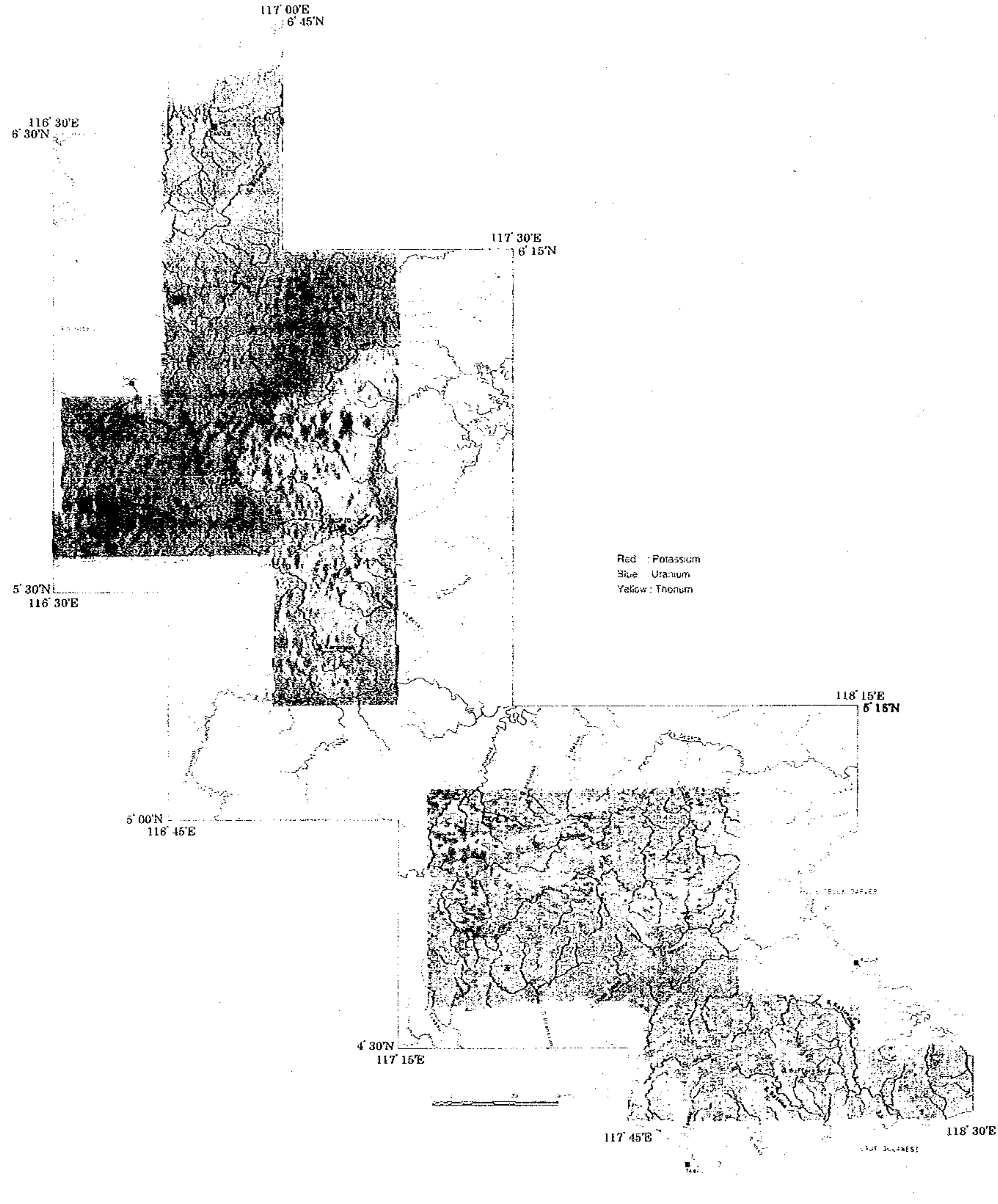


Fig. II-3-4 Radiometric ternery map of the survey area

magnetic anomalies of large amplitude on the total field magnetics map. Tuff and sandstone of different age indicate different values. This fact may suggest the different sedimentary environment. Some hydrothermally altered rocks show low magnetic susceptibility. While, the results of radioactivity measurements are not satisfactory, because the volume of each rock sample seem not to be large enough to measure radioactivities.

(2) Results of magnetic survey

The magnetic anomaly map of the survey area is shown in Fig.II-3-5. Highly magnetized rocks and magnetic discontinuity lineaments are delineated qualitatively and quantitatively from the total field magnetics map.

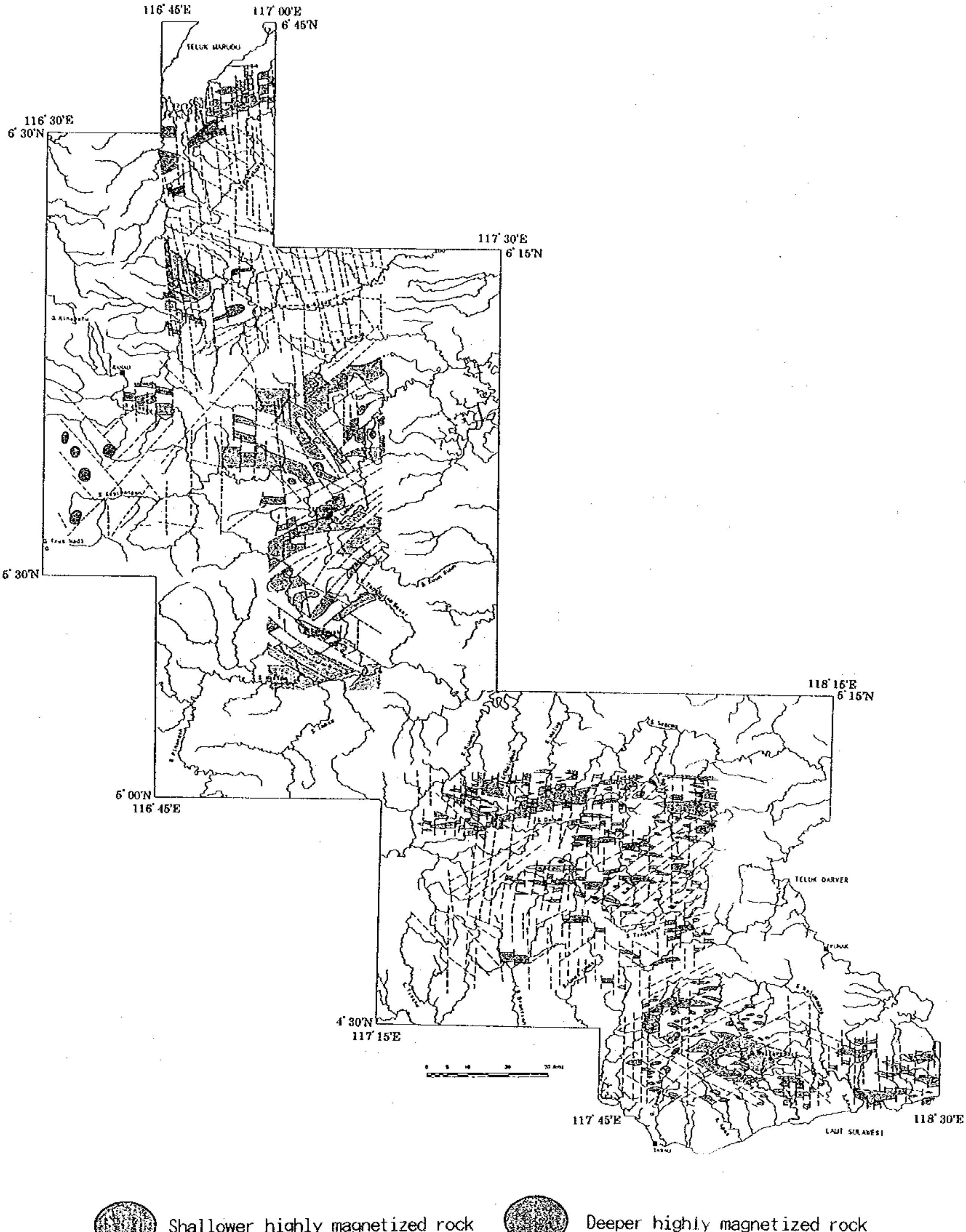
Northern Kinabalu area

In the northern part of the northern Kinabalu area, magnetic anomalies of large amplitude and short wave length are aligned in E-W and ENE-WSW directions and form a large-scale low magnetic anomalies trending in an ENE-WSW direction. These anomalies suggest the existence of magnetized bodies near surface, which are bounded at the north and south edges by magnetic discontinuity lineaments trending in E-W and ENE-WSW directions, and divided by N-S trending magnetic discontinuity lineaments. These causative bodies correspond to the distribution of the Chert-Spilite(KPcs) formation.

In the central part of the northern Kinabalu area, low magnetic anomalies of long wavelength and relatively large amplitude are found at the western side, and a number of small scale magnetic anomalies are distributed entirely. There are distribution of a number of N-S and NW-SE trending magnetic discontinuity lineaments. Low magnetic anomalies at the western side are due to the highly magnetized bodies such as ultra-basic rocks at depth.

At the southwestern part of the northern Kinabalu area, there are a distribution of a number of large-amplitude magnetic anomalies of relatively short wavelength aligning in NW-SE direction, which seem to be caused by the highly magnetized rocks near surface. Those rocks are bounded at the north and south edges by NW-SE trending magnetic discontinuity lineaments and divided into small blocks by N-S trending magnetic discontinuity lineaments. These anomalies are due to ultra-basic rocks, adamellite, granodiorite and Chert-Spilite (KPCs) formation near surface and/or at the shallower part.

High magnetic anomalous zone is found at the east of the above magnetic anomalies, suggesting sediment rocks of low magnetics are dominance. This part



Shallower highly magnetized rock   Deeper highly magnetized rock

Magnetic discontinuity lineament

Fig. II-3-5 Magnetic anomaly map of the survey area

shows the similar distribution of magnetic discontinuity lineaments trending in NW-SE to WNW-ESE directions and N-S direction as those at the south western part. There are a distribution of NE-SW trending lineaments at the southeastern part which are found at the north of the Labuk area.

Southern Kinabalu area

In the high magnetic anomalous zone in the Southern Kinabalu area, the values of total field magnetics increase towards the southeast where low magnetic bodies such as sandstone and mudstone occur.

Contour lines trending in a N-S direction are distributed predominantly. This direction reflects the geological structure in the area. Those of NW-SE, NS to NNW-SSE, and EW directions are dominated in the western, central-to-northern and central-to-southern parts, respectively.

Magnetic anomalies of relatively long wave-length and small amplitude show alignments in NW-SE at the west, N-S and E-W directions at the central-to-southeast and south parts. These magnetic anomalies seem to be caused by highly magnetized rocks (intrusive rocks) at depth. According to the results of curve matching method, these magnetic anomalies are caused by highly magnetised bodies at a depth of 1 - 2 km below ground level and the susceptibilities of $0.2 - 0.7 \times 10^{-3}$CGSemu, corresponding to dacite and/or gabbro.

At the north of this high anomalous zone, there occurs a part of a long wave-length and large-scale low magnetic anomaly. While at the northwest end short wave- length magnetic anomalies of large amplitude are distributed, which are thought to be induced by magnetized rocks at and near the ground surface.

Labuk area

Magnetic anomaly distribution shows a remarkable difference between the southern Kinabalu and Labuk area. That is, small scale low magnetic anomalies of short-wave-length are dominance in the Labuk area. These anomalies correspond to highly magnetized rocks such as the Chert-Spilite formation and ultra-basic rocks.

Short wave-length magnetic anomalies are dominated in the Labuk area, which show 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 alignments reflect the geology and geological structure in the area.

At the northwestern part, short wave-length anomalies of relatively large amplitude align in a direction of NNW-SSE to NW-SE, which suggest the existence of highly magnetized rocks near ground surface and magnetic discontinuity lineaments with the same direction. And these highly magnetized rocks are divided into small blocks by N-S trending magnetic discontinuity lineaments.

At the northeastern part, magnetic anomalies of small amplitude align in the NE-SW direction, and the causative bodies seem to show weaker magnetization than those at the southern Kinabalu area. The magnetized bodies are also divided into small blocks by N-S trending magnetic discontinuity lineaments similarly at the Southern Kinabalu area.

At the western side of the central part, low magnetic anomalies of relatively large amplitude surround the large high magnetic anomalous zone and align in NW-SE and NE-SW to ENE-WSW directions at the north and south of the zone, respectively, which suggest the existence of highly magnetic bodies of relatively large scale. On the other hand, at the eastern side, high magnetic anomalies of small amplitude dominated, and small-amplitude magnetic anomalies of short wave length align in ENE-WSW direction, which are caused by relatively low magnetized bodies trending in the same direction.

At the southern part, short wave-length magnetic anomalies align in NW-SE to WNW-ESE directions, caused by highly magnetised rocks near ground surface. Many magnetic discontinuity lineaments trending in NW-SE to WNW-ESE and N-S to NE-SW directions, are also found there.

Relatively large-scale low magnetic anomalies are found at the south end, caused by highly magnetized bodies of large scale near ground surface and at the shallower part.

The highly magnetized rocks are possibly ultra-basic rocks and slightly lower than this are the Chert-Spilite formation.

<u>Segama area</u>

E-W trending magnetic anomalies of large amplitudes occur at the north. A lot of small-scale magnetic anomalies with an E-W direction are distributed at the western and eastern parts and long wave-length magnetic anomalies are found at the southeastern end of the area. These anomalies are caused by ultra-basic rocks at the ground surface. Magnetic discontinuity lineaments trending in E-W and NE-SW are found predominantly, by which highly magnetized bodies are divided into a lot of small blocks.

There are high magnetic anomalies of long wave-length at the western-to-southwestern part, reflecting the distribution of non-magnetic sedimentary rocks.

And in the southwestern part, magnetic anomalies of small amplitude and relatively short wave length are found in the southwestern high-magnetic anomalies. Those small anomalies suggests the existence of highly magnetized bodies at the shallower part, corresponding to intrusive rocks of ultra-basic rocks. Moreover, these highly magnetized bodies are divided into small blocks by magnetic discontinuity lineaments trending in the NE-SW to ENE-WSW directions.

Northern Semporna area

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

At the central to eastern part, there occur a lot of magnetic anomalies of small amplitude and relatively long wave-ength suggesting the existence of highly magnetized bodies at the shallower part. These highly magnetized bodies seem to correspond to ultra-basic rocks which occur in the sedimentary rocks. These bodies are sepalated into small blocks by NE-SW to ENE-WSW trending magnetic discontinuity lineaments.

Southern Semporna area

This area is located at the south of high magnetic anomalous zone of the northern Semporna area, and magnetic anomalies of large amplitude are distributed showing circular pattern opened southward. At the south of the circular pattern, there occur a lot of low magnetic anomalies of short-to-long wave length. At the western side of the area, magnetic changes are very small so that it suggests non-magnetic rocks such as sedimentary rocks are dominance.

Magnetic discontinuity lineaments trending in N-S, NW-SE and NE-SW directions are distributed in this area. The northern end of the circular pattern is limited by NW-SE and NE-SW trendingmagnetic discontinuity lineaments. A lot of low magneticanomalies of long-to-short wave length are distributed at the south of the circular pattern, which are due to highly magnetized bodies such as andesite at the ground surface. And these bodies extend toward the southeast, but decrease in sizes.

At the southeastern part, low magnetic anomalies of large amplitude extending in E-W directions, reflecting the existence of highly magnetizedbodies such as andesite at the ground surface are found. These highly magnetized bodies are divided into small blocks by N-S trending magnetic discontinuity lineaments.

(3) Results of radiometric survey

A radiometric anomaly map showing the distribution of high count anomalies of total count (T.C.) radiomerics and radiometric discontinuity lineaments were delineated qualitatively from "Total Count Radiometrics" and "Ternery Map". The radiometric anomaly map is shown in Fig. II-3-6.

Northern Kinabalu area

In the northern Kinabalu area, high total count(T.C.) values are found in the whole area. Within these high values, low T.C. zones are found sparsely. Potassium (K) high count zone coincides almost with high total count zone so the total count radiometrics in this area are mainly contributed by potassium. Very high T.C. anomalous zones are distributed at the southwestern and southeastern parts of the area. The south western very-high anomalous zone which shows large contribution of uranium(U) and thorium(Th) is located on low magnetic anomalies due to basalt.

High count anomalies aligned in N-S directions are predominantly distributed and those aligning in NW-SE and NE-SW directions are also found.

Southern Kinabalu area

Very high total count zones are found at the central to southwestern part in a high total count zone. It is difficult to infer radiometric discontinuity lineaments in this area due to high background counts.

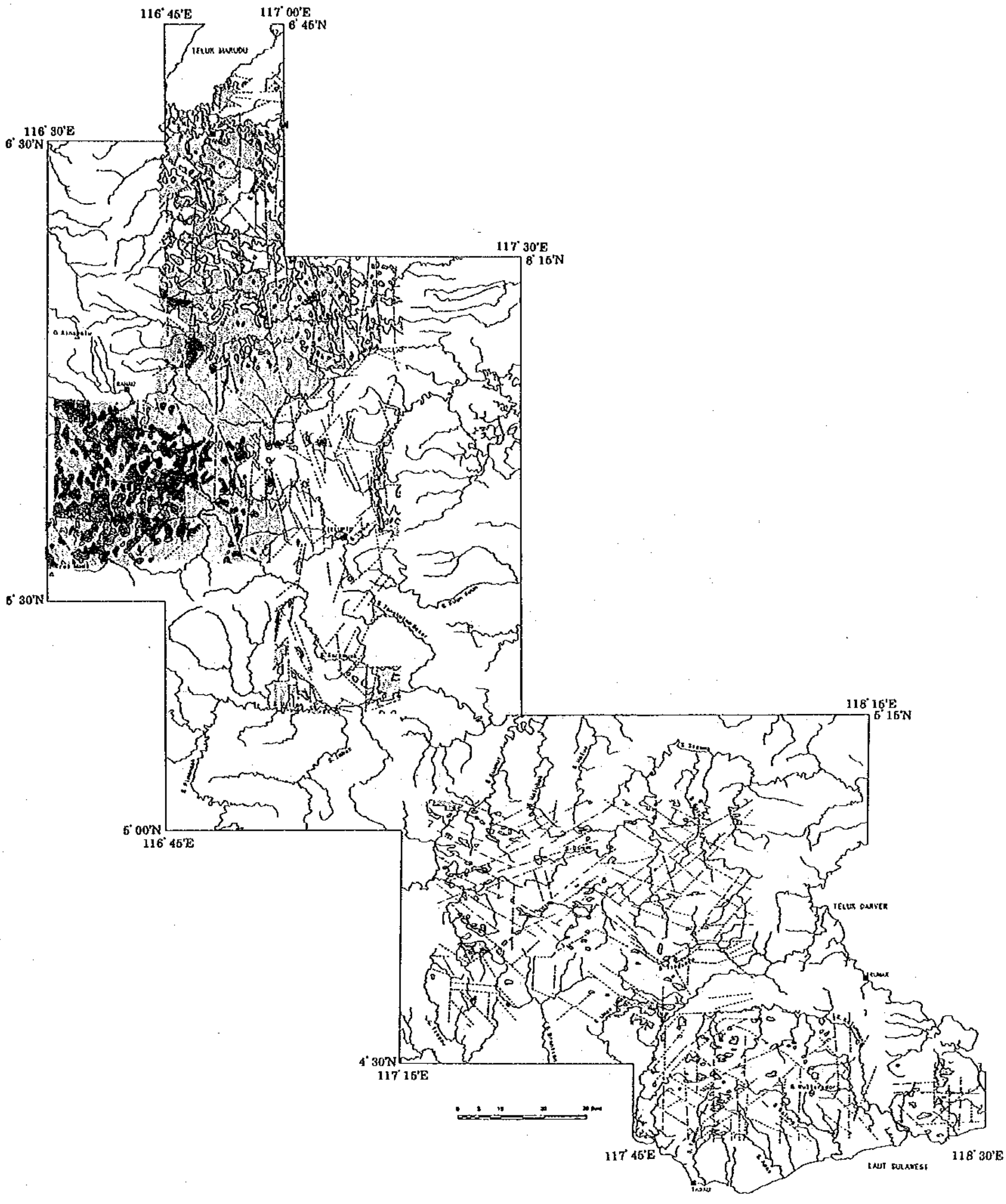
As a potassium(K) high count zone coincide almost with a high total count zone, the total count radiometrics in this zone are contributed by potassium mainly.

While, there are small-scale uranium(U) high count anomalies in the central to south western part, uranium radiometrics also contribute to the total count.

Labuk area

The Labuk area is occupied by low total count radiometrics, and high total count radiometrics are found broadly at the northeastern, southeastern, south-western and southern parts, and scarcely at the central part. Those, except for that at the southern part, align in NNW-SSE, N-S and NNE-SSW directions. These directions correspond to the main geological structure in this area, and separate the highly magnetized bodies into small blocks.

Potassium (K) high count radiometrics are distributed broadly at the northeastern and southern parts, where total count radiometrics are contributed by potassium mainly. Uranium(U) shows low count in the whole area, but there are small-scale uranium high count anomalies in the central part. Thorium (Th) high count zones are concentrated at the southeastern and southwestern parts, where thorium



Very high total count (T.C.) zone
High total count (T.C.) zone
Radiometric discontinuity lineament

Fig. II-3-6 Radiometric anomaly map of the survey area

contributes to total count radiometrics mainly.

Segama area

The Segama area is occupied by low total counts except the western side, and small-scale high count anomalies are isolated, which are contributed by potassium only. There occur many radiometric discontinuity lineaments trending in NW-SE to WNW-ESE and NE-SW to ENE-WSW directions.

On the other hand, at the western side, there are distribution of high total count anomalies controlled by NW-SE to WNW-ESE trending radiometric discontinuity lineaments. Uranium high count anomalies are found at the same locations of high total count anomalies, where contribution of uranium to total count occupy very large portion. These high uranium count anomalies extend to the western side of the northern Semporna area.

Northern Semporna area

This part is occupied by high total count zone, corresponding to the sedimentary rocks. Radiometric discontinuity lineaments are distributed in the direction of NW-SE at the central, and E-W, NW-SE and NE-SW. Spotted low- count zones are found where highly magnetized bodies such as ultra-basic rocks existed at the ground surface and/or at the shallower part. Except for the western side, uranium high count anomalies of small scale are spotted and total count are contributed by potassium mainly.

Southern Semporna area

In the south western part, high count radiometric rocks are distributed circularly at the north of the circular pattern and overlapping partially the distributions of the highly magnetized bodies at the south of the circular pattern. ENE-WSW trending radiometric discontinuity lineaments are dominated, and a N-S trending radiometric lineament is found at the western end as shown on the total field magnetic map. Potassium contributes total count radiometrics mainly. Uranium high count anomalies of small scale are isolated, but according to the ternery map uranium count become higher southward from the southern end.

In the south eastern part of the area, high count radiometric anomalies are distributed overlapping partially the highly magnetized rocks such as andesite. Potassium contributes total count radiometrics mainly. Uranium high count anomalies of small scale are isolated.

Chapter 4 Regional geochemical survey

4-1 Coverage of work

The regional geochemical survey was completed in the entire area covering 26,500 km^2. This area is subdivided into four areas of the Kinabalu, Labuk, Segama and Semporna areas.

4-2 Methodology and work amounts

(1) Methodology

Using the optimum survey methods deliniated by the orientaion survey in Phase I, the regional geochemical survey was carried out for entire four areas which are the Kinabalu, Labuk, Segama and Semporna areas in order to assess the mineral potential 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 geological 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 point the sample was collected from the edge of stream flow which is the optimum samplimg site determined from the orientation survey. The sample collected is - 60 mesh fraction sample. Sample density applied is 2 km^2/sample except in flat area where the density in the flat area is 4 km^2/sample. The sampling work could not be conducted in the mountainous areas in the Kinabalu area and western part of the Segama area. The sampling work also could not be conducted in a northern part of Kinabalu area and a northeastern part of the Labuk area which is widely occupied with swamp.

At each sampling site, the scale of stream, color and grain size of sediment etc. were described and sample list was prepared. More than 150 grams of -60 mesh fraction sample were collected at each sampling site. After drying up the sample, the sample was divided into two samples. One is for chemical analyses and other is for storage in the Geological Survey of Malaysia, Sabah office. The samples for the chemical analyses were sent 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 panning of five pan (approximately 25 liters). The sample density of the pan concentrate sample is 40 km^2/sample. The samples were dried up and weighed. Qualitative Mineral Examination (QME) was conducted for these samples.

During the survey, representative rock samples were collected and chemically analyzed. The elements analysed are the 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. Each sample was collected at the top of B horizon. The sampling density is 3 km^2/sample. The sample collected are dried up then sieved and -80 mesh fraction sample was collected for the chemical analyses.

The work was conducted by camp and flying camp along the streams.

(2) Work amounts

The work amounts completed for each area is as follows:

Area	Kinabalu	Labuk	Segama	Semporna	Total
Geochemical survey					
Stream sediments	3,342 spls	2,974 spls	2,740 spls	2,580 spls	11,636 spls
Pan concentrates	193 spls	169 spls	175 spls	160 spls	697 spls
Rock	52 spls	70 spls	51 spls	50 spls	223 spls
Soil	48 spls	225 spls	74 spls	17 spls	364 spls
Laboratorial studies					
Thin section	5 spls	1 spls	12 spls	10 spls	28 spls
Polished section	1 spls	2 spls	5 spls	5 spls	13 spls
X-ray diffraction	0 spls	0 spls	5 spls	5 spls	10 spls
Ore assaying	6 spls	5 spls	5 spls	5 spls	21 spls

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

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

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

Element	Detection limit	Element	Detection limit	Element	Detection 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 detection limits are as the following:

Element	Detection limit	Element	Detection limit	Element	Detection limit
Au	0.1 g/t	Fe	0.01 %	Pt	3 ppb
Ag	0.1 g/t	Mo	1 ppm	S	0.01 %
Co	1 ppm	Ni	1 ppm	Zn	1 ppm
Cr	1 ppm	Pb	1 ppm		
Cu	1 ppm	Pd	2 ppb		

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

4-3 Data processing and analyses

The analytical results of the stream sediment samples were treated by computer Statistical data treatment. Single element and multi element analyses were made using these analytical data.

In order to carry out the single element analyses, histograms and cumulative frequency graphs were prepared and statistics for each element were calculated. A half value of the detection limit was used for the sample indicating less than the detection limit of the element in this calculation. The means calculated are the geometric means.

The drainage system of the survey areas were input in the computer using digitizer and distribution maps of each element were prepared. The correlation 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 for the multi element analyses, cluster and factor analyses were utilized in this survey. The cluster analysis is a grouping method of elements using correlations among the elements. The factor analysis is the method to delineate the factor which forms the relationship among the samples.

For the pan concentrate samples, magnetite and ilmenite were separated using magnet and the remaining samples were observed under a microscope to determine the minerals and their volume percentage. 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 from the results of the chemical analyses. The data analyses and interpretation were made using newly prepared geological maps in this survey.

4-4 Survey results

4-4-1 Geology and mineralization

(1) Geology

The survey area is underlain by pre-Triassic crystalline rocks, Cretaceous to Tertiary ultra-basic to basic rocks, Tertiary to Quaternary sedimentary rocks and Pliocene to Holocene volcanic rocks according to Y.E. Heng; 1985. A geological map is shown in Fig.I-2 compiled using the previous geological data and the data obtained from the present survey.

The crystalline rocks (Cb) widely occur as the basement rocks from the eastern part of the Segama area to the northern marginal part of the Semporna area. Basement rocks are also found in the small area of the eastern part of Labuk area along Sungai Tungud. These rocks composed mainly of gneiss, schist and amphibolite with subordinate tonalite, granodiorite and granite.

Pre-Cretaceous limestone occurs in a small area at the northeastern part of the Segama area.

Cretaceous to Tertiary ultra basic to basic-rocks (Ub) are found in the surrounding zones of the crystalline rocks in the Segama area and occur as the basement rocks in the Kinabalu and Semporna areas. Ultra-basic rocks are also foundwith a N-S direction in the central part of the Labuk area. The ultra-basic rocks composed mainly of serpentinite, serpentinized peridotite and amphibolite. The basic rocks composed of dolerite and gabbro. Chert-Spilite formation (KPCs) is found surrounding 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 basaltic pyroclastic rocks deposited during the Cretaceous to Eocene in age.

The Sapulut formation (KPSp), which is Late Cretaceous to Late Eocene age, occurs in the southern part of the Labuk area streching a WNW-ESE direction. This formation consists of mudstone with subordinate sandstone, chert and conglomerate.

In the southern part of the Kinabalu area, the Trusmadi formation (P_1Ts) is widely found. This formation consists of phyllite and shale with subordinate siltstone and sandstone. The river systems in this formation form extremely steep topography.

The eastern part of the Labuk area is widely occupied by the Kulapis formation (P_2Ks) of Eocene to Oligocene age. This formation mainly consists of massive sandstone. The Crocker formation (P_2Cr) of Eocene to Oligocene age occupies most parts of the Kinabalu area and the northern to eastern part of the Labuk area. This formation consists mainly of sandstone with intercalation of shale and siltstone beds.

Eocene to Oligocene formations are covered by the Oligocene formations of the Labang formation (P_3Lb) and the Kudat formation (P_3Kd). The Labang formation is distributed southwestern margin of the Labuk area and northwestern part of the Segama area. This formation consists of siltstone, shale, midstone and conglomerate. From the northern part of the Labuk area to the eastern part of the Kinabalu area, the Kudat formation (P_3Kd) is distributed in a small area. This formation also consists of sandstone, siltstone, shale, mudstone and conglomerate.

Sedimentary rocks of Oligocene to Middle Miocene age are classified into the Wariu formation (P_4Wr), the Garinono formation (P_4Gr), the Ayer formation (P_4Ay), the Kuamut (P_4Km), the Kalabakan (P_4Kl) and the Kalumpang formation (P_4Kg). The Wariu formation (P_4Wr) is distributed in the small area in the northwestern part of the Kinabalu area and consists of sandstone and mudstone with minor intercalation of tuff. The Garinono formation is found in the central east part of the Labuk area and consists of slump breccia, mudstone , tuff, sandstone and shale. The Ayer formation occurs at the northeastern margin of the Segama area and cosists of tuff, slump breccia, mudstone and sandstone. The Kuamut formation covers wide area from the Segama to the Semporna areas. This formation consists of conglomerate, sandstone and siltstone and is characterized by slump breccia. At the western part of the Semporna area, the Kalabakan formation occurs and is formed by sandstone, siltstone mudstone and shale. The eastern part of the Semporna area is widely occupied by the Kalumpang formation which consists of tuff, tuffaceous sandstone, shale and mudstone.

From southern part of the Labuk area to the western part of Semporna area through the western part of the Segama area, the Tanjong formation (N_2Tj) of Early to Middle Miocene age occurs. This formation consists of mudstone, sandstone, siltstone and conglomerate. At the western part of the Semporna area, the Kapilit formation (N_2Kp), which is the same age as the Tanjong formation, is distributed in a small area. This formation mainly consists of mudstone and siltstone.

At northeastern margin of the Labuk area, the Bongoya formation (N_4By) of Middle Miocene to Pliocene age is found. This formation consists of sandstone, mudstone, siltstone and conglomerate. In the central part of the Semporna area, the Umas Umas formation (N_4Um) has a limited distribution. This formation composed of sandstone, shale and mudstone. In a small area along Sungai Balung in the Semporna area, the Balung formation (N_4B) occurs. This formation consists of ash, tuff, mudstone and shale.

The south central to southeastern part of the Semporna area is widely covered with Pliocene volcanics (I_1) and Pleistocene to Holocene volcanics. The Pliocene volcanics are classified into andesite dominance part and dacite dominance part. The Pleistocene to Holocene volcanics consists of dacite, basalt and their pyroclastics.

Small intrusive bodies of Oligocene to Late Miocene in age include adamellite, granodiorite, andesite porphyry and dacite porphyry are distributed in the central part of the Kinabalu area. A small body of diorite porphyry of Oligocene age occurs at the southern margin of the Labuk area. Mineralization and alteration are found in this body. In the volcanic zones of the Semporna area, small bodies of fine-grained diorite and granodiorite are found.

Pleistocene terrace deposits (Q_1) are found along the rivers and alluvium sediments (Q_2) are found along the coast and rivers. Terrace deposits are widely distributed in the south central to the southeastern part of the Semporna area.

The most significant fault system is the N-S system and other systems including ENE-WSW, NE-SW and NNW-SSE systems are also recognized (Y.E. Heng; 1985) in the Kinabalu area. On the other hand, in the Labuk area, a N-W system is dominance and N-S and NNW-SSE system faults are also observed. Many different systems are found in the Segama area and the systems form complicated geological structure. The Semporna area is characterized by a ENE-WSW direction which is the general trend of the volcanics in the area. Among the fault system, NNW-SSE and NNE-SSW are dominance in the Semporna area. A ring structure is found at the margin of the volcanic zone.

(2) Mineralization

The most significant mineralization in the survey area is the Mamut copper ore deposits situated north of Ranau in the Kinabalu area. This ore deposit is a porhyry copper type ore deposits hosted by adamellite of Pliocene to late Miocene age. Other significant mineral showings are the Bidu Bidu Hill ore deposits in the Labuk area and hydrothermal gold deposits near Mantri in the Semporna area. The Bidu Bidu Hill ore deposits is hosted by the Chert-Spilite formation and is a Cyprus-type massive sulfide deposits. The mineralization is also observed in several places in Chert-Spilite formation. Chromite showings are recognized in the ultra-basic rocks, but known showings are small in scale. In the area of ultra-basic rocks, lateritic soil are found. Potential of lateritic nickel deposits is expected in the area.

From the results of this survey, mineralized zones were confirmed in the upper stream of Sungai Danum in the Segama area. This mineralization is possibly a Cyprus-type copper deposits. The mineralization confirmed in this survey at the southern margin of the Labuk area, has potential for hydrothermal gold deposits.

4-4-2 Sampling

Samples of stream sediments, pan concentrates and rocks were collected along the rivers.

Descriptions of stream sediment at the sampling sites such as geology, scale of the stream, color and size of sediments, etc. were conducted. The locations of stream sediments samples are shown in Fig. II-4-1.

At the sampling site of pan concentrates, a description of the geology, river scale etc., were made, and the samples were weighed.

Rock samples collected are representative rocks of the survey area. At the sample site a description on the coordinates and geological unit were made.

The soil sampling was carried out in the zone of ultra-basic to basic rocks (Ub). A description on the coordinates, geology and topography at the each sampling site and color of soil were also made.

List and location of the samples for pan concentrate, rock and soil samples are shown in the reports of Phase II and III.

In addition to the above mentioned geochemical sampling, geological survey was simultaneously carried out and the samples for laboratorial studies were also collected. The laboratorial studies include thin section observation, polished section observation, x-ray diffraction analyses and ore assaying.

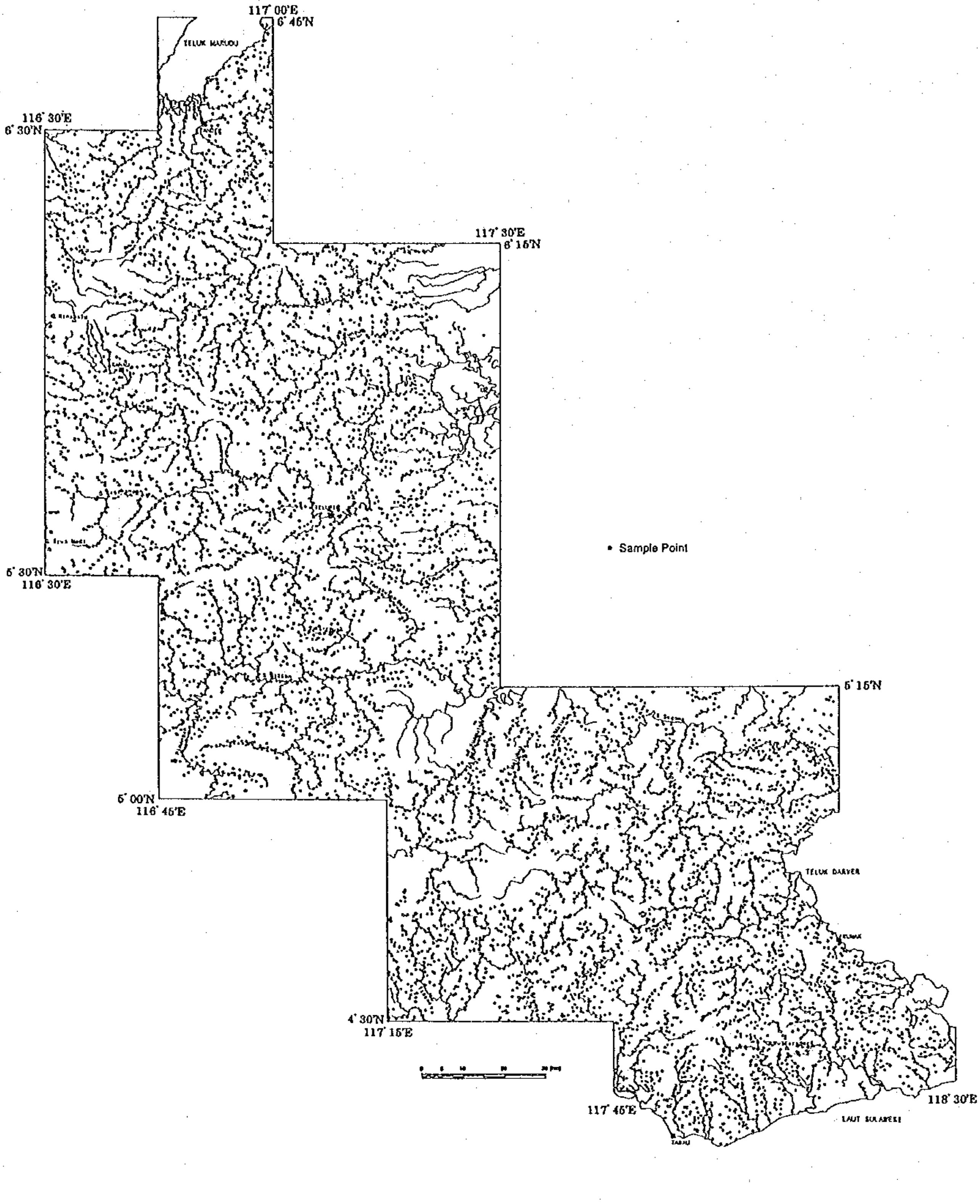


Fig. II-4-1 Location map of stream sediment samples in the survey area

4-4-3 Stream sediment geochemical survey

(1) Element

The stream sediment samples were chemically analyzed for 21 elements. Results of statistical processing conducted for the analytical results are given in Table II-4-1. Analytical results of Mo (81.1 %) and W (90.0 %) give values of less than the detection limits for most the samples. The maximum values of Au (9,320 ppb), Cr (11.75 %), Hg (24,736 ppb), Sb (3,488.0 ppm) and Ti (51.07 %) are extreamly high values.

Correlation coefficient between the elements was calculated to clarify relationship among the elements. Correlation matrix is shown in Table II-4-2. Pairs of elements which has good correlation (more than 0.600 correlation coefficient) are as follows;

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

Pairs of element with significantly high correlation coefficient are Ba-K (0.800), Co-Mg(0.860), Cr-Ni(0.841) and Na-Sr(0.809). Au has no good correlation with other elements. Cu has good correlation (more than 0.500) with Mg, Mn, Na, Ni, S and Zn.

(2) Single element analysis

From the results of the orientation survey in Phase I, geochemical anomalies of stream sediments were detected within 2 km from the ore deposits. The survey area was devided into 250 m x 250 m cell and the data within 2 km from the center point of each cell was calculated by reverse square distance. Each cell then colored depending on the calculated value. Distribution map of each element was made using this method.

An EDA method was applied to determine the threshold value (anomalous value). Results of the EDA method are shown in Table II-4-1. Value of Upper Fence was used as the threshold value. However, 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 where their threshold value is not obtained by this way, background value plus two times standard deviation (SD) value was applied as the threshold value. Distribution maps of each element are shown in a separately printed Atlas except for Au and Cu. Distributions of each element are summarizes as below. High value sample described in this paragraph indicate the sample with more than the value of

Table II-4-1 Statistics of stream sediment geochemical survey

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)	53.5	929	< 1	1.7	0.633	32.1	0.5	10.0	366.7
Au (ppb)	81.9	9,320	< 1	0.8	0.539	9.5	0.5	0.5	0.5
Ba (ppm)	2.1	1,478	< 2	81.8	0.383	477.8	88.0	164.0	589.1
Co (ppm)	4.6	1,088	< 1	10.2	0.579	146.8	10.0	32.0	352.7
Cr (ppm)	—	117,538	43	338.2	0.549	4,245.7	244.0	569.0	1,013.9
Cu (ppm)	0.2	3,632	< 1	13.9	0.338	66.1	13.0	27.0	124.7
Hg (ppb)	26.5	24,736	< 10	19.7	0.520	216.4	18.0	48.0	744.8
K (%)	3.2	4.95	< 0.01	0.271	0.527	3.068	0.330	0.700	3.655
Mg (%)	0.6	21.00	< 0.01	0.486	0.636	9.103	0.490	1.910	31.342
Mn (ppm)	10.9	13,316	< 1	168.0	0.902	10,707.0	243.0	1,160.0	70,268.4
Mo (ppm)	81.1	54	< 1	0.6	0.219	1.7	0.5	1.0	0.5
Na (%)	1.5	6.53	< 0.01	0.178	0.598	2.788	0.200	0.590	8.619
Ni (ppm)	0.0	6,778	< 1	48.2	0.570	665.0	37.0	114.0	669.8
Pb (ppm)	44.0	789	< 2	2.9	0.476	26.2	3.0	8.0	129.6
S (%)	—	6.128	0.003	0.025	0.333	0.118	0.024	0.046	0.174
Sb (ppm)	10.9	3,488.0	< 0.2	2.92	0.705	75.12	3.60	9.40	76.12
Sr (ppm)	0.9	1,207	< 1	31.2	0.459	258.6	29.0	67.0	350.5
Ti (%)	—	51.07	0.01	0.333	0.442	2.548	0.250	0.900	4.729
U (ppm)	4.8	49.2	< 0.2	1.10	0.353	5.60	1.40	2.00	5.09
W (ppm)	90.5	112	< 2	1.1	0.160	2.3	1.0	1.0	1.0
Zn (ppm)	5.6	747	< 1	32.6	0.604	526.4	42.0	91.0	703.6

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

Table II-4-2 Coorelation matrix of elements for stream sediments

	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	.093	1.000																			
Ba	-.160	.062	1.000																		
Co	-.212	.004	-.192	1.000																	
Cr	-.097	.051	-.515	.611	1.000																
Cu	-.072	.129	.209	.648	.214	1.000															
Hg	.195	.207	.228	.149	.003	.310	1.000														
K	.179	.044	.800	-.200	-.451	.238	.255	1.000													
Mg	-.214	-.006	-.104	.860	.552	.688	.117	-.070	1.000												
Mn	-.267	.014	-.109	.765	.399	.579	.051	-.196	.742	1.000											
Mo	.084	.116	.172	-.015	-.067	.177	.231	.172	-.032	-.045	1.000										
Na	-.203	-.036	.307	.478	.012	.591	.047	.354	.631	.501	.001	1.000									
Ni	-.102	.036	-.337	.794	.841	.502	.109	-.272	.793	.577	-.050	.282	1.000								
Pb	.256	.142	.293	-.302	-.261	-.110	.145	.216	-.359	-.274	.227	-.259	-.270	1.000							
S	-.026	.013	.175	.424	.030	.602	.166	.153	.486	.371	.125	.526	.282	-.015	1.000						
Sb	-.117	.050	-.241	.571	.543	.353	.087	-.242	.530	.495	.053	.223	.553	-.227	.209	1.000					
Sr	-.216	-.033	.466	.220	-.314	.454	-.008	.389	.354	.357	.012	.809	-.060	-.151	.477	.053	1.000				
Ti	-.339	.009	.045	.512	.029	.457	.027	-.109	.484	.643	-.026	.527	.176	-.208	.413	.344	.627	1.000			
U	.232	.052	.565	-.512	-.538	-.242	.158	.529	-.524	-.426	.133	-.214	-.547	.416	-.143	-.407	.003	-.213	1.000		
W	.033	.068	.082	-.032	-.048	.045	.129	.091	-.024	-.048	.203	-.032	-.024	.149	.041	.015	.000	-.026	.102	1.000	
Zn	-.132	.004	.000	.749	.396	.621	.080	-.033	.736	.641	.040	.488	.582	-.168	.465	.424	.306	.504	-.329	-.011	1.000

background value plus standard deviation (SD).

As : The most conspicuous anomalous zone is found at a tributary of Sungai Imbak at the southern marginal part of the Labuk area. In this zone, andesite porphyry with hydrothermal alteration was confirmed. A significant anomalous zone was also found at the upper most part of Sungai Kalumpang in the Semporna area. Strong hydrothermal alteration was confirmed in this zone. High value zones are found in and around Mt. Wullersdorf in the Semporna area. Mineralized zones of gold are known in this area. The anomalous samples are distributed in the area of the Sungai Melaut at south of Ranau and Sungai Sugut at north of Ranau in the Kinabalu area. Mamut mine is located in the area of Sungai Melaut. High value samples are also found in the area of Trusmadi formation in the Kinabalu area.

Au : Conspicuous anomalou samples are concentrated in two areas. One is the tributary of Sungai Imbak in the Labuk area and the other is the area around Mt. Wullersdorf. The high value samples are scattered in the area surrounding Mamut mine and the area of crystalline basements in the Segama area. As intrusive rock of diorite porphyry and mineralization are confirmed in the area of the tributary of Sungai Imbak, this area is interpreted to have mineral potentiality. Exploration work for gold has been carried out for the anomalous zones in the Semporna area. Distribution map of Au is shown in Fig. II-4-2.

Ba : High value samples are found in the area of the Trusmadi formation, surroundings Mt. Kinabalu in the Kinabalu area and the areas of volcanics in the Semporna area. The vales are characteristically low in the area of ultra- basic rocks in the Labuk and Segama areas.

Co : Samples with high and anomalous values are restricted in the area of ultra-basic and basic rocks. Volcanic rocks in the Semporna area also indicate higher values.

Cr : Samples with high and anomalous values are restricted in the area of ultra-basic and basic rock. The most conspicuous anomalous samples are found at the north and south of Telupid in the Labuk area. These areas may have potential for chrome ore deposits.

Cu : The most significant anomalous samples are found in the area of Mamut mine. The sample with the maximum value (3,632 ppm) is also situated in this area. Bidu Bidu Hill ore deposits in the Labuk area is delineated as a significant anomalous zone. One of the significant anomalous zone is also delineated at the Sungai Karamuak area in the Labuk area. The mineralized zones confirmed by the reconnaissance geological survey were also delineated as the an anomalous zone. However, the zone is not significant when compare with the above mentioned anomalouse zones. In general, high value samples are found in

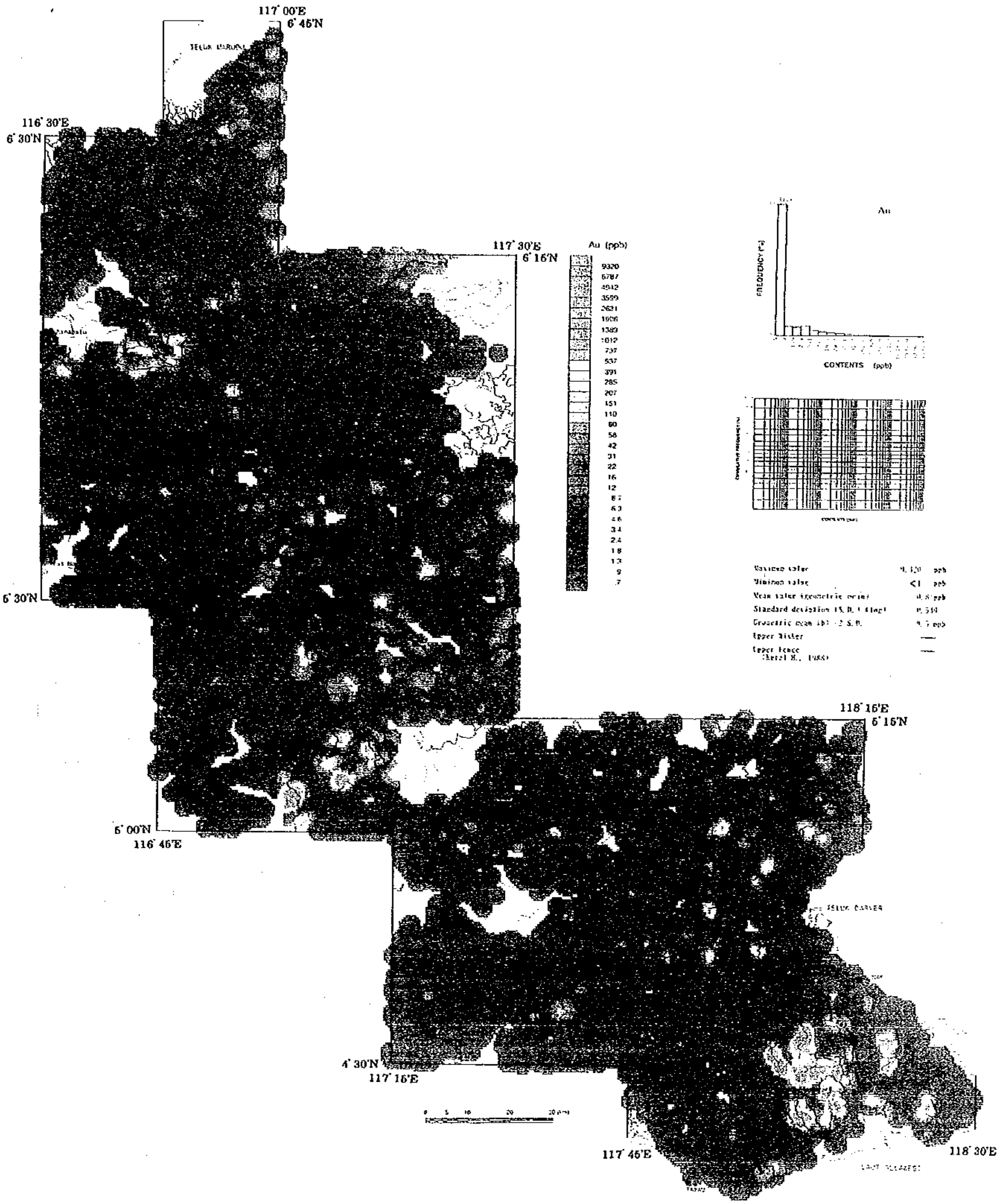


Fig. II-4-2 Distribution map of Au in the survey area

the Chert-Spilite formation and volcanics in the Semporna area. Distribution map of Cu is shown in Fig. II-4-3.

Hg : Significant anomalouse zones are found in the surroundings of Mamut mine, in the area of the Trusmadi formation and at the upper stream of Sungai Kinaram in the Kinabalu area. Another significant anomalous zone is found at the tributary of Sungai Imbak in the southern margin of the Labuk area. No significant anomalous zone is found in the Segama and Semporna areas, but altered zones in the volcanic zones indicate higher values.

K : High value samples are found in the area of Trusmadi formation and volcanics. Low value samples are characteristically found in the area of ultra-basic rocks.

Mg : High value samples are restricted in the area of ultra-basic and basic rocks. Some high value samples are found in the area of volcanics in the Semporna area.

Mn : Anomalous samples are mostly found in the area of Chert-Spilite formation. High value samples are found in the area of ultra-basic and basic rocks, crystalline basements in the Segama area and volcanics in the Semporna area. Sedimentary rocks excluding the Chert-Spilite formation indicate lower values of Mn.

Mo : A large number of samples indicate the value less than the detection limit. The most conspicuous anomalous samples are found in the surroundings of Mamut mine. Two significant anomalous zones are found in the southeastern part of the Semporna area. High value samples are scattered and no relationship with the geology is recognized.

Na : High value samples are restricted in the area of ultra-basic to basic rocks, Chert-Spilite formation, Trusmadi formation, crystalline basements and tuffaceous sediments.

Ni : Anomalous and high value samples are restricted in the areas of ultra-basic to basic rocks. This distribution tendency is the same as Co and Cr.

Pb : The most significant anomalous zones are found in the surroundings of Mt. Wullersdorf in the Senporna area where gold mineralization occurs. Conspicuous but small scale anomalous zones are found at the tributary of Sungai Imbak and the upper stream of Sungai Karamuak in the Labuk area. High value samples are also found in the surroundings of Mamut mine and the middle stream of Sungai Liwagu in the Kinabalu area.

S : The most significant anomalous zones are found in the surroundings of Mamut mine. High value samples are scattered in the entire survey area. These high value samples are correspond to the area of hydrothermally altered zone or muddy sedimentary rocks. From the results of the geological survey, primary

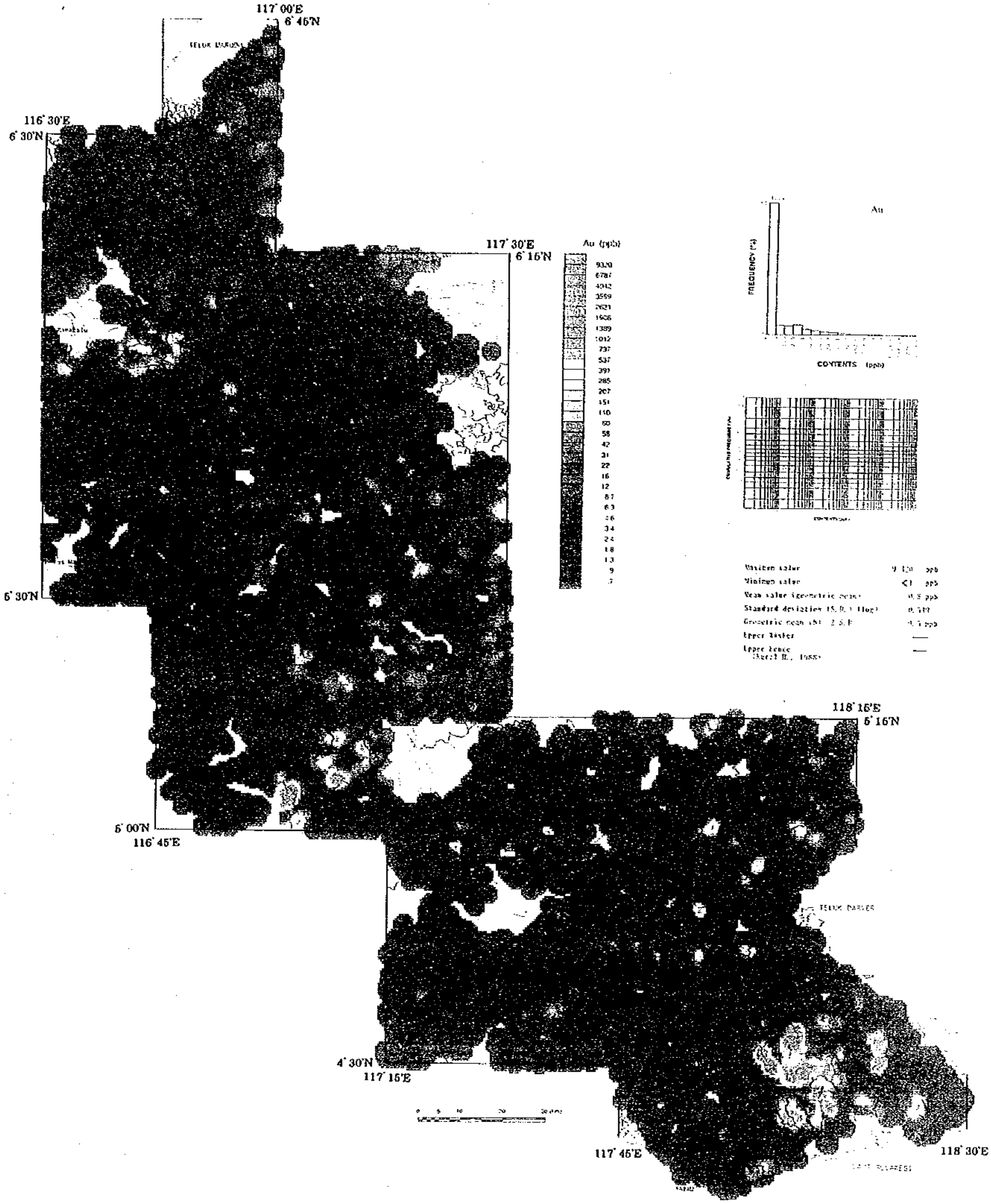


Fig. II-4-2 Distribution map of Au in the survey area

fine-grained pyrite was confirmed in the muddy sedimentary rocks.

Sb : Conspicuous anomalous zones are concentrated in the area of the Labuk area where ultra-basic to basic rocks occur. Other anomalouse zones are found at the middle and upper stream of Sungai Liwagu, the northeast of Mt. Kinabalu in the Kinabalu area and the eastern marginal part of the Semporna area.

Sr : Distribution of the anomalous zones tend to correspond to the distribution of crystalline basement rocks in the Segama area. High value and/or anomalous samples are scattered in the area of volcanics in the Semporna area. High value samples are found in the surroundings of Ranau in the Kinabalu area. Low value zones are characteristically found in the Labuk area.

Ti : High value samples have a relationship with basic rocks, Chert-Spilite formation, crystalline basements and volcanics. The most conspicuous anomalous zone was found at the upper most stream of Sungai Karamuak in the southern margin of the Kinabalu area. The maximum value in this area is 51.07 %.

U : Anomalous samples are restricted in the area of Pinosuk gravels (Q_1) around Mt. Kinabalu in the Kinabalu area and the southern part of the Semporna area. These anomalous sample correspond to the areas of intrusives and volcanics. Comparatively high value samples are found in the area of Trusmadi formation in the Kinabalu area. But the absolute values are low.

W : Most samples are less than the detection limit. The high value samples are scattered and no distribution tendencies are recognized.

Zn : Distribution of high value zones generally correspond to the distribution of ultra-basic to basic rocks, Chert-Spilite formation, Trusmadi formation, crystalline basements and volcanics. The distribution tendencies are similar to those of Co, Ni and Ti.

Judging from the distribution patterns of the anomalous and high value samples, distribution of some of the elements corresponds well to the geology while some are not. The elements including Co, Cr, Mg, Mn, Ni, Sb and Zn show higher values, and Ba and K show lower values in the area of the ultra-basic to basic rocks. The elements of Ba, K and S show higher concentration in the area of muddy sedimentary rocks (Trusmadi formation). The elements, Mn, Na, Ti and Zn, show higher value in the area of the Chert-Spilite formation. The area of volcanics show higher values of Ba and Ti. In the area of crystalline basements, Sr, Ti and Zn show higher values.

Judging from the distribution pattern of the elements, the elements reflecting the mineralization and alteration are As, Au, Cu, Hg, Mo and Pb.

(3) Multi elements analysis

Cluster analysis is the method for the multi elements analysis and is conducted to clarify the relationship among the elements. The Ward method was used in this method. The dendrograms of element obtained from the cluster analysis is shown in Fig. II-4-4. In the dendrogram by the Ward method, following groups of elements form clusters;

U-Ba-K, As-Pb, Au-W-Hg-Mo, Cu-S, Ti-Na-Sr, Zn-Mn-Co-Mg, Sb-Cr-Ni

These elements making a group show a similar distribution tendencies. Judging from the results of the cluster analysis, the relationships between the cluster and geology are as follows;

U - Ba - K : volcanic and sedimentary rocks
As - Pb : hydrothermally altered zone
Au - W - Hg - Mo : gold mineralization
Cu - S : copper mineralization
Ti - Na - Sr : crystalline basements
Zn-Mn-Co-Mg and Sb-Cr-Ni:ultra-basic rocks

In addition to the cluster analysis, factor analyses by varimax rotation were conducted. Results of the factor analyses are shown in Table II-4-3. From the results, six factors were delineated. Elements closely related with each factor are as follows;

Factor 1: Co - Cr - (Cu) - Mg - Mn - Ni - (Sb) - Zn
Factor 2: Ba - K
Factor 3: (Au) - (Hg) - (Mo)
Factor 4: (Mn) - (Sr) - Ti
Factor 5: (Cu) - (Na) - S - (Sr)
Factor 6: —

Among these factors, Factor 1, 3 and 5 show negative relationship with the above-mentioned elements. The elements in blanket ( ) have weak relationship with the factor. Judging from the elements related to the factor and distribution of each element, factor 1 have relationship with ultra-basic and basic rocks and weak relationship with copper mineralization. Factor 2 may have relation with volcanics and sedimentary rocks. Factor 3 is interpreted to be related with alteration and gold mineralization. Factor 4 is thought to be related with Chert-Spilite formation and volcanics. Factor 5 related with S has relationship with muddy sedimentary and volcanic rocks. Factor 6 is not clear regarding the relationship. Distribution map of Factor 3 factor scores is shown in Fig. II-4-5.

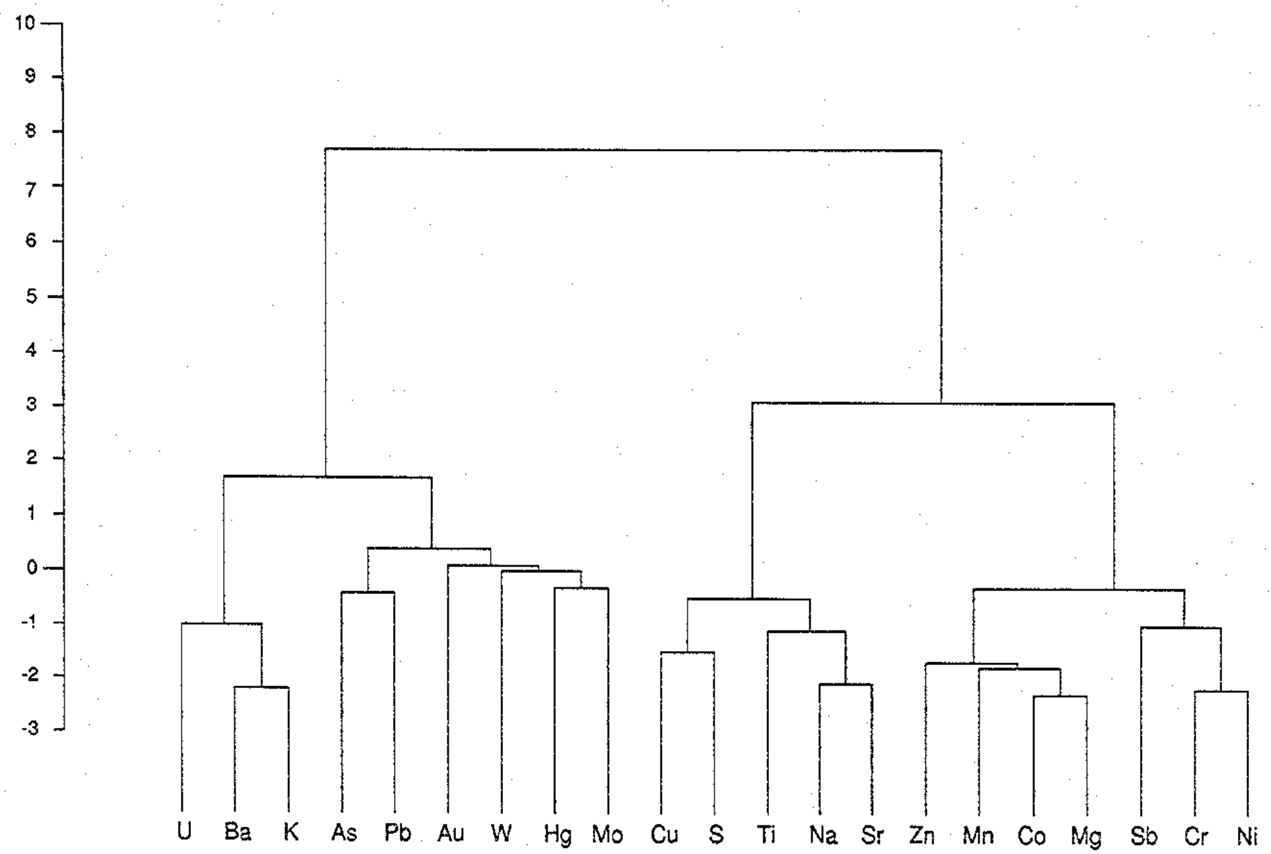


Fig. II-4-4 Dendrogram of elements for stream sediments

Table II-4-3 Results of factor analyses for stream sediments

Element	Factor loading (Varimax rotation)						Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Facyor 6	
As	0.095	0.126	-0.194	-0.447	-0.011	0.129	0.2790
Au	-0.051	0.015	-0.355	-0.010	0.046	0.019	0.1313
Ba	0.200	0.837	-0.197	0.050	-0.148	0.126	0.8198
Co	-0.860	-0.085	-0.002	0.258	-0.245	0.052	0.8764
Cr	-0.793	-0.368	0.021	-0.141	0.192	-0.140	0.8404
Cu	-0.564	0.225	-0.261	0.193	-0.503	-0.012	0.7279
Hg	-0.160	0.201	-0.469	-0.109	-0.071	0.057	0.3059
K	0.154	0.857	-0.180	-0.117	-0.161	-0.085	0.8368
Mg	-0.831	0.029	0.057	0.233	-0.356	-0.130	0.8927
Mn	-0.661	-0.053	0.030	0.509	-0.212	0.118	0.7583
Mo	0.025	0.071	-0.460	-0.045	-0.098	0.033	0.2298
Na	-0.336	0.403	0.107	0.412	-0.546	-0.289	0.8377
Ni	-0.905	-0.183	0.007	-0.087	-0.087	-0.117	0.8820
Pb	0.272	0.147	-0.361	-0.233	0.020	0.342	0.3977
S	-0.273	0.098	-0.150	0.129	-0.689	0.052	0.5999
Sb	-0.597	-0.200	-0.178	0.242	0.011	-0.105	0.4980
Sr	0.004	0.440	0.069	0.589	-0.535	-0.157	0.8567
Ti	-0.269	0.005	-0.004	0.718	-0.330	0.120	0.7112
U	0.478	0.489	-0.209	-0.136	0.148	0.254	0.6155
W	0.046	0.012	-0.348	0.000	-0.016	-0.026	0.1242
Zn	-0.688	0.062	0.026	0.226	-0.363	0.233	0.7148
F.C.*1	39.7 %	18.5 %	8.5 %	14.7 %	14.8 %	3.7 %	—

*1: Factor contribution

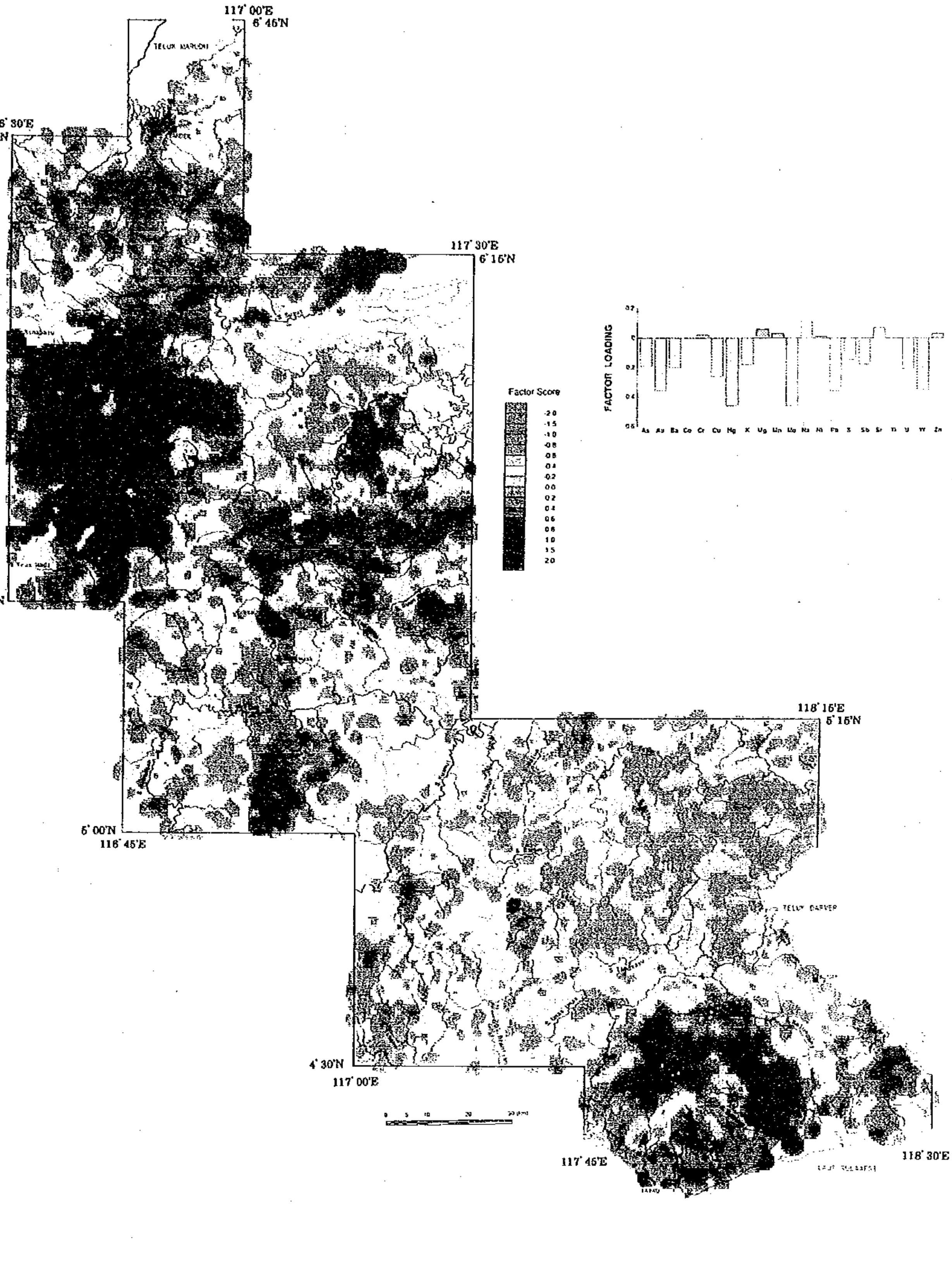


Fig. II-4-5 Distribution map of Factor 3 factor scores

Distribution tendencies of high factor scores for these factors are as follows;

Factor 1 : Because of a negative relationship between the elements and factor scores, high negative score is called high factor score in this case. The most significant high factor score (negative) zones are distributed in the central part of the Labuk area with a direction of N-S. This area correspond to the area of ultra-basic rocks. High factor score zones are also found in the surroundings of the ultra-basic rocks, the surroundings of Mt. Kinabalu and a part of the Segama and Semporna areas. These areas correspond to the area of the Chert-Spilite formation and basic rocks. No high factor score zones are found in the area of sedimentary rocks.

Factor 2 : High factor score zones are found in the area of sedimentary rocks and volcanic rocks in the Semporna area. Negative high factor score zones correspond to the area of ultra-basic and basic rocks.

Factor 3 : The high factor score (negative factor) zones delineate known mineralized and hydrothermally altered zones. The most significant high factor score zone is found in and around Mamut mine in the Kinabalu area. The significant anomalous zones are found at the tributary of Sungai Imbak in the southern margin of the Labuk area, the surroundings of Mt. Wullersdorf and the upper most stream of Sungai Kalumpang in the Semporna area. Conspicuous high factor score zones are also found along Sungai Sugut in the northern margin of the Labuk area and south of Ranau in the Kinabalu area.

Factor 4 : The high factor score zones correspond to the area of the Chert-Spilite formation, crystalline basements in the Segama area and viocanics in the Semporna area.

Factor 5 : The high factor score zones (negative factor) are found in the surroundings of Mamut mine in the Kinabalu area, the tributary of Sungai Imbak in the southern marginal part of the Labuk area and upper stream of Sungai Danum in the Segama area. High factor score zones are also found in the area of muddy sedimentary rocks.

Factor 6 : High factor score zones are mainly found in the area of volcanics in the Semporna area.

High factor score zones of Factor 3 delineated mineralized and altered zones. Therefore, the high factor score zones of Factor 3 are thought to have mineral potential.

4-4-4 Pan concentrate survey

(1) Sampling

During the survey, pan concentrate samples were collected from main streams in the survey area. The sample was collected by five panns (approximately 25 liters of gravels) and the weight were measured. The samples collected in the area of ultra-basic rocks have a large weight. But the samples collected in the area of sedimentary rocks show small volume and weight.

(2) QME analysis

Qualitative Mineral Examination (QME) was made for the heavy minerals in the pan concentrates. From the results of the QME analyses, magnetite, chromite, hematite, ilmenite, goethite, pyrite and zircon were recognized as the heavy minerals. Minor amounts of leucoxene, rutile, monazite, tourmaline and native gold were also observed. Some samples contain comparatively large amounts of pyroxenes and hornblende. The samples with small amount collected in the area of sedimentary rocks contain mainly quartz and plagioclase. The relationship between heavy minerals and geology is summarized as follows:

Magnetite : Magnetite was detected in most of the samples. Significant amounts of magnetite were confirmed in the samples collected in the area where ultra-basic to basic rocks and Chert-Spilite formation are widely distributed.

Chromite : Significant amounts of chromite was confirmed for the samples collected in the area of ultra-basic rocks. Distribution of chromite has close relationship with ultra-basic rocks.

Ilmenite : A small amount of ilmenite was observed in the most of the samples. Comparatively large amounts are found in the area of basic to ultra-basic rocks and volcanics in the Semporna area.

Goethite : Goethite was detected in more than half of the samples. Comparatively large amounts were detected in the area of sedimentary rocks.

Pyrite : A small amount of pyrite was confirmed in the samples collected in the area of Chert-Spilite formation and sedimentary rocks. A significant amounts of pyrite were confirmed for the samples collected in the surroundings of Mamut mine.

Zircon : Zircon was confirmed in many samples. Zircon tends to occur in the samples collected in the area of sedimentary rocks.

Native gold : Native gold were detected for the samples collected in the Segama and Semporna areas. Native gold was detected in five samples collected in the Segama area. These samples are collected from Sungai Malog, middle stream of Sungai Segama, upper stream of Sungai Danum and Sailam villege. In the Semporna area, all four samples with native gold are collected in the surroundings of Mantri area.

The results indicate similar geochemical tendencies as the regional geochemical survey.

4-4-5 Rock geochemical survey

Representative rock samples were collected in this survey and chemically analyzed for 21 elements, same as the stream sediment samples. Locations of the sample and the analytical results are shown in the report of Phase II and III.

From the results of the chemical analyses, many samples give less than the detection limit for the elements of As, Au, Hg, Mo and Pb.

The relationship between the rock and contents of each element are summarized as follows:

As : The maximum value is 29 ppm and is detected from sedimentary rock. The rocks indicating higher values are sedimentary rocks. Some samples of altered volcanic rocks collected in the Semporna area show higher values.

Au : Altered rock samples collected from the volcanics in the Semporna area show high values (maximum 23 ppb). Other than these rocks, no significant values were recognized and most of the sample show less than the detection limit.

Ba : Intrusive rocks show higher values (maximum 1,636 ppm). Volcanic and sedimentary rocks show comparatively high values. The ultra-basic and basic rocks show lower values less than 100 ppm.

Co : Specularite give the maximum value (337 ppm). Most peridotite and serpentinite samples indicate high values of more than 100 ppm. Sedimentary rocks indicate lower values in general.

Cr : Peridotite gives the maximum value of 2,795 ppm. Only ultra-basic rocks give higher values of more than 1,000 ppm. Basic rocks such as gabbro and basalt show comparatively higher values ranging from 200 ppm to 500 ppm.

Cu : Volcanic breccia gives a maximum value of 173 ppm. Basic and intrusive rocks give comparatively higher values. Some samples of altered volcanics collected in the Semporna area indicate higher values.

Hg : The maximum value (2,905 ppb) was obtained in altered volcanic rock in the Semporna area. The altered volcanic rocks give higher values. The Trusmadi formation in the Kinabalu area also give higher values (maximum 2,142 ppb).

In general, muddy sedimentary rocks show comparatively high values.

K : Altered volcanic rock indicates a maximum value of 5.23 %. Possibly hydrothermal alteration enriched potassium in this altered rock. Acidic to intermediate intrusives and sedimentary rocks generally give comparatively higher values. The value of K is extremely low in the ultra-basic rocks.

Mg : Peridotite gives the maximum value (24.71 %). Only ultra-basic rocks give high values.

Mn : Chert collected in the Labuk area give the maximum value of 16,148 ppm. High value samples (4,371 ppm and 2,570 ppm) are sandstone. Sedimentary rocks tend to have high values, but some sandstone give low values less than the detection limit (5 ppm).

Na : Basalt gives the maximum value of 4.65 %. Gabbro and basalt show comparatively higher values of more than 2 %. Ultra-basic rocks and altered rocks give lower values of less than 0.20 %.

Ni : Serpentinite gives the maximum value of 3,177 ppm. Ultra-basic rocks indicate high values.

Pb : The maximum value of 51 ppm was obtained from phyllite of the Trusmadi formation in the Kinabalu area. Sedimentary rocks generally give higher values. Altered volcanic rock collected in the Semporna area give comparatively higher values (maximum 6 ppm).

S : The maxmum value of 7.944 % was obtained from altered volcanic rock from the Semporna area. The altered rocks collected in this area gives extremely high value of more than 3.000 %. Sedimentary rocks such as phyllite and shale give comparatively high values in general. Some gabbro samples also give high values.

Sb : Specularite collected in the Labuk area gives the maximum value (37.4 ppm). Basic rocks show slightly higher values. Other than basic rocks, no clear tendencies are recognized.

Sr : Gneiss of the crystalline basement gives the maximum value of 1,216 ppm. Basement rocks show higher values. Gabbro and volcanic rocks give comparatively higher values. Ultra-basic rocks give low values.

Ti : Volcanic breccia collected in the Segama area gives the maximum value (2.24 %). Basic rocks such as basalt and gabbro indicate slightly higher values Ultra-basic rocks give low values.

U : Volcanic breccia collected in the Segama area give the maximum value of 8.8 ppm. Some intrusive and volcanic rocks give high values. Generally, sedimentary rocks tend to have higher values. Ultra-basic rocks give low values.

W : The maximum value (1,044 ppm) was obtained from chert in the Segama area.

Sedimentary rocks such as sandstone and shale tend to give higher values.

Zn : Peridotite gives the maximum value of 250 ppm. Ultra-basic rocks give high values of more than 100 ppm. Some intrusives also give high values (maximum 233 ppm).

From the results of this survey, ultra-basic rocks give high values of Co, Cr, Mg, Ni and Zn. Basic rocks show high contents of Cu, Sb and Ti. Sedimentary rocks have higher contents of As, Hg, Pb, S and U. Intrusives and altered rocks concentrated some elements which are related to hydrothermal activity. The results have no big differences compare to the general chemical composition of each type of rocks.

4-4-6 Soil geochemical survey

A total of 364 soil samples were collected in this survey and six elements (Al, Co, Cr, Fe, Ni and Pt) were chemically analyzed. Sample were collected in the area of ultra-basic to basic rocks where lateritic soil was developed. The location of these samples, list of samples and the analytical results are shown in the report of Phase II and III.

The statistics for these samples are as follows:

Element	Minimum value	Maximum value
Al	0.26 %	16.86 %
Co	5 ppm	2,173 ppm
Cr	28 ppm	17,305 ppm
Fe	0.68 %	48.24 %
Ni	19 ppm	10,797 ppm
Pt	< 5 ppb	105 ppb

<u>Kinabalu area</u>

The sample collected at 4 km northeast of Ranau give high values of Ni (10,797 ppm) and Co (1,212 ppm). This area may have potential for nickel ore deposits. The samples collected in the northwestern part of the Kinabalu area give high value (7,229 ppm) of Ni. Samples indicating high contents of Cr are found at the northern part of the Kinabalu area. Contents of six samples in this area range from 7,932 ppm to 13,594 ppm. In this area contents of Fe give high values ranging from 31.96 % to 45.78 %.

<u>Labuk area</u>

The analytical results give a high maximum value (2,173 ppm) of Co. This sample is collected at 2 km west of Telupid where lateritic soil is developed over serpentinite. This sample also show high contents of Fe (46.37 %) and Ni (9,024 ppm). The sample collected at the southern bank of Sungai Labuk gives the maximum value of Fe (48.24 %). This sample give high content of Cr (12,432 ppm), but the content of Ni (3,734 ppm) is not so high. The sample with high content of Ni (10,587 ppm) is situated at 3 km west of Telupid in the area of serpentinite. This sample indicates high content of Cr (11,382 ppm) and Fe (45.52 %). Among 225 samples in total in this area, 18 % samples give more than 5,000 ppm Ni. The maximum content (105 ppb) of Pt is not high.

Segama area

The samples collected at the eastern margin of the Segama area where ultra-basic rocks occur, give high value of Cr (17,305 ppm). Some samples collected in this area give more than 3,000 ppm of Ni. Compare with the results in the Kinabalu and Labuk areas, contents of Ni are low and the lateritic soil is not well developed. Lateritic soil in the central to western part of the Segama area show no significant values of Ni and Co.

Semporna area

The lateritic soil samples collected in the Semporna area show lower Ni contents of less than 2,000 ppm. No potential are indicated in this area.

4-4-7 Laboratorial studies

(1) Observation of thin sections

Kinabalu area

Five intrusive rock samples collected in the surroundings of Ranau and Mt. Kinabalu were observed under the microscope and confirmed that these rocks are acidic to intermediate intrusive rocks. Green rock from the Trusmadi formation was examined, and confirmed that this rock was affected by metamorphism. The metamorphism may be related to the igneous activity of granite which forms Mt. Kinabalu.

Labuk area

One thin section sample was collected from intrusive rock in the area of the tributary of Sungai Imbak. From the results of this observation, this intrusive is diorite porphyry and is hydrothermally altered.

Segama area

From the results of the observation, layered structure is found in peridotite, dunite and gabbro. Serpentinization is observed in ultra-basic rocks. Basalt of the Chert-Spilite formation is chloritized. The sample collected from pyrite disseminated zone at the upper stream of Sungai Danum is strongly silicified.

Semporna area

Gabbro samples collected in this area also show layered structure. Pyroclastic samples collected from the Chert-Spilite formation are chloritized. Alteration minerals including chlorite, montmorillonite and zeolites are observed in the Pleiocene to Holocene volcanics.

(2) Observation of polished sections

Kinabalu area

A sample of quartz vein in Chert-Spilite formation at the marginal part of the area was observed and pyrite with minor chalcopyrite were confirmed.

Labuk area

Two samples were collected from the mineralized and gossanized zones. One sample was collected from the Chert-Spilite formation in the western part of the area. From the results, minor chalcopyrite, bornite and chalcocite were recognized in this sample. Other sample was collected from a gossanized zone in the southeastern margin of the area. Pyrite, limonite, goethite and malachite were confirmed in this sample.

Segama area

Samples were collected from the mineralized zone at the upper stream of Sungai Segama and the upper stream of Sungai Danum. Disseminated pyrite with subordinate chalcopyrite, covelline, sphalerite and pyrrhotite were observed in the samples from Sungai Segama, and disseminated pyrite and sphalerite with minor covelline and bornite were observed in the samples from Sungai Danum.

Semporna area

The samples collected from mineralized and altered zones in the Pleistocene volcanics were examined by polished section. From the results, pyrite, goethite and pyrolusite were noted. A large amount of pyrolusite was confirmed in a gossanized sample collected at the north of Sungai Balung.

(3) X-ray diffraction analyses

Altered rock samples collected in the Segama and Semporna areas were examined by X-ray diffraction analyses.

Segama area

Sericite was detected in one sample and chlorite, quartz and prehnite were confirmed in other samples as the alteration minerals . These samples were collected from the mineralized zone at the upper stream of Sungai Segama. The samples collected from strongly mineralized zone in the upper stream of Sungai Danum indicate quartz, sericite and montmorillonite. Other sample collected in the same area shows quartz and chlorite as the alteration minerals.

Semporna area

Alteration minerals including montmorillonite, kaolinite, halloysite, chlorite sericite, cristobalite, quartz and K-feldspar were detected in the samples collected from altered volcanic zone. Other than these minerals, plagioclase and pyrite were also detected. Judging from the assemblage of these alteration minerals, acidic to intermediate hydrothermal alteration are expected in this volcanic zones.

(4) Ore assaying

During the survey mineralized rock samples were collected for ore assaying.

Kinabalu area

Two pyritized samples in mudstone and four quartz vein samples were collected and assayed. No significant results were obtained.

Labuk area

Five samples were collected from mieralized zones in this area. All samples give Au and Ag values of less than the detection limit. The sample collected from dolerite in Chert-Spilite formation situated in the south of Telupid indicates 686 ppm Cu. The sample collected from gossanized zone in the area of the tributary of Sungai Imbak shows comparatively high content (177 ppm) of Zn.

Segama area

The samples collected from the upper stream of Sungai Segama show no significant values of Cu and Zn. Floats samples were collected from the upper stream of Sungai Danum. One sample of 3 m in diameter shows 1.2 g/t Au, 42.6 g/t Ag, 0.9 % Cu and 3.9 % zn. Othe sample of 10 cm in diameter indicates 0.4 g/t Au, 15.0 g/t Ag and 5.1 % Cu.

Semporna area

Five samples collected in this area show no significant values.

Chapter 5 Semi-detailed survey

5-1 Coverage of work

A semi-detailed geochemical and geological surveys were carried out for eighteen selected areas. These areas are selected as areas with mineral potential based on the results of the regional geochemical survey in Phase II and III. The survey areas and their targets are as below;

Segama area

- Area A : S. Sabahan - S. Diwata area ; Cyprus type copper deposits
- Area B : Upper stream of S. Danum area ; Cyprus type copper deposits
- Area C : Upper stream of S. Segama area ; Cyprus type copper deposits
- Area D : Middle stream of S. Tingkayu area ; Cyprus type copper deposits

Semporna area

- Area E : Most upper stream of S. Kalumpang area; hydrothermal gold deposits
- Area F : Tawau Hill area; ; hydrothermal gold deposits
- Area G : S. Apas area; ; hydrothermal gold deposits
- Area H : S. Sipit area; ; hydrothermal gold deposits

Kinabalu area

- Area J : Middle stream of S. Sugut ; porphyry copper deposits
- Area K : East of Ranau ; lateritic nickel deposits
- Area L : Upper most stream of S. Karamuak ; titanium deposits
- Area M : Lower stream of S. Sugut ; porphyry copper deposits

Labuk area

- Area N : West of Telupid ; lateritic nickel deposits
- Area P : S. Mailo area ; chromium deposits
- Area Q : Middle stream of S. Karamuak ; chromium and copper deposits
- Area R : S. Karamuak - S. Milian area ; copper deposits
- Area S : Tributary of S. Imbak ; hydrothermal gold deposits
- Area T : Tributary of S. Imbak ; hydrothermal gold deposits

Locations of these survey areas are shown in Fig. II-5-1.

5-2 Methodology and work amounts

In this survey semi-detailed stream sediment geochemical, soil geochemical and geological surveys were completed. Each area is covered by following methods;

- Area A : soil geochemical survey
- Area B : stream sediment and soil geochemical surveys, geological survey.
- Area C : stream sediment and soil geochemical surveys.
- Area D : soil geochemical survey.
- Area E : soil geochemical survey.

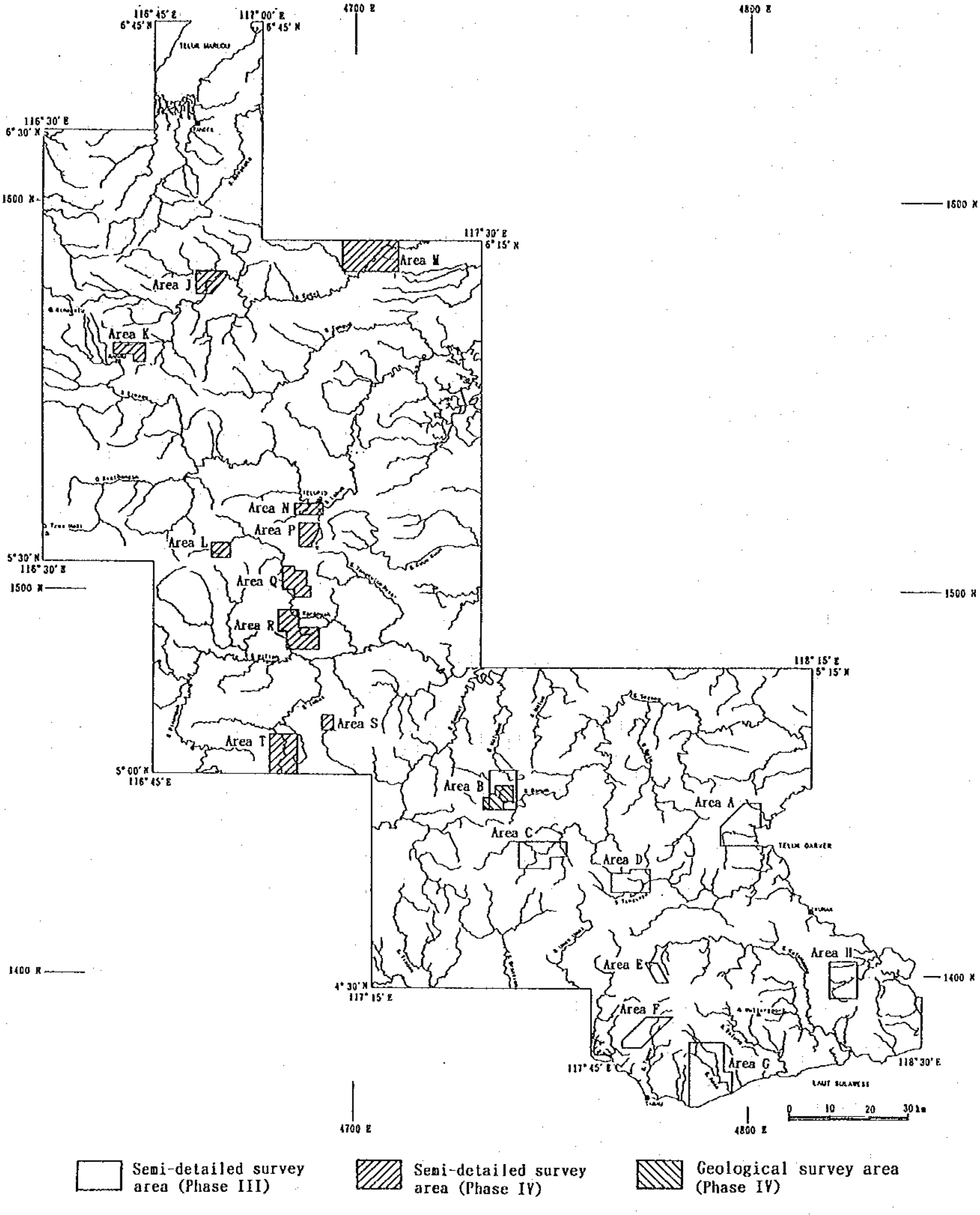


Fig. II-5-1 Location map of semi-detailed syrvey areas

Area F : soil geochemical survey.
Area G : soil geochemical survey.
Area H : soil geochemical survey.
Area J : soil geochemical survey.
Area K : soil geochemical survey.
Area L : stream sediment geochemical survey.
Area M : soil geochemical survey.
Area N : soil geochemical survey.
Area P : stream sediment geochemical survey.
Area Q : stream sediment and soil geochemical survey.
Area R : stream sediment and soil geochemical survey.
Area S : stream sediment and soil geochemical survey.
Area T : soil geochemical survey.

Soil and stream sediments were collected as the sample media along the stream. A geological survey and sampling work for laboratorial studies were simultaneously carried out along the geochemical sampling routes for overall interpretation. The soil sample was collected from the upper part of B horizon based on the results of orientation survey in Phase I. The stream sediment sample was collected at the edge of stream as same as the regional geochemical survey. The sample collected is -60 mesh fraction sample. Density of soil sample is 4 samples/km^2.

At each sampling site, description for the sampling site are made and sample list was prepared. More than 1 kg for soil sample and more than 100 g for stream sediment sample were collected at each sampling site. After drying the soil sample, -80 mesh fraction sample was collected, and divided into to two samples. One is for chemical analyses and other is for storage in the Geological Survey of Malaysia, Sabah office. The samples for the chemical analyses were sent to the laboratories in Japan and Canada.

Among eighteen areas, 21 elememts were analysed in the fourteen areas, excluding Area K, L, N and P. These 21 elements are same as the regional geochemical survey. Following elements were analyzed for the areas of Area K, L, N and P.

Area K and N (soil)

Al, Co, Fe, Cr, Ni (five elements)

Area L (stream sediments)

Fe, Ti (two elements)

Area P (stream sediments)

Al, Co, Fe, Cr, Ni (five elements)

The work amounts completed for each area are the following:

Area	Geochemical survey			Laboratorial studies			
	Soil	Stream sediment	Rock	Thin section	Polished section	X-ray diffract	Ore assaying
Area A	340 spls.	0 spls.	2 spls.	2 spls.	1 spls.	2 spls.	2 spls.
Area B	144 spls.	140 spls.	12 spls.	10 spls.	7 spls.	4 spls.	8 spls.
Area C	140 spls.	140 spls.	7 spls.	6 spls.	2 spls.	2 spls.	5 spls.
Area D	221 spls.	0 spls.	4 spls.	3 spls.	0 spls.	0 spls.	2 spls.
Area E	72 spls.	0 spls.	1 spls.	1 spls.	0 spls.	1 spls.	1 spls.
Area F	122 spls.	0 spls.	1 spls.	1 spls.	1 spls.	2 spls.	2 spls.
Area G	581 spls.	0 spls.	2 spls.	2 spls.	1 spls.	3 spls.	1 spls.
Area H	282 spls.	0 spls.	1 spls.	1 spls.	0 spls.	1 spls.	0 spls.
Area J	150 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area K	240 spls.	0 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.	0 spls.
Area M	476 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area N	170 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.	2 spls.
Area P	0 spls.	105 spls.	0 spls.	1 spls.	0 spls.	0 spls.	0 spls.
Area Q	85 spls.	85 spls.	0 spls.	0 spls.	0 spls.	0 spls.	2 spls.
Area R	150 spls.	150 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area S	25 spls.	25 spls.	0 spls.	0 spls.	0 spls.	0 spls.	0 spls.
Area T	280 spls.	0 spls.	0 spls.	11 spls.	10 spls.	10 spls.	13 spls.

5-3 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 carry out the single element analyses, statistics for each element were calculated. A half value of the ditection limit was used for the sample indicating less than the detection limit of the element in this calculation. The mean values calculated are the geometric means. Based on this calculated results, distribution map of each element was drawn by computer.

The correlation 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 for the multi element analyses, factor analysis was utilized in this survey. The factor analysis is the method to delineate the factor which forms the relationship among the samples.

The data analyses and interpretation were made using newly prepared geological maps in this survey.

During the geological survey along the sampling route, rock samples were also collected for the laboratorial studies.

The samples for the laboratorial studies are thin section, polished section and x-ray diffraction analysis. These data were also used for the interpretation.

5-4 Survey results

5-4-1 Segama area

(1) Area A

Area A is situated in a eastern part of the Segama area. Semi-detailed soil geochemical survey was completed in this area in order to assess the potential for Cyprus-type copper deposits.

Geology of Area A consists of crystalline basement with limestone, Chert-Spilite formation and Kuamut formation of Oligocene to middle Miocene age.

As the results of soil geochemical survey, anomalous and high value samples of Cu and Zn are scattered. Pyrite dissemination is confirmed at the upper stream of Sungai Sabahan where the Kuamut formation occurs. Analytical results of a sample collected in this mineralized zone, show slightly high values of Cu (107 ppm) and Zn (117 ppm). Observation from a polished section confirmed the existance of minor amounts of chalcopyrite and sphalerite.

As the anomalous zones are scattered and are not significant, potential for Cyprus-type massive sulfide ore deposits near surface is possibly low. A mineralized zone was confirmed in the area of the Kuamut formation, but the anomalous zone is not conspicuous.

(2) Area B

This area is situated at the upper most stream of Sungai Danum in the central part of the Segama area. This area was also interpreted to be a potential area of Cyprus-type copper ore deposits from the results of the regional geochemical survey. Soil and stream sediment geochemical surveys were adopted for this area. As the area has a steep topography, the survey was conducted along streams.

Geology of this area consists of ultra-basic and basic rocks, the Chert-Spilite formation and the Kuamut formation in ascending order.

From the results of soil geochemical survey, significant anomalous zone of Cu and Zn are confirmed in the central and southwest parts of the area where the Chert-Spilite formation crops out.

The results of stream sediment geochemical survey also delineated significant

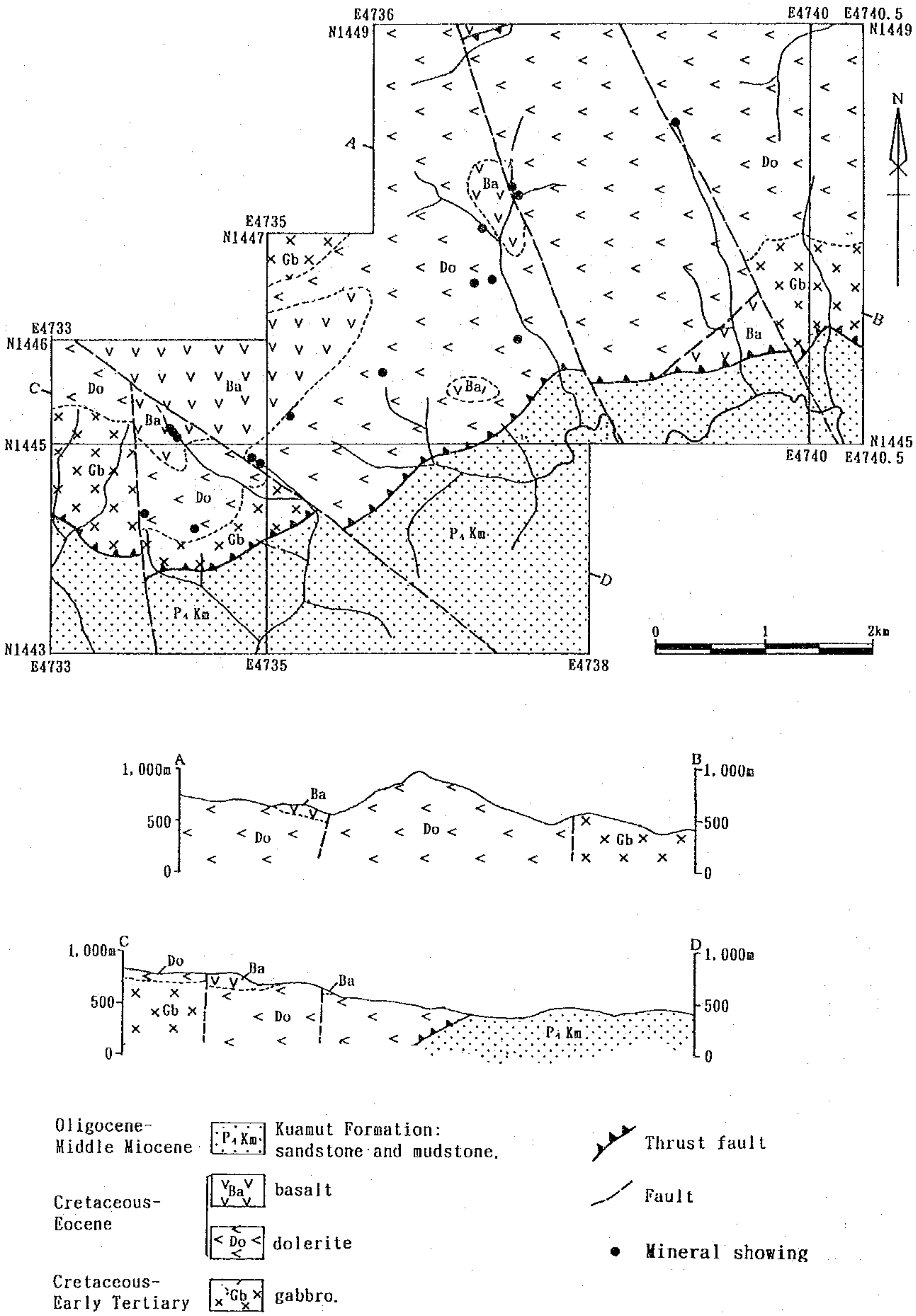


Fig. II-5-2 Geological map of Area B

anomalous zones in the same parts of the area where anomalous zones of soil geochemical survey are cofirmed. This promising zones were also clearly delineated by the results of factor analysis.

During the sampling work copper mineralized zones were confirmed in the area of geochemical anomalous zones. This mineralized zone consists of stockwork and disseminations of sulfide minerals over the area extending 5 km x 2 km. Assay results for the ore sample collected in this mineralized zone give 2.12 % Cu and 3.04 % Zn which are very significant. This mineralized zone is also strongly silicified, chloritized and brecciated.

Following to the geochemical survey in Phase Ⅲ, a detailed geogical survey was conducted in Phase Ⅳ over the mineralized zones. The geological map of this survey area is shown in Fig. Ⅱ-5-2.

Geology of this survey area consists of basic rocks which thrust over the Kuamut formation. 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, the most significant mineral showing was found at the central part. The width of the mineralized zone is approximately 6 m. The zone consists of quartz veins with width ranging 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 of 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.

(3) Area C

Area C is situated at the upper most stream of Sungai Segama in the southern central part of the Segama area. Potentiality of Cyprus type copper ore deposits was expected in this area. Soil and stream sediment geochemical survey were simultaneously carried out in this area.

Geology in this area consists of pre-Triassic phyllitic schist and green schist, ultra-basic and basic rocks of Cretaceous to early Tertiary age, the Chert-Spilite formation of Cretaceous to early Eocene age and the Kuamut formation of Oligocene to middle Miocene age.

Geochemical anomalous zone of Cu are mainly found in the area of green schist. From the results of surface survey, sulfide disseminations, mostly pyrite, are confirmed in this geochemical anomalous zone. From the results of soil geochemical survey, a geochemical anomalous zone with Cu, Pb, S, Zn anomalous samples was confirmed in the Kuamut formation at the southern central part of the area. But mineralized zone was not confirmed in this survey.

Mineralization in this area is found in the sheared zones of green schist. Based on the geology, potential for Cyprus type copper deposits in this area is thought to be low. The geochemical anomalous zone in the Kuamut formation is small scale,but it is conspicuous. Some work should be carried out for this anomalous zone.

(4) Area D

Area D is situated at the middle stream of Sungai Tingkayu in a central southern margin of Segama area. The exploration target in this area is also Cyprus type copper deposits. The soil geochemical survey was completed in this area.

Geology of Area D consists of pre-Triassic amphibolite schist and green schist, ultra-basic and basic rocks of Cretaceous to early Tertiary age, the Chert- Spilite formation of Cretaceous to Eocene age and the Kuamut formation of Oligocene to middle Miocene age. Intrusives of andesite porphyry is found in the area of green schist. No significant mineralization was confirmed during the fieldwork.

The geochemical anomalous zones delineated in this survey are small scale and are scattered. Judging from the survey results, no significant mineralized zones are expected in this area. Because of limited distribution of Chert-Spilite formation, potential for Cyprus-type copper ore deposits is also thought to be low.

5-4-2 Semporna area

(1) Area E

Area E is situated at upper most stream of Sungai Kalumpang in the central part of Semporna area. In order to assess the potential for epithermal gold deposits, soil geochemical survey was conducted in this area.

Geology in this area consists of the Kuamut formation of Oligocene to middle

Miocene age, and andesite and its pyroclastics of Pliocene age.

From the results, anomalous zones of As, Au, Cu, Hg, Mo and Pb are overlapped in the south eastern part of the area. Results of a factor analysis also clearly delineated this zone. On the surface, silicified zones of hydrothermal alteration are observed in this anomalous zone. However, significant mineralized zones have not been confirmed on the surface. These altered zones may be formed by geothermal activity.

(2) Area F

Area F is situated in the southern central part of the Semporna area, and is the upper stream of Sungai Tawau. A soil geochemical survey was carried out in order to assess the potential for epithermal gold deposit in this area.

Geology in Area F consists of Pliocene volcanics (andesite) and Pleistocene volcanics (dacite and basalt).

From the results of soil geochemical survey in this area, anomalous zones of As, Cu, Hg, Pb and S are overlapped in the northern part of the area where andesite and its pyroclastics are observed. In this part, some silicified and argillized zones with pyrite dissemination and hot spring were confirmed. Results of factor analysis also clearly delineated these altered zones. Judging from the relation between altered zone and anomalous elements, this altered zone may have some relation with geothermal activity.

(3) Area G

Area G is situated along Sungai Apas, in the southern central part of the Semporna area. The target in this area is also for epithermal gold deposits. The soil geochemical survey was conducted in this area as same as the areas of Area E and Area F.

Geology in Area G consists of Pliocene volcanics (augite-hypersthene andesite and hornblend andesite) and Pleistocene volcanics (dacite and hypersthene andesite). A small stock of granodiorite porphyry, possibly Pliocene in age, occurs in a southeastern part of the area. The central to eastern part of the area is widely occupied by tuff, sand, silt and ash and these sediments are strongly weathered. The tuffaceous sediments are mostly dacitic tuff and are possibly Pleistocene in age.

From the results of soil geochemical survey, anomalous zones of several elements overlap in the south eastern and south western parts of the area. The south eastern part is the area of granodiorite porphyry and the surroundings. The south western part is the area of strongly argillized andesite. Anomalous zones of As, Au and Pb overlap in the northwestern part of the area where altered andesite occurs. These anomalous zones were also delineated from the results of factor analysis.

A significant mineralized zone has not confirmed in this area. Judging from the geochemical survey results, the potential areas may be limited in the altered zones and nearby gronodiorite porphyry stock.

(4) Area H

Area H is situated along Sungai Sipit in the eastern part of the Semporna area. A soil geochemical survey was conducted in this area in order to assess the potential for epithermal gold deposits.

Geology in this area consists of the Kalumpang formation of Oligocene to middle Miocene age and andesite of Pliocene age. The Chert-Spilite formation occurs in a small area of northeastern part of the area.

Anomalous zones of several elements overlap in the area of the Chert-Spilite formation and southern margin of the area where andesite crops out. Other than these two area, anomalous zones are scattered. Therefore, these two areas may have some potential in this area. However, the potential seems to be low, because no significant mineralized zone was confirmed on the surface.

5-4-3 Kinabalu area

(1) 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 though 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.

(2) Area K

Area K is situated at east of Ranau in the central part of the Kinabalu 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 suvey should be carried out at deeper part.

(3) 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 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 PhaseIII 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.

(4) 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.

5-4-4 Labuk area

(1) 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.

(2) 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.

(3) 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.

(4) 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 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 form these facts, potential for copper and/or gold in this area is thought to be low.

(5) 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 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.

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

(6) 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 south 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.

Chapter 6 Investigation of mineral showings

6-1 Coverage of work

Collection and compilation of existing data and investigation of known mineral showings were carried out in this survey. From the results of the investigation one potential area of mineral deposit was selected and a detailed survey was conducted over the selected area. The survey was carried out in a period from Phase I to Phase IV. The surveys conducted each phase are as follow;

Phase I : Collection and compilation of existing data. Three dimensional compilation of topograpy and geological map. Three dimensional compilation of topography and satellite image.

Phase II : Investigation of nine mineral showings in the Segama area and forty six showings in the Semporna area.

Phase III : Investigation of twelve mineral showings in the Kinabalu area and twenty eight showings in the Labuk area.

Phase IV : Detailed investigation for the Bt. Tampang area in the Kinabalu area.

6-2 Work amounts

A geological survey and laboratorial studies were conducted for the mineral showings in the survey. The work amounts and the number of samples collected are as follow:

Table II-6-1 Work amounts of mineral showing investigation

Item	Phase II	Phase III	Phase IV	Total
Investigation of mineral showings	55 showings	40 showings	50 km^2	95 showings 50 km^2
Laboratorial studies				
K-Ar dating	20 samples	20 samples	10 samples	50 samples
Whole rock and minor element analyses	40 samples	50 samples	40 samples	130 samples
Thin section	40 samples	50 samples	50 samples	140 samples
Ore assaying	50 samples	60 samples	65 samples	175 samples
Polished section	30 samples	30 samples	30 samples	90 samples
X-ray diffraction	40 samples	15 samples	50 samples	105 samples
Fluid inclusion	20 samples	10 samples	20 samples	50 samples

6-3 Survey results

(1) Phase Ⅰ survey

Collection and compilation of existing data were carried out in Phase Ⅰ at the Geological Survey of Malaysia, Sabah Office. From the results of the compilation, promising mineral showings were delineated, and the investigation for these promising showings were conducted in Phase Ⅱ and Ⅲ.

(2) Phase Ⅱ survey

Investigation for the mineral showings in the Segama and Semporna areas were carried out. Nine (9) showings in the Segama area and forty six (46) showings in the Semporna area were investigated during the survey. The results are summarized as follow:

① Among the mineral deposits in the Segama and Semporna areas, a gold deposit in the Semporna area has the highest possibility to be discovered in the future.

② The representative gold deposit in the Semporna area is found in the Mantri area. This mineralization consists of epithermal quartz vein and/or quartz stockwork vein and occurs in volcanics and their pyroclastics. Hydrothermal activity of this mineralization may have relationship with the volcanic activity of late Miocene to Pliocene age.

③ The hydrothermal solution retated with gold mineralization at the Mantri area is intermediate to alkaline solution and the solution alterd the host rocks. Quartz, sericite, Kaolinite and K-feldspar are found as the alteration minerals. As the mineralization is stockwork type and the grades are low ranging from 1.0 g/t to 3.0 g/t Au, gold-quartz veins of bonanza type (vein type) are expected at depth.

④ Silicification and argillization which possibly related with acidic hydrothermal solution, are found in the Nagos area which situated in the eastern part of the Semporna area. This type of alteration is generally found at the upper part of vein type gold ore deposits. As the acidic alteration of silicification, argillization and alunitization occurs in the area, there is possibility of emplacement of the stockwork type and/or bonanza type deposits at depth.

⑤ It is infered that gold mineralization in the Semporna peninsula region is related possibly to the volcanic activity of calc-alkaline rock series. Therefore, potentiality of gold deposit is thought to be high in the hydrothermally altered volcanics and their pyroclastics of the calc-alkaline rock series.

⑥ Following to the gold deposits, the potentiality of the Cyprus-type massive sulfide deposit in the Chert-Spilite formation is thought to be high in the Segama and Semporna areas.

⑦ Four localities of mineral occurrences are found in the Chert-Spilite formation at a small island to the south of the Silam harbour in the eastern part of the Segama area. This mineralized zone seem to be the indication of stockwork mineralization accompanying with the Cyprus type massive sulfide deposit. As the Chert-Spilite formation occurs in the surroundings of Kg. Silam, potential for this type mineralization is expected.

(3) Phase III survey

Investigation of mineral showings in the Kinabalu and Labuk areas are conducted in this phase. The mineral showings investigated are twelve (12) showings in the Kinabalu area and twenty eight (28) showings in the Labuk area. The results of the investigation are summarized as below:

① As the results of the investigation of forty mineral showings in the Kinabaru and Labuk area, for areas namely Bt. Tampang area in the Kinabalu area, Sungai Telupid, Kg. Porog and Sungai Tungud areas in the Labuk area were selected as potential area of mineral deposits. The Bt. Tampang area has potential for gold deposit and remaining three areas have potential for the Cyprus-type massive sulfide deposits.

② In the Bt. Tampang area, hydrothermally altered acidic to intermediate volcanics and their pyroclastics are found at the western and southern foots of Bt. Tampang. Minerarization of quartz veinlets, quartz stockwork veins and disseminations of pyrite and limonite is recognized in the altered zone. Assay results for the samples collected in the mineralized zones indicate comparatively high values of Au (maximum; 2.68 g/t), Sb (maximum; 0.13 %) and Hg (maximum; 22.45 ppm). The alteration mineral assemblage of hydrothermally altered rocks consist mainly of quartz, sericite, kaolinite with subordinate K-feldspar and smectite. The homogenization temperature of fluid inclusions in quartz ranges from 218° to 259°C. Judging from these facts, the mineralization in the area is interpreted to be upper part of epithermal gold deposits emplaced by intermediate to alkalin hydrothermal solution retated with Miocene to Pliocene volcanic activity.

③ In the Sungai Telupid area, mineralized zones occur in basalt and dolerite and are found along Sungai Telupid. The mineralization consists of pyrite, limonite, quartz and chalcopyrite with minor bornite, chalcosite, covellite, malachite, sphalerite and magnetite. The mineralized zones show the occurrences of semi-massive, vein, stockwork and dissemination. The whole zone can be regarded as a stockwork orebody with a length of approximately 155 m stretching NE-SW and a width of approximately 15 m. However, the copper grade of this zone is not significant. Judging from the geology in this area, potentiality of high copper grade stockwork and/or massive mineralization can not be neglected.

④ The mineralized zones confirmed in the Kg. Porong area are two outcrops and floats which can be nearly regarded as a outcrop, and consist of massive gossan of limonite and hematite. Assay results of the gossan samples indicate 55.58 % to 58.34 % Fe and 0.11 to 0.40 Cu. These massive gossans are considerably similar to those which are found at the surface of the Cyprus-type massive sulfide deposits of West Sualog and Kiabau in the Bidu Bidu Hill area in points of the megascopic observation, microscopic observation and assay results. Therefore, it seems that the massive gossans confirmed in this area have been formed by oxidation of the Cyprus-type massive sulfide deposit. Further exploration work should be conducted for the depth and/or the extensions to confirm the potential.

⑤ In the Sungai Tungud area, a mineralized zone with 20 m long and 8 m high is found along Sungai Unsadan which is a tributary of Sungai Tungud. The mineralized zone consists of pyrite and quartz with subordinate chalcopyrite and show the occurreces of semi-massice, stockwork and dissemination. As the whole, the mineralized zone is semi-massive and the copper grade is 0.27 %. Conspicuous geochemical anomalous zones of Cu and Zn have been repoted in the previous surveys completed 1980-1984 and 1986-1990. Therefore, potential for copper deposits is present in this area.

(4) Phase IV survey

Among the four potential areas delineated in the survey for the Kinabalu and Labuk areas, the Bt. Tampang area was selected as a higher potential area of mineral deposits. Further detailed investigation, as the follow-up survey, was made for the Bt. Tampang area in Phase IV. Location of the investigated area is shown in Fig. II-6-1.

① Hydrothermally altered sandstone, mudstone and acidic to intermediate volcanics are found at the eastern half, east of Kg. Poring, of the area. Quartz veinlets, quartz stockwork veins, silicified veins and silicified/argillized zones are found within the altered zones. Limonite and pyrite with subordinate hematite and chalcopyrite are recognized in these mineralized zones. As the results of the assaying, the samples indicating more than 0.1 g/t Au (0.10 - 2.48 g/t), more than 0.10 % Cu (0.22 - 0.64 %) and more than 1,000 ppm As are mostly found in the southern and eastern foots

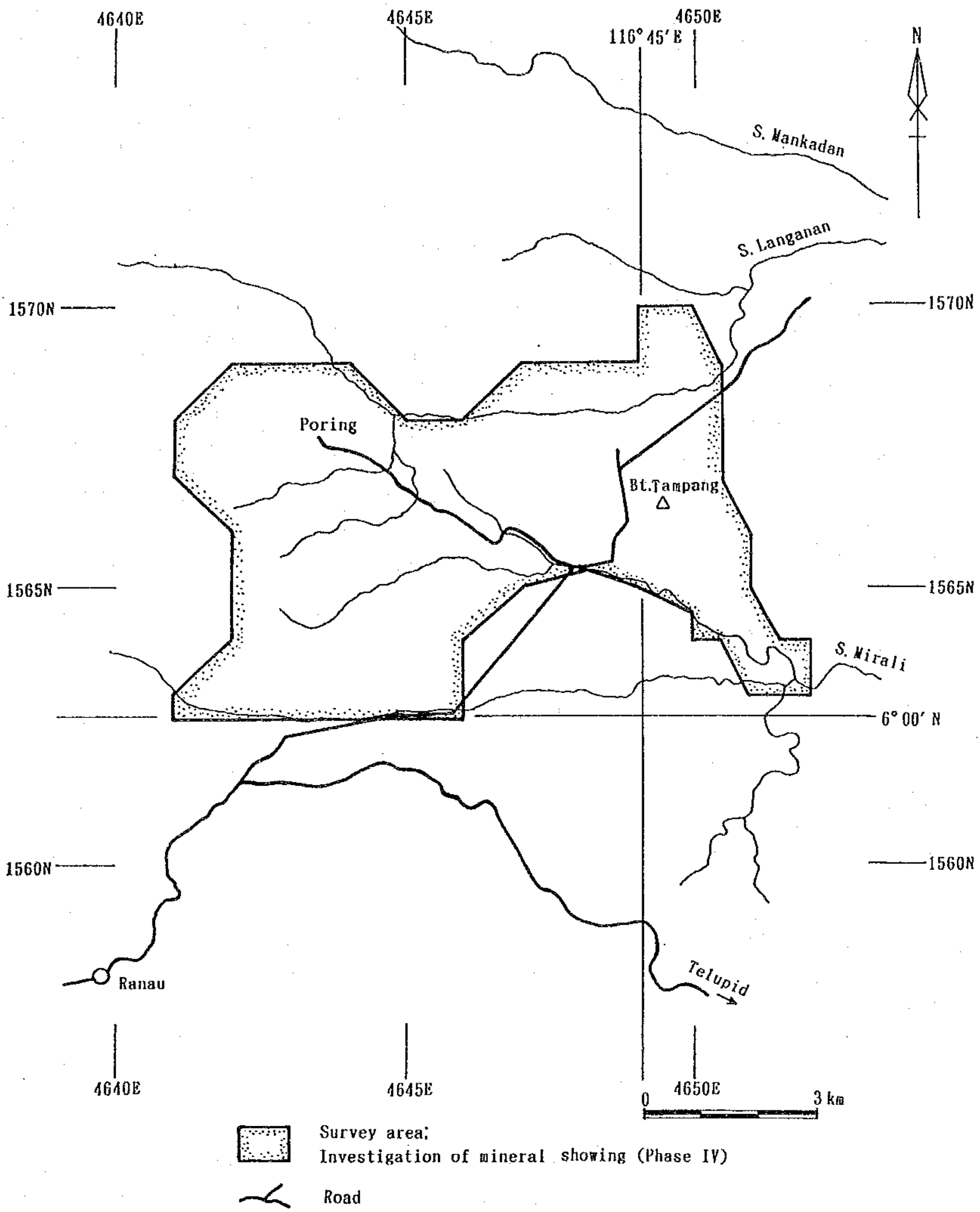


Fig. II -6-1 Location map of Bt. Tampang area of Bt. Tampang. These samples also indicate high contents of Hg ranging from 1,399 ppb to 38,785 ppb.

② The mineral occurrences observed at the southern foot of Bt. Tampang are quartz veinlets, quartz stockwork veins and silicified veins. These occurrences forms, as the whole, one quartz stockwork zone. The host rocks are strongly hydrothermally altered by silicification, sericitization and kaolinitization and consist of felsic tuff, sandstone and altered rocks. The assemblage of the alteration minerals indicate hydrotherma alteration of epithermal gold mineralization.

③ The sandstone is a part of the Crocker formation and the felsic tuff unconformably covers the sandstone. The results of whole rock analyses indicate that the acidic to intermediate volcanics in the area are calc-alkaline rock series in composition.

④ Judging from the survey results, the mineralization confirmed in the southern and eastern foots of Bt. Tampang is epithermal gold-quartz stockwork mineralization which relates with the intermediate hydrothermal solution and relates with volcanic activity of calc-alkaline rock series in late Miocene age.

Part Ⅲ Conclusions and recommendations

Chapter 1 Conclusions

This Supra-regional survey was carried out within a period of four fiscal years, in four phases of Phase Ⅰ, Ⅱ, Ⅲ and Ⅳ started from October 1990 and ended at February 1994. The orientation geochemical survey was conducted in Phase I, and then after the satelliteimage analysis, heliborne geophysical survey, regional geochemical survey and semi-detailed survey were carried out over the four years. These survey results are conclusively summarized as follows:

Orientation geochemical survey

① The orientation survey was carried out over three known mineralized areas in order to delineate the optimum geochemical survey methods in this project. From the results of the regional and semi-detailed geochemical suvey, the survey methods applied in these survey delineated known mineralized zone very clearly. Therefore, the survey method decided by the orientation survey are useful and applicable for this project area.

Satellite image analyses

① No significant differences are recognized between the interpreted results and the existing geological map.

② Significant fault zones with a direction of N-S in the Kinabalu area and many ring structures were newly discovered in this analyses. The results indicated that this analysis is quite useful to understand the large scale geological structure in this area.

Heliborne geophysical survey

① The anomaly maps of magnetics and radiometrics reflect well the geology and the geological structure in this area. Significant discontinuous lineaments with a direction of N-S are distributed in the Kinabalu area. On the other hand, NE-SW trending discontinuous lineaments are dominance in the Labuk area. The differences of the geological structure in each area are clearly delineated in this survey results.

② Strongly altered volcanic zones in the Semporna area are delineated from the anomaly maps. The altered zone indicate low magnetics and high radiometric cunt.

③ The survey results indicates high magnetic bodies at depth in the southern part of the Kinabaru area. High magnetic bodies are also expected at shallow depth in the northern part of the Semporna area.

Regional geochemical survey

① Geochemical anomalous zones are found in and around the known mineralized zones. The results indicate that this survey was effective for the exploration work in this project area.

② Samples with high contents of Cu, Hg, Mo and S are found in the surrounding area of Mamut mine. The elements including As, Au, Pb and S show higher values in the known mineralized zone of gold in the Semporna area. High concentrations of As and Hg are recognized in the altered volcanic zones in the Semporna area. These facts suggest that the concentrations of elements depend on the type of mineralization and/or alteration. In another words, it is possible toexpect the nature of the mineralization on the basis of the assemblage of anomalous elements.

③ Because the survey covers a wide area, distribution tendencies of each element are observed for the entire project area. Therefore, it is possible to make relative evaluation and to carry out efficient exploration work for the target areas selected in future exploration.

Semi-detailed survey

The semi-detailed survey was completed for eighteen areas which were selected as promising areas for mineral resources by the regional geochemical survey.

Among eighteen areas investigated in this survey, five areas were selected as potential. These five areas and their targets are as follows;

① Area T in the south of the Labuk area : gold and/or porphyry copper
② Area N west of Telupid in the Labuk area : lateritic nickel
③ Area Q along S. Karamuak in the Labuk area: vein or disseminations of copper
④ Area B along S. Danum in the Segama area : vein or disseminations of copper
⑤ Area K east of Ranau in the Kinabalu area : lateritic nickel

Among these areas, the most significant mineralized zones were confirmed in Area T. The assay results from the samples collected in this area indicate a maximum of 18.4 g/t Au, and 932 g/t Ag. Area N and Area K were selected as potential area for lateritic nickel ore deposits. In these areas, some samples indicat more than 1.00 % Ni. The samples in this survey is collected from a depth up to 1.50 m. Concentration of nickel are usually know at the boundary between the latritic soil and the basement rocks situated at depth. Chalcopyrite and pyrrohtite mineralization is known in Area Q. Mineralized zones of pyrite and chalcopyrite were confirmed in Area B in this survey.

Investigation of mineral showings

① Among the mineral deposits, an epithermal gold deposit which may occurs in the Semporna area, has the highest possibility to be discovered in the Segama and Semporna areas. Following to the gold deposit, the Cyprus type copper deposit, hosted by the Chert-Spilite formation, has possibility to be discovered in the Segama and Semporna areas.

② From the results of investigation, four areas are selected as the potential areas of mineral deposits in the Kinabalu and Labuk areas. These are Bt. Tampang area for gold in the Kinabalu area and Sungai Telupid, Kg. Porong and Sungai Tungud areas for the Cyprus type copper deposits in the Labuk area.

③ Further detailed survey was conducted for the Bt. Tampang area. From the results, epithermal quartz stockwork gold mineralization which related with calc-alkaline volcanic activity of late Miocene age, was confirmed in the area. However, assay results give low values ranging from 1.0 g/t to 2.48 g/t Au.

Chapter 2 Recommendations for Phase IV survey

Juging from all the survey results in this project, the following items are recommended for future exploration work in the project area;

(1) Results of the interpretation of satellite images confirm N-S trending fault zones in the Kinabalu area and a number of ring structures. The satellite image analysis is quite useful to understand the entire geology and the relationship between the geology and mineralization. Consequently, the satellite images generated in this survey should be used for future exploration work in this area.

(2) Results of the heliborne geophysical survey reflect well the geology and the geological structure in this survey area. Because the low magnetics and high total count radiometrics zones correspond to altered volcanic zones, it is possible to delineate hydrothermally altered zone. The data of this survey should be used to make more accurate interpretation of the geological structure in future survey.

(3) Results of the regional geochemical survey clarify the distribution tendencies of each element over the entire survey area. In this survey, many geochemical anomalous zones of each element were delineated, but the semi-detailed survey was only conducted over the significant anomalous zones. Therefore, the remaining anomalous zones should be examined in future. Significant anomalous zones were also detected in the known mineralized zones such as Bidu Bidu Hill ore deposits and Mantri area. These areas are excluded for the semi-detailed surveybecause exploration work has been conducted.

(4) The sample density in the semi-detailed survey was basically 4 samples/km^2. Because of the spare samples in the survey area, only the outline of the mineralized zones were confirmed in this survey. Therefore, detailed survey should be carried out on the newly discovered potential zones in this survey in the future. The potential areas delineated in this survey and the recommendable survey method for these areas are as follows:

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

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

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

④ Area B along S. Danum in the Segama area:
trenching

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

If these survey give attractive results, drilling survey shoud be conducted. These areas are shown in Fig. I-4.

(5) A huge amounts of heliborne geophysical and geochemical data obtained in this survey were input in the magnetic tapes. The drainage data of 1:50,000 in scale were also input. These data are basic data in this area and anybody can access to any part of the data for re-examination in future investigation. These data can be effectively used for future exploration. Therefore, computer software for the operation should beobtained and training for the operator should be carried out in near future.

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