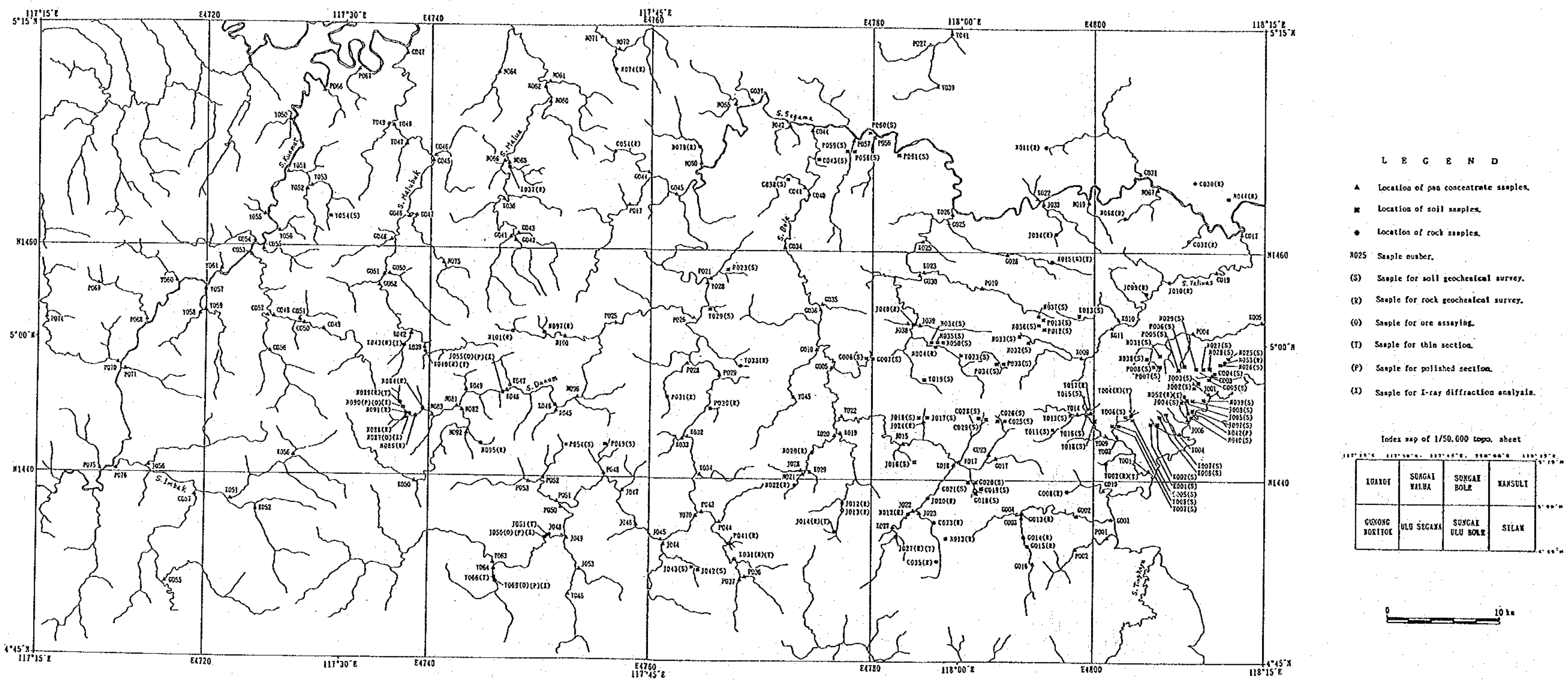

Fig. II-1-3 Location map of samples for geochemical and laboratorial studies in the Segama area

The sampling site of pan concentrates was described about geology, river scale etc., and the samples were weighted. List of these samples are shown in Appendix 6. The locations of samples are shown in Fig. II-1-3.

Rock samples cpllected are typical rocks in the survey area. The samples were described about the coordinates and geologic unit at the sampling point. The locations of the samples are shown in Fig. II-1-3. Float samples were collected instead of the rock of outcrops in the strongly weathered zone.

The soil sampling was carried out in the zone of ultra-basic to basic rocks (Ub). The samples were described about the coordinates, geology and topography at the each sampling site and color of soil. The location of samples are shown in Fig. II-1-3.

In addition to the above mentioned geochemical sampling, geological survey was carried out and the laboratorial samples were also collected. The laboratorial studies include thin section observation, polished section observation, ore assaying and X-ray diffractometry. The locations of the laboratorial samples are shown in Fig. II-1-3. The laboratorial samples include mineralized floats.

1-2-3 Stream sediment geochemical survey

(1) Element

The stream sediment samples collected in the area were chemically analyzed for 21 elements. Results of statistical processing conducted for the analytical results shown in Appendix 2 are given in Table II-1-1. Analytica results of Au, Mo and W give the values of less than the detection limits for most the samples. The maximum values of Au (2,500 ppb), Cr (18,532 ppm), Mn (12,390 ppm), Ni (3,605 ppm) and Sr (1,207 ppm) indicate relatively high values. Histograms and cumulative frequency distribution graphs for each element are shown in Appendix 3 to clarify a tendency of distribution pattern. Correlation coefficient between the elements was calculated to clarify relationship among the elements. Correlation matrix is shown in Table II-1-2. Pairs of elements which has good coorelation (more than 0.600 correlation coefficient) are as follows;

Ba-K, Co-Cu, Co-Mg, Co-Mn, Co-Na, Co-Ni, Co-Ti, Co-Zn, Cr-Ni, Cu-Mg, Cu-Na, Cu-S, Cu-Zn, K -U, Mg-Mn, Mg-Na, Mg-Ni, Mg-Ti, Mg-Zn, Mn-Na, Mn-Sr, Mn-Ti, Mn-Zn, Na-S, Na-Sr, Na-Ti, Na-Zn, Ni-Zn, Sr-Ti, Ti-Zn.

Pairs of element with significantly high correlation coefficient are Co-Mg, Co-Zn, Cr-Ni, Mg-Zn and Mn-Ti. Au has not good correlation with other elements. Cu has good correlation with Na, Mg, Zn and S. Mg has negative good coorelation with U.

(2) Single element analysis

Distribution maps of each element were made using four ranks as mentioned in the paragraph 1-1-3. EDA method was applied to determine threshold value (anomalous value). Results of the EDA method are shown in Appendix 4 and Table II-1-1. Value of Upper Fence was used as the threshold value. But if the maximum value is lower than the value of Upper Fence, the value of Upper Whisker was used as the threshold value. For the elements which their threshold value is not obtained by this way, background value plus two times standard deviation (SD) value was applied as the threshold value. Distibution maps of each element are shown in Appendix 5. Distributions of each element are summarizes as mentioned below. High value sample described in this paragraph indicate the sample with more than the value of background value plus standard deviation (SD).

As : High value samples are mainly found in the areas of sedimentary rocks (P_3Lb, P_4Ay, P_4Km and N_2Tj). Many samples in the Kuamut formation (P_4Km) show higher values of As. Some high value samples are also found in the area of the Chert-Spilite formation, ultra-basic rocks and crystalline basement rocks. The anomalous samples are widely distributed in the area because of the low threshold value.

Au : It is difficult to clarify the distribution tendency of the high value samples, because of many samples showing the value less than the detection limit. The high value samples, however, are mainly located in the zone of the basement rocks around the upper stream of Sungai Taliwas, Sungai Kawag and and Sungai Juak. Some samples with high value are recognized in the area of the ultra-basic and basic rocks in the eastern part of the area, the Chert-Spilite formation and the Kuamut formation in the western part of the area.

Ba : High value and anomalous samples are found in the area of the basement rocks in the southern part, the Chert-Spilite formation in the western part, the Kuamut formation in the northern part and the Tanjong formation in the southwestern part of the area.

Co : Samples with high and anomalous values are restricted in the area of ultra-basic and basic rocks, especially around the upper stream of Sungai Sepagaya, in the western part of village of Silam, around the upper stream of Sungai Dewata and Sungai Lunkasa.

Cr : Samples with high and anomalous values are restricted in the area of ultra-basic and basic rock, especially in the northwest and west of Silam. The disrribution tendency Cr reflects the distribution of ultra-basic rocks. Relatively high value samples are recognized in the area of the basement rocks and Chert-Spilite formation in the eastern part of the area.

Cu : Anomalous value of Cu is 60.4 ppm. The maximum value is 395 ppm. Small number of samples with anomalous values are scattered in the area of the basement rocks, basic rocks from the central to western part, Chert- Spilite formation in the eastern and western part of the area. Samples with relatively high

Table II-1-1 Statistics of stream sediment geochemical survey in the Segama area

Element	Statistics						EDA method*3		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard deviation	b + 2S.D. *2	Median	Upper Wisker	Upper Fence
As (ppm)	72.6	63	< 1	1.0	0.490	9.1	0.5	4	4.25
Au (ppb)	92.8	2,500	< 1	0.6	0.361	3.2	0.5	0.5	0.5
Ba (ppm)	1.6	772	< 10	83.1	0.332	383.1	92	143	229
Co (ppm)	0.2	470	< 1	15.7	0.355	80.5	17	32	52.5
Cr (ppm)	—	18,532	58	336.8	0.370	1,847.1	279	610	937
Cu (ppm)	0.1	395	< 1	18.5	0.257	60.4	19	31	50.5
Hg (ppb)	44.8	766	< 10	10.7	0.345	52.5	11	23	40
K (%)	4.9	4.95	< 0.01	0.267	0.555	3.436	0.34	0.68	1.205
Mg (%)	—	20.46	0.03	1.112	0.415	7.629	1.22	2.62	4.81
Mn (ppm)	1.1	12,390	< 5	569.4	0.562	7,573.0	706	1,544	2,734
Mo (ppm)	92.0	14	< 1	0.5	0.131	1.0	0.5	0.5	0.5
Na (%)	1.8	6.53	< 0.01	0.559	0.533	6.492	0.63	1.70	2.96
Ni (ppm)	—	3,605	7	64.6	0.382	375.6	59	125	196
Pb (ppm)	68.0	222	< 2	1.7	0.373	9.5	1	4	6
S (%)	—	2.555	0.009	0.035	0.244	0.108	0.036	0.054	0.086
Sb (ppm)	9.7	148.1	< 0.2	3.26	0.619	56.49	4.9	9.5	17.85
Sr (ppm)	—	1,207	2	78.5	0.449	619.5	65	221	380
Ti (%)	—	10.75	0.04	0.567	0.403	3.630	0.52	1.36	2.26
U (ppm)	5.9	3.4	< 0.2	0.83	0.344	4.05	1.0	1.6	2.6
W (ppm)	93.1	7	< 2	1.1	0.116	1.8	1	1	1
Zn (ppm)	—	502	8	52.7	0.235	155.5	55	81	129.5

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

Table II-1-2 Coorelation matrix of elements for stream sediment in the Segama area

	As	Au	Ba	Co	Cr	Cu	Hg	K	Mg	Mn	Mo	Na	Ni	Pb	S	Sb	Sr	Ti	U	W	Zn
As	1.000																				
Au	-.058	1.000																			
Ba	.154	.002	1.000																		
Co	-.375	.079	-.255	1.000																	
Cr	-.192	.015	-.355	.589	1.000																
Cu	-.233	.026	.170	.600	.188	1.000															
Hg	.159	-.033	.227	.023	.009	.117	1.000														
K	.182	-.055	.774	-.285	-.364	.236	.217	1.000													
Mg	-.437	.054	-.223	.896	.570	.648	-.044	-.214	1.000												
Mn	-.444	.115	-.203	.780	.374	.473	-.100	-.287	.763	1.000											
Mo	.015	-.008	.073	-.066	-.077	.024	.030	.062	-.079	-.090	1.000										
Na	-.389	.095	.069	.632	.118	.650	-.044	.091	.713	.673	-.048	1.000									
Ni	-.214	-.006	-.245	.759	.811	.448	.064	-.211	.767	.504	-.073	.314	1.000								
Pb	.265	-.073	.222	-.351	-.149	-.214	.160	.176	-.431	-.357	.144	-.382	-.176	1.000							
S	-.158	.043	.110	.506	.136	.613	.152	.101	.551	.407	.083	.611	.298	-.147	1.000						
Sb	-.322	.073	-.170	.502	.384	.259	-.141	-.209	.502	.552	-.012	.398	.389	-.277	.199	1.000					
Sr	-.414	.156	.051	.519	.013	.472	-.119	-.058	.572	.628	-.074	.793	.128	-.423	.500	.378	1.000				
Ti	-.466	.147	-.272	.712	.339	.343	-.126	-.386	.684	.819	-.116	.629	.373	-.429	.421	.564	.719	1.000			
U	.327	-.034	.521	-.586	-.336	-.293	.193	.612	-.602	-.515	.068	-.408	-.384	.365	-.280	-.291	-.451	-.573	1.000		
W	-.018	-.013	-.020	-.062	-.025	-.063	-.071	-.025	-.054	-.054	.257	-.090	-.025	.073	-.039	.041	-.098	-.067	.052	1.000	
Zn	-.355	.076	-.119	.864	.507	.628	.140	-.175	.835	.720	-.011	.611	.664	-.284	.592	.463	.537	.704	-.490	-.052	1.000

values are recognized in the area of the Chert-Spilite formation. Very limited number of samples with than anomalous values are recognized in the areas of the Kuamut, Ayer and Tanjong formations.

Hg : High value samples are found in the area of the basement rocks, ultra-basic to basic rocks in the eastern part, Chert-Spilite formation and Kuamut formation. Samples with the high values are limited in the area of the Chert-Spilite formation in the central part, Kuamut formation in the western part and Tanjong formation in the southwestern part of the area.

K : Number of samples with value more than anomalous value is two samples. Samples with relatively high value are sporadically distributed in the area. Samples in the area of sedimentary rocks in the western part of the area show high contents.

Mg : High value samples are restricted in the area of ultra-basic and basic rocks.

Mn : Anomalous value is 7,573 ppm. Only several samples contain more than anomalous value. High value samples are found in the area of ultra-basic and basic rocks in the eastern part of the area.

Mo : It is difficult to clarify the distribution tendency, because a large number of samples indicate the value less than the detection limit and high value samples are scattered in the area.

Na : High value samples are found in the area of basement rocks, ultra-basic to basic rocks and the Chert-Spilite formation.

Ni : Anomalous and high value samples are restricted in the areas of ultra-basic to basic rocks. Some of samples with high values are recognized in the area of the basement rocks, the Ayer and Kuamut formations.

Pb : Anomalous and high value samples are mainly found in the area of sedimentary rocks (P_4Ay, P_4Km and N_2Tj), and the samples are also recognized in the area of the Chert-Spilite formation.

S : Anomalous and high value samples are found in the basement rocks of the upper stream of Sungai Bole, in the basic rocks of the upper stream of Sungai Danum, in the Chert-Spilite formation around Sungai Sabahan, in the sedimentary rocks of the upper stream of Sungai Latang, Sungai Belang and Sungai Kuamut.

Sb : Two anomalos samples and are found in the area of the basement rocks in the southern part of the area and the ultra-basic rocks in the eastern part of the area.

Sr : High value samples are limitedly found in the area of the basement rocks in the eastern and southern parts of the area. Samples with the relatively high value are recognized in the area of the Chert-Spilite formation around Sungai Dewata, Sungai Sabahan and the middle stream of Sungai Kuamut.

Ti : High value samples are found in the area of the ultra-basic and basic rocks in the eastern part of the area.

U : High value samples are scattered in the area of the sedimentary rocks.

W : It is difficult to clarify the distribution tendency, because of a large number of samples with less than detection limit and sporadical distribution of high value samples.

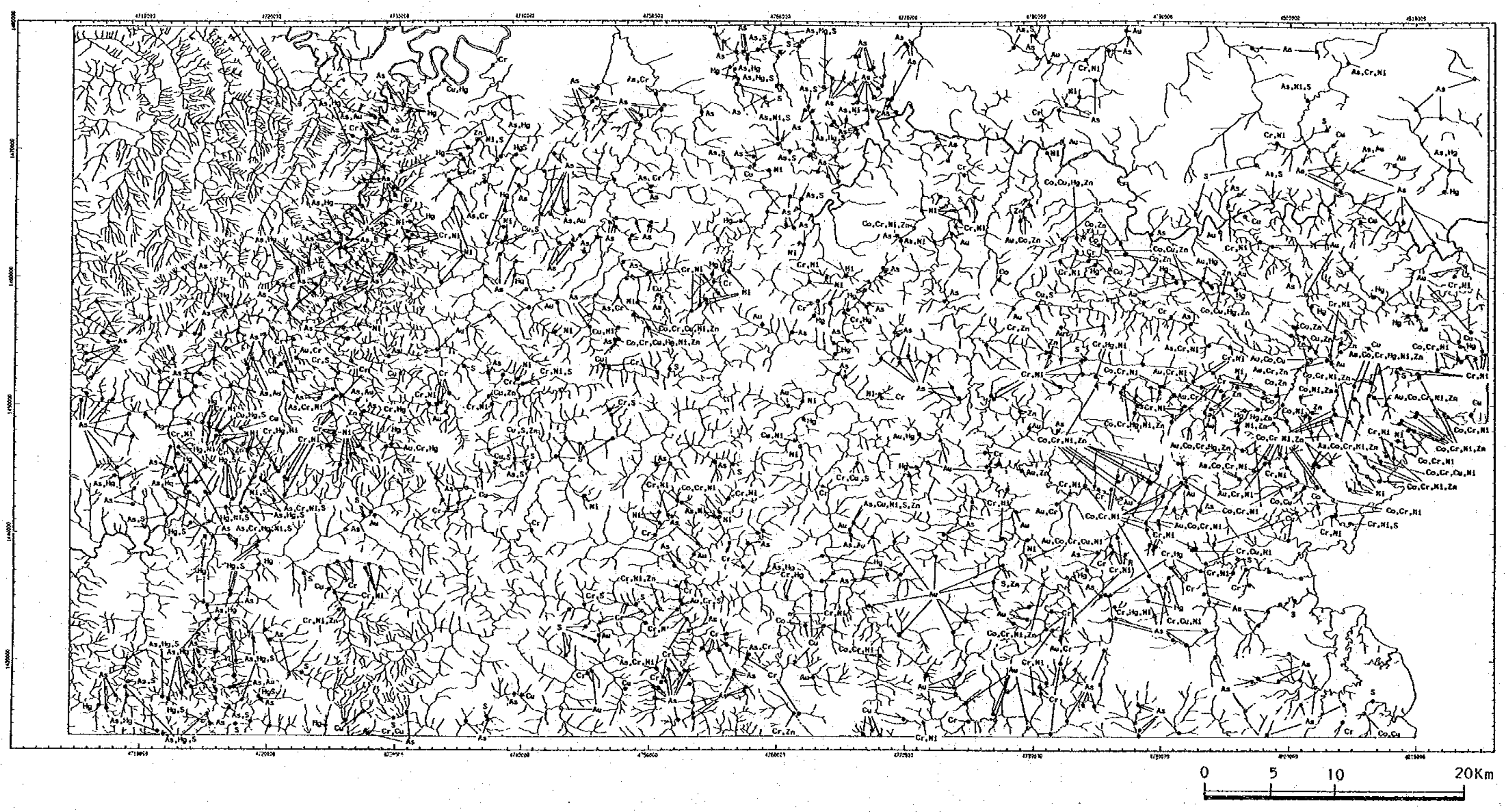

Fig. II-1-4 Distibution map of anomalous stream sediment samples for major elements in the segama area

Zn : Anomalous value is 155.5 ppm. Anomalous and high value samples are found in the area of the ultra-basic rocks and basic rocks and basement rocks. Samples with high value are recognized in the area of Kuamut formation in the western part of the area.

Judging from the distribution pattern of the anomalous and high value samples, ditribution of some elements well corresponds to the geology but distributions of some elements are not related with the geology. The elements including Co, Cr, Mg, Mn, Na, Ni, Sb, Ti and Zn show higher values in the area of the ultra-basic and basic rocks. The elements of Au, Mn, Na, Sb, Sr, Ti and Zn show high concentration in the zone of the basement rocks. The element including As, K, Pb and U show high value in the area of the sedimentary rocks. The element including Ba, Cu, Hg, Mo, S and W show no distinct relationship with the geology. High value Cu samples are sporadicaly recognized in the areas of the basement rocks and basic rocks, and are concentrated in the areas of the Chert-Spilite formation. This fact may reflect the copper mineralization in the Chert-Spilite formation. In the area of the Chert-Spilite formation, the element of As, Au, Ba, Hg, Mn and S show also relatively high values.

Judging from the distribution pattern of the elements, the elements reflecting the mineralization such as gold, copper, chromium and nickel are As, Au, Cr, Co, Cu, Hg, Ni and S. Locations of anomalous sample for above-mentioned nine elements are shown in Fig. II-1-4.

(3) Multi elements analysis

Cluster analysis being a method of the multi elements analysis is conducted to clarify the relationship among the elements. Dendrogram of element obtained from the cluster analysis is shown in Fig. II-1-5. In the dendrogram, the groups of elements including Zn-Co-Mg, Mn-Ti, Cr-Ni, Na-Sr and U-Ba-K form clusters. These elements making a group show the similar distribution tendencies as shown in the the distribution maps of each element. Judging from the results of the cluster analysis, the cluster of Zn-Co-Mg, Mn-Ti and Cr-Ni corresponding to the ultra-basic and basic rocks, the cluster of Na-Sr corresponding to the basement rocks and the cluster of U-Ba-K corresponding to the sedimentary rocks.

In addition to the cluster analysis, factor analyses by varimax rotation were conducted. Results of the factor analyses are shown in Table II-1-3. As the results, seven factors were delineated. Elements closely related with each factor are as follows;

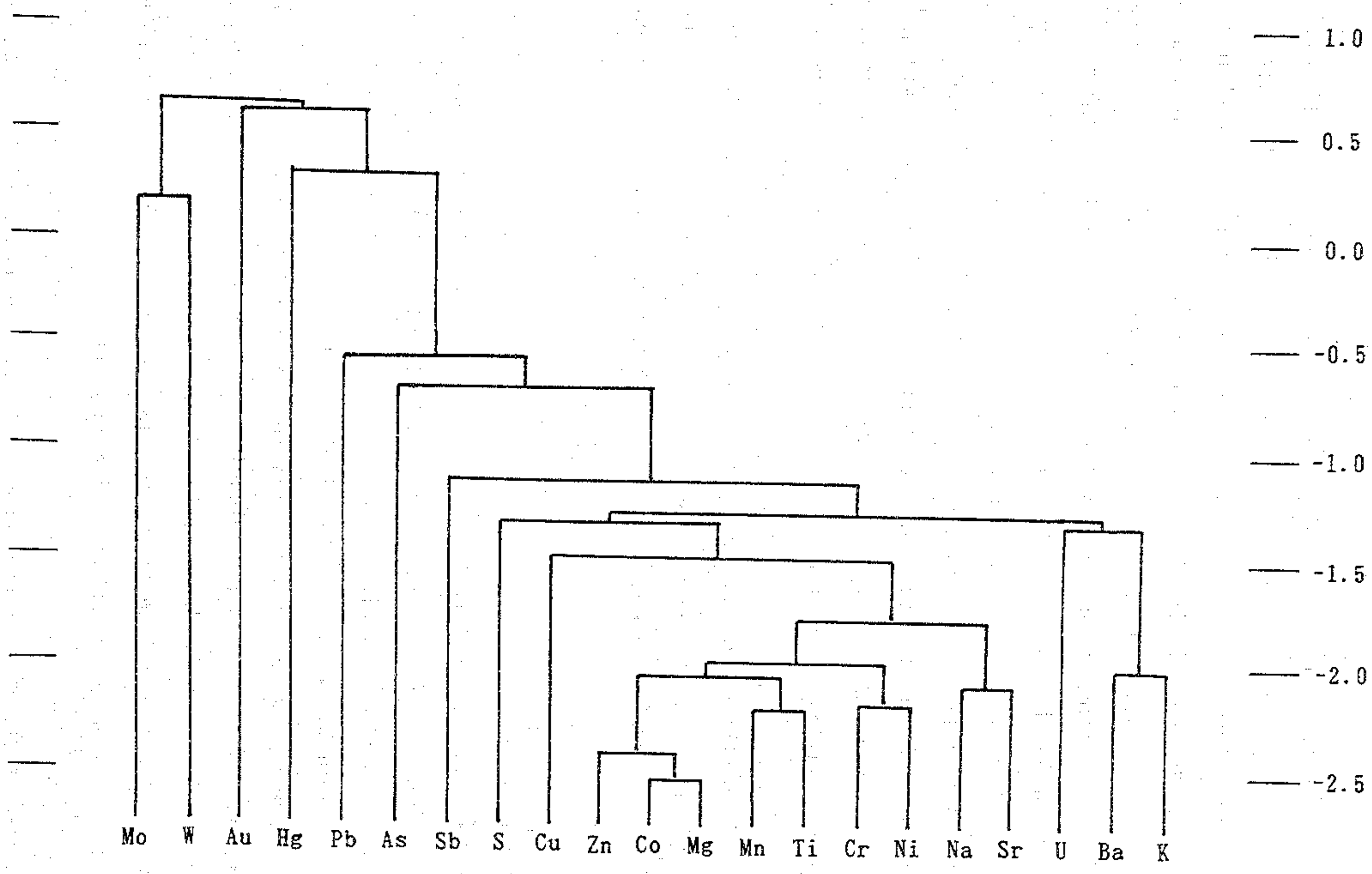

Fig. II-1-5 Dendrogram of elements for stream sediments in the Segama area

Table II-1-3 Results of factor analyses for stream sediments in the Segama area

Element	Factor loadings (Varimax rotation)							Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	
As	0.267	-0.124	-0.131	-0.241	0.027	-0.523	-0.080	0.4426
Au	-0.046	0.014	-0.015	0.023	0.020	-0.002	0.245	0.0636
Ba	-0.096	-0.821	-0.205	-0.191	-0.012	-0.002	0.021	0.7624
Co	-0.639	0.244	0.594	-0.014	0.075	0.195	0.181	0.8980
Cr	-0.053	0.244	0.853	-0.007	0.049	0.024	0.029	0.7935
Cu	-0.761	-0.190	0.253	-0.004	-0.001	0.044	-0.049	0.6840
Hg	-0.091	-0.194	0.063	-0.413	0.051	-0.135	-0.070	0.2461
K	-0.108	-0.868	-0.163	-0.068	-0.004	-0.103	-0.150	0.8295
Mg	-0.706	0.179	0.573	0.170	0.075	0.197	0.081	0.9379
Mn	-0.537	0.200	0.357	0.090	0.082	0.397	0.411	0.7972
Mo	-0.043	-0.036	-0.063	-0.088	-0.507	-0.025	-0.041	0.2742
Na	-0.807	-0.082	0.087	0.224	0.085	0.199	0.237	0.8185
Ni	-0.321	0.134	0.854	-0.030	0.049	0.046	-0.070	0.8606
Pb	0.307	-0.171	-0.098	-0.435	-0.200	-0.053	-0.165	0.3920
S	-0.753	-0.043	0.095	-0.154	-0.074	-0.051	0.100	0.6197
Sb	-0.208	0.064	0.417	0.245	-0.101	0.220	0.438	0.5316
Sr	-0.694	0.037	-0.095	0.245	0.132	0.266	0.411	0.8095
Ti	-0.505	0.318	0.231	0.118	0.115	0.356	0.545	0.8600
U	0.438	-0.618	-0.182	-0.186	-0.072	-0.135	-0.066	0.6687
W	0.073	0.012	0.014	0.066	-0.498	0.025	-0.007	0.2584
Zn	-0.685	0.147	0.503	-0.190	0.020	0.199	0.231	0.8734
F.C.*1	35.3 %	17.0 %	22.1 %	5.9 %	4.7 %	6.6 %	8.4 %	—

*1: Factor contribution

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

Among these factors, Factor 1, 2, 4 and 5 show negative relationship with above-mentioned elements. Factor 1 may have weak relationship with copper mineralization. Factor 2 may have relation with the sedimentary rocks. Factor 3 is interpreted to be related with the ultra-basic rocks, basic rocks and Chert-Spilite formation. This factor also have some relation with mineralization of chromium and nickel. Factor 4 is weakly related with the sedimentary rocks. Other factors are difficult to clear the relationship. Distribution maps of factor score of factor 1 and factor 3 which possibly have some relation with mineralization are shown in Fig. II-1-6 and Fig. II-1-7 respsectively. Distribution tendencies of high factor scores for these factors are as follows;

Factor 1 The high factor score (negative) zones are distributed in the area of the basement rocks around the lower stream of Sungai Segama and Sungai Kawag, in the area of the Chert-Spilite formation distributed between Sungai Dewata and Sungai Sabahan. These zones are also found in the area of the basement rocks occured from Sungai Bole to the middle stream of Sungai Segama, and in the areas of ultra-basic rocks and Chert-Spilite formation around the upper stream of Sungai Segama. The areas of the basic rocks and Chert-Spilite formation distributed in the upper stream of Sungai Danum to Sungai Malubuk have also high score zones. Copper ore deposits expected in this area is Cyprus type copper ore deposits occurring in the Chert-Spilite formation, therefore the zones of the high factor score in the Chert-Spilite formation are important for a potentiality of copper mineralization.

Factor 3 Zones of high factor score are distributed in the areas of the ultra-basic rocks, basic rocks and Chert-Spilite formation from the west of Silam to the upper stream of Sungai Kawag, the ultra-basic rocks basic rocks and Chert-Spilite formation from the central part to the western part of the area. Chromium and nickel deposits expected in this area are situated in the ultra-basic rocks and surrounding laterite, therefore the limited zones of high factor score from the west of Silam to the upper stream of Sungai Kawag are important for the chromium and nickel deposits.

Factor 1

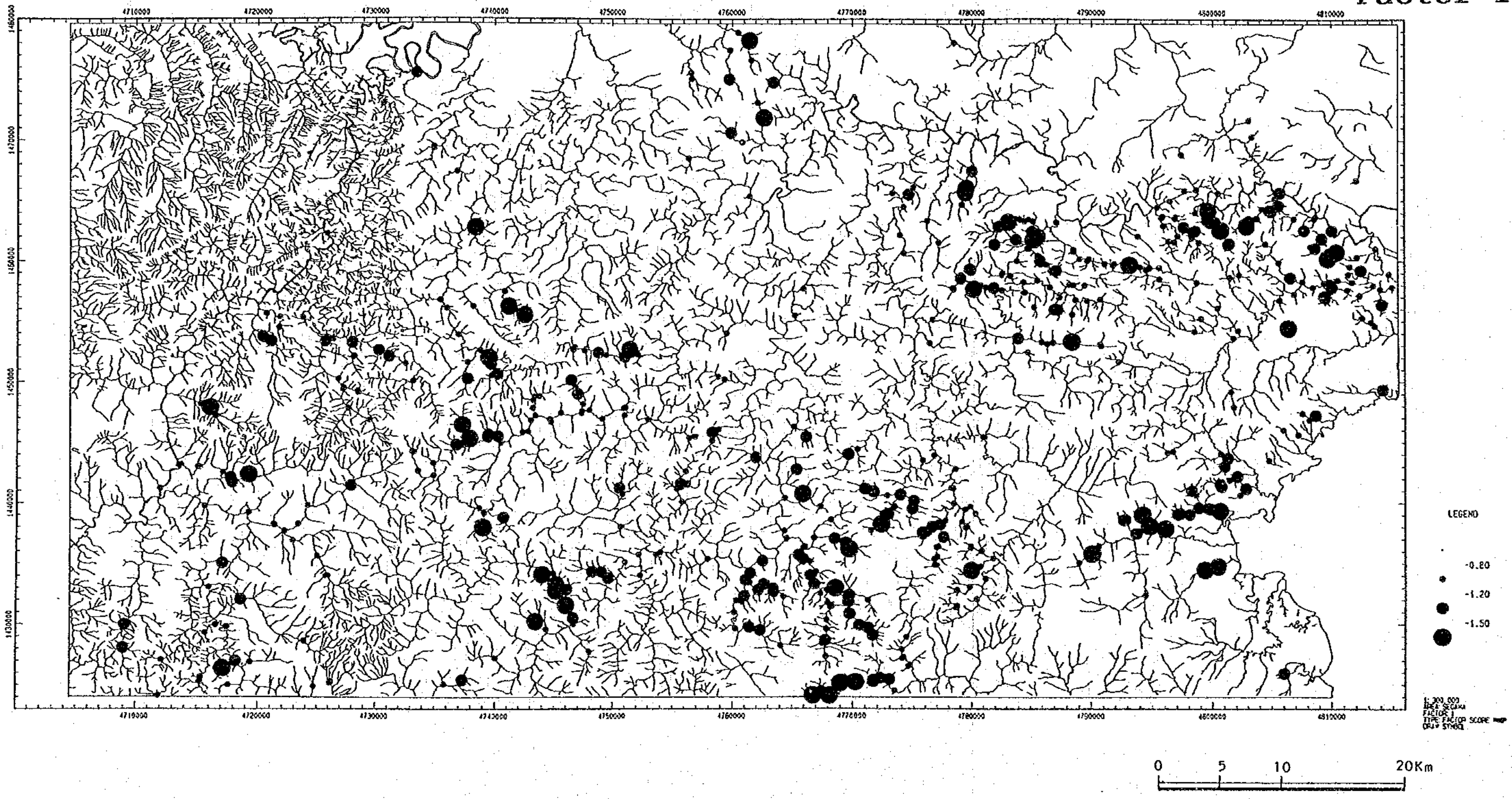

Fig. II-1-6 Distribution map of factor 1 factor scores for stream sediment samples in the Segama area