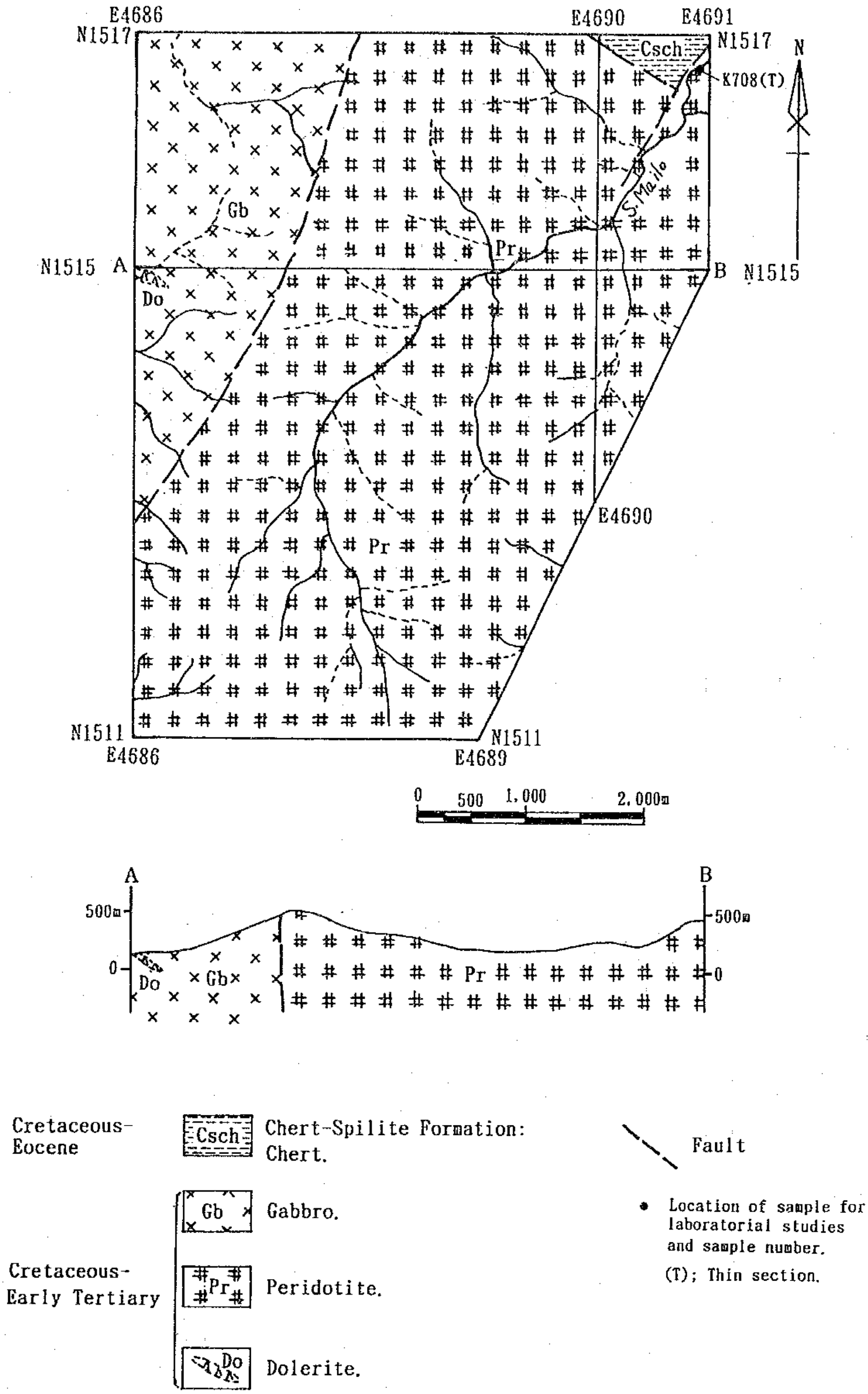


Fig. II-1-19 Geologic map and cross sections of Area P area. At the northeastern edge of the area, reddish brown, laminated chert of Chert-Spilite formation (Csch) occur as a small block surrounded by faults. The finding of amphibolite float with garnet porphyroblasts in northeastern part of the area suggests the occurrence of the basement rock close to the area.

(2) Mineralization

Neither exposure nor float of chromite was found during the field work.

1-8-2 Stream sediment geochemical survey

(1) Sampling

A stream sediment geochemical survey was conducetd in Area P. Locations of collected samples and their list are, respectively, shown in Fig. II-1-20 and Appendix 16. The samples were collected using 60 mesh sheave. After drying up these samples, they were sent for chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 17. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-12.

Comparing the statistical figures of Area P with those of similar geological environment such as Area Q and Area R, Cr shows very high concentration with maximum value and average of, respectively, 107,357 ppm and 29,516 ppm. Al and Fe, also, are much higher in the stream sediment samples of Area P than common values of ultra-basic rocks. Co and Ni show similar values to those of Area Q and Area R.

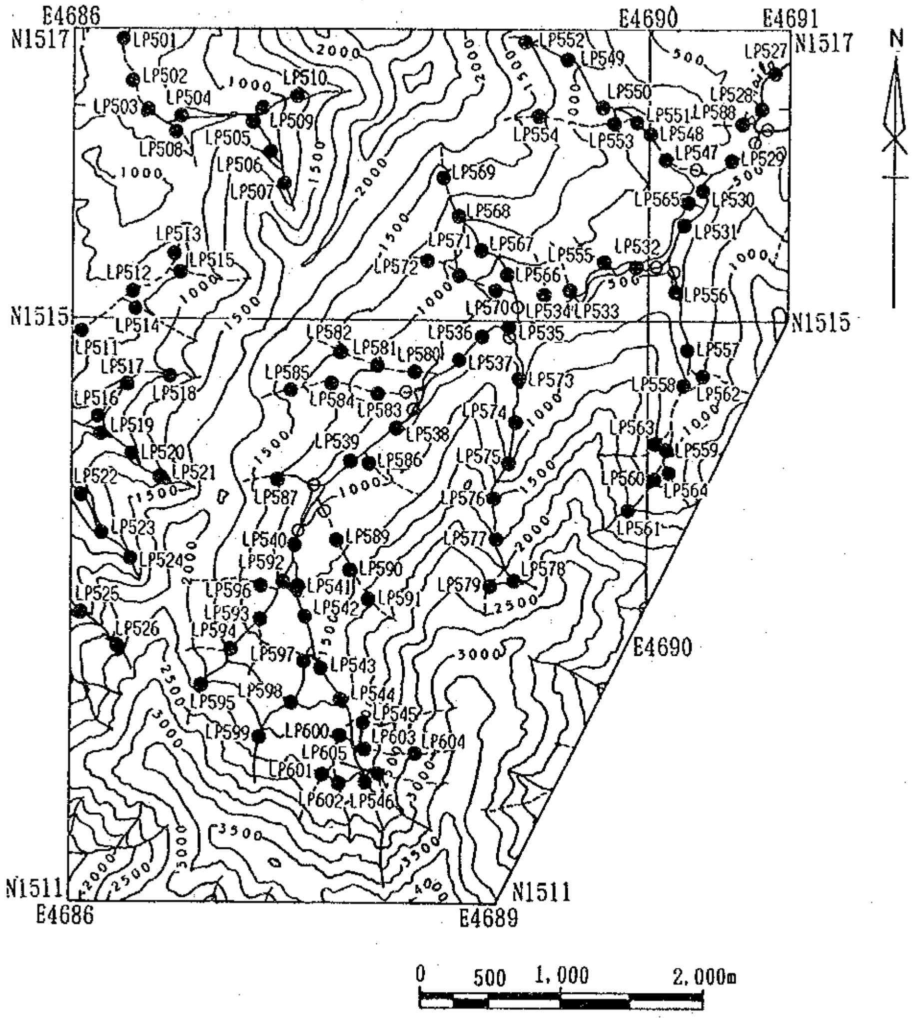
In order to clarify relationships among the elements, correlation coefficients were also calculated. The results show following pairs of element to be comparatively good (correlation coefficient: more than 0.500) correlations.

Co-Cr, Co-Fe, Co-Ni, Fe-Ni

Co, Fe and Ni show good correlations each other, while Cr shows good correlation only with Co.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 18) using the values obtained by EDA method. Distributions of each element are summarized as follows;



LP501 Location of stream sediment samples and sample number.

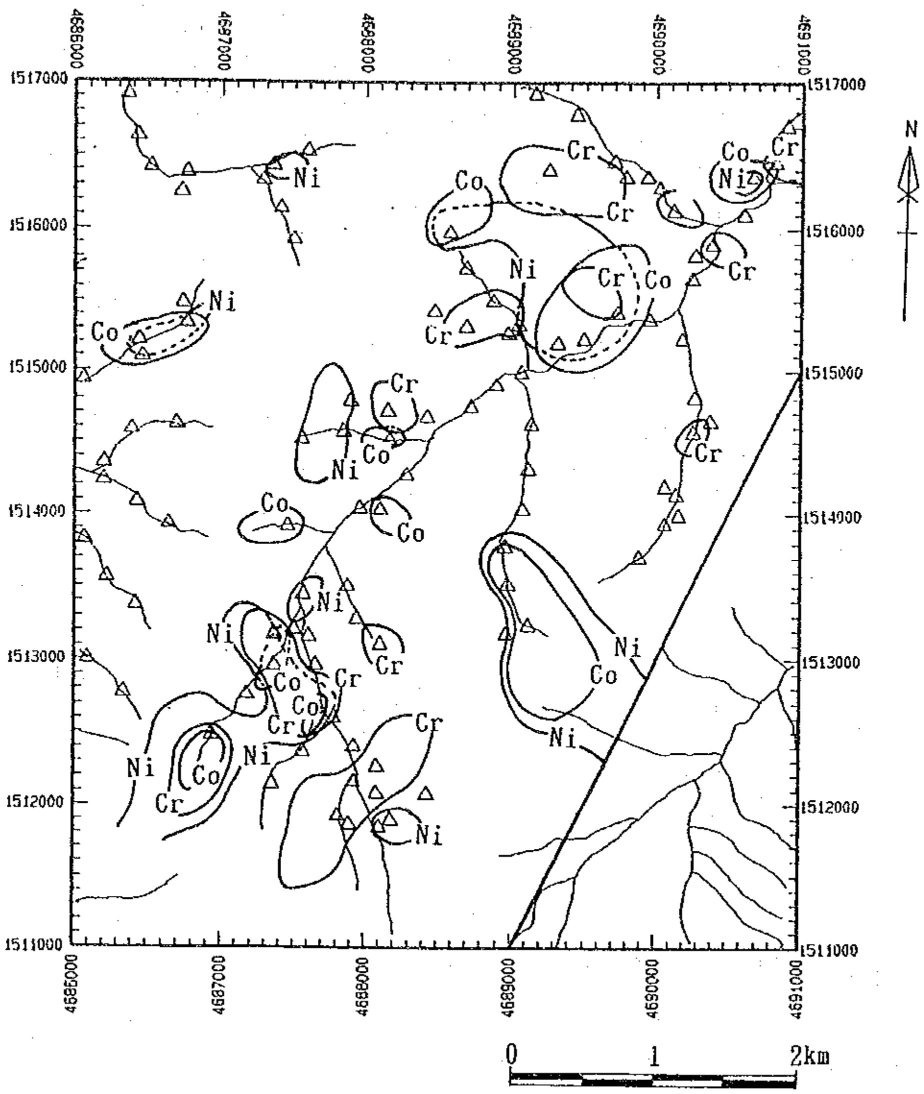
o Location of stream sediment samples collected in phase III.

Fig. II-1-20 Location map of geochemical samples in Area P

Table II-1-12 Statistics of stream sediments geochemical survey in Area P

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
Al (%)	—	15.02	1.19	4.275	0.275	—	4.940	7.510	—
Co (ppm)	—	851	64	237.9	0.184	554.0	229.0	343.0	667.2
Cr (ppm)	—	107,352	1,765	28,516.2	0.282	104,637.7	31,745.1	44,476.1	—
Fe (%)	—	34.86	7.19	13.196	0.125	23.417	12.200	17.400	24.321
Ni (ppm)	—	5,731	54	2,229.7	0.251	—	2,379.0	3,081.0	5,399.4

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



Co > 343 ppm
Cr > 44,476 ppm
Ni > 3,081 ppm

Fig. II-1-21 Distribution of geochemical anomalous zones in Area P

Al: High value samples are scattered over the area, and no characteristic distribution feature is observed.

Co: Samples of high value and anomaly are distributed over the area of peridotite in the lower stream and upper stream areas of Sungai Mailo.

Cr: Similar to Co distribution, samples of high value and anomaly are separately distributed in the both areas of lower stream and upper stream of Sungai Mailo.

Fe: Distribution of high value and anomalous samples are observed along the main stream of Sungai Mailo, especially at its upper most and lower stream areas.

Ni: Similar to Fe distribution, high value and anomalous samples occur along the main stream of Sungai Mailo, at its upper most and lower stream areas.

Aanomaly maps showing the anomalies of Co, Cr and Ni are given in Fig. II-1-21. Closely associated anomalies of Co, Cr and Ni are distributed in lower stream and upper stream areas of Sungai Mailo.

(4) Multi element analysis

Factor analysis was examined as the multi element analysis in this survey. The results of facter analysis are given in Table II-1-13. Following relationships between elements and factors were obtained by the factor analysis.

Factor 1 : Co-(Cr)-Fe-Ni
Factor 2 : Al-(-)Ni
Factor 3 : (Co)-Cr-(Ni)

The factor analysis shows a close relation among the elements of Ni, Fe and Ni and Cr is slightly isolated from these. Factor 3 may have some relation with chromite. A distribution map of factor score is given in Fig. II-1-22 , allocating three different colors to each factor. Three factors are shown by following colors.

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

Distribution tendencies of these factors are summarized as follows;

Factor 1: Samples of the highest factor score are found at the lower stream of Sungai Mailo, and samples of slightly higher factor score are scattered over the areas of upper stream of Sungai Mailo and its tributaries.

Factor 2: Samples of high factor score occur in northwestern part of the area.

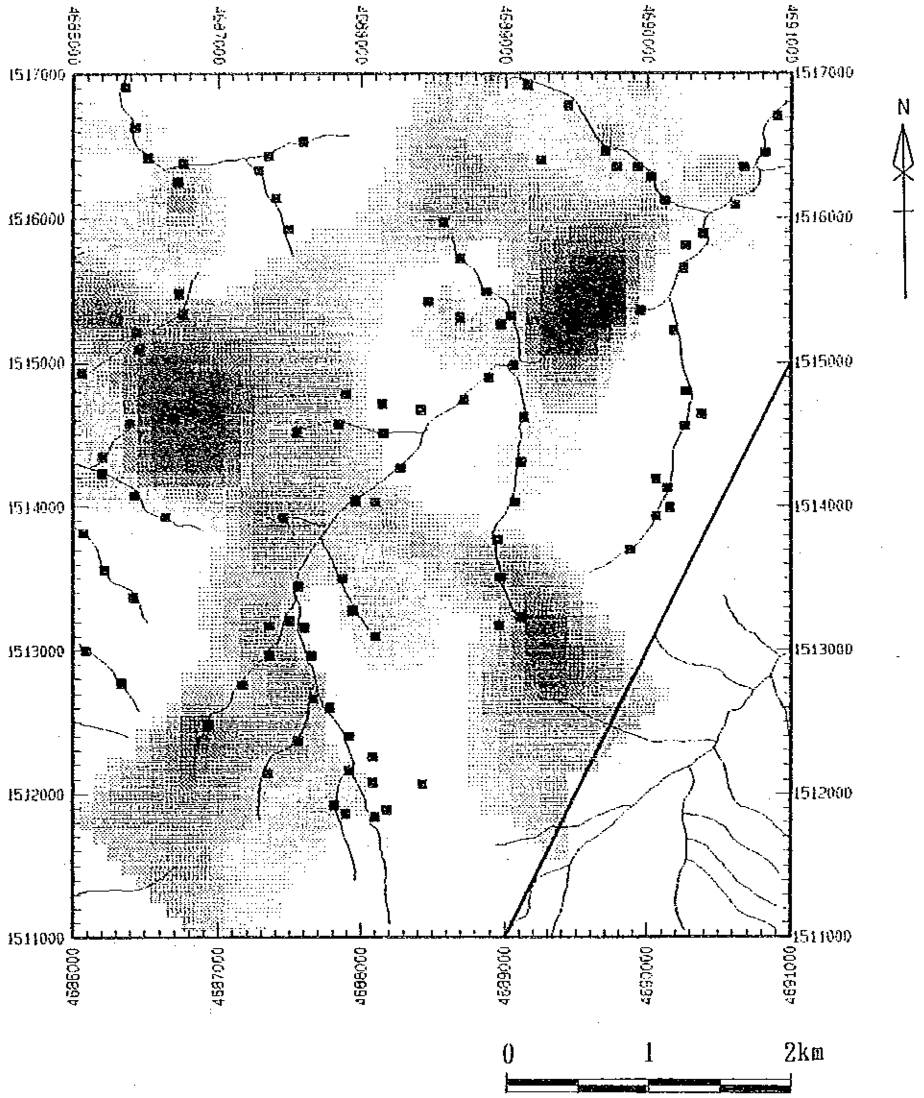
Factor 3: Samples of slightly higher factor score were distributed in the areas of upper stream and lower stream of Sungai Mailo.

The potentiality for chromite deposits in the Area P seem to be restricted in two areas, upper most and lower stream of Sugai Mailo.

Table II-1-13 Results of factor analyses for stream sediments samples in Area P

Element	Factor loading (Varimax rotation)			Communality
	Factor 1	Factor 2	Factor 3	
Al	-0.070	0.617	-0.012	0.3860
Co	-0.870	-0.080	-0.403	0.9253
Cr	-0.284	-0.018	-0.657	0.5126
Fe	-0.900	0.165	-0.245	0.8965
Ni	-0.574	-0.556	-0.410	0.8072
F.C.*[1]	56.2 %	20.5 %	23.3 %	—

*[1]: Factor contribution



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

Fig. II-1-22 Distribution of factor scores in Area P

1-9 Area Q

1-9-1 Geology and mineralization

(1) Survey area

Based on the geology and the regional geochemical survey results, this area was selected as a potential area for copper and chromium deposits. In order to clarify these potentials, soil and stream sediment geochemical survey was carried out in this area.

Area Q is located at the middle stream of Sungai Karamuak in the central south of the Labuk area. The area is northeastern bank of Sungai Karamuak and Sungai Karamuak flow southeastward in the southwestern part of the area. Sugai Pinanduan, Sungai Nobusu etc are the tributaries of Sungai Karamuak in the area. Flat low land of approximately 75 m altitude are found along Sungai Karamuak in the southwestern part of the area. Flat highland with the elevation upto approximately 500 m which called Tavai Plateau, occupies in the northeastern part of the area and extends futher east. The area between Tavai Plateau and Sungai Karamuak shows steep topography. The area is covered by secondary jungle and logging work is found nearby the area. Camp was established in the area and the survey was conducted.

Exploration work had been carried out in 1960's (Lewis, 1964), but at the time no conspicuous mineralized zone was confirmed.

(2) Geology

The area is covered by ultra-basic rocks (Pr) and gabbros (Gb) of Cretaceous to Tertiary age, and Crocker formation (P_2Cr) of Eocene to Oligocene age. Geological map is given in Fig. II-1-23.

The ultra-basic rocks (Pr) occupy wide area between Tavai Plateau and Sungai Karamuak and consists of peridotite and serpentinized ultra-basic rocks. Tavai Plateau is occupird by thick lateritic soil over the ultra-basic rocks. Small bodies of gabbro are found in the southwestern and northwestern parts of the area. Crocker formation (P_2Cr), consisting of pale gray sandstone and mudstone, contacts with the ultra-basic rocks by a thrust fault.

(2) Mineralization

Mineralized zones of copper and zinc minerals with pyrrotite were reported by Lewis (1964) in the surroundings of the gabbro bodies. The gabbro bodies were

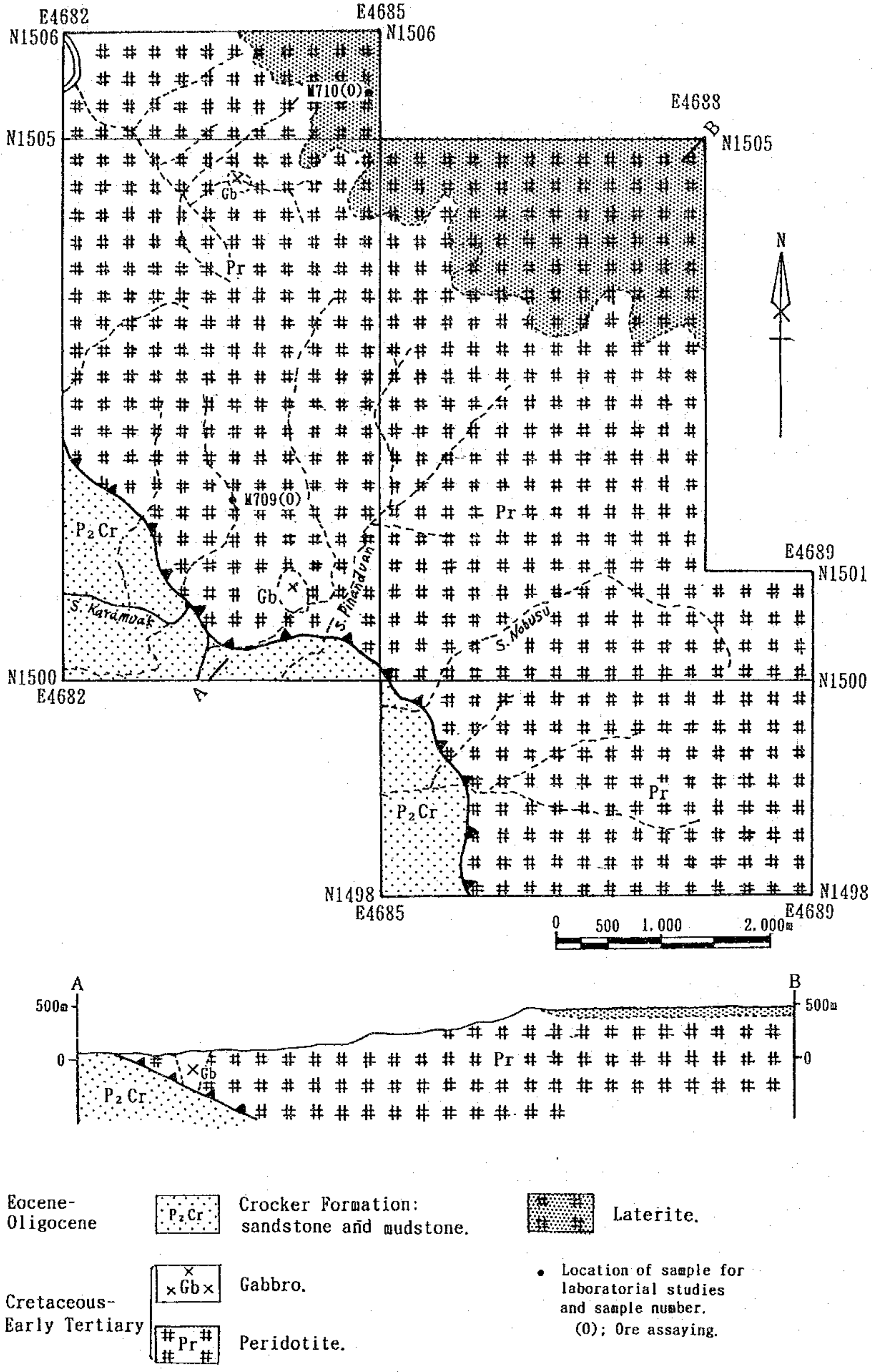


Fig. II-1-23 Geologic map and cross sections of Area Q confirmed, but no significant mineralized zones was recognized during the survey. survey. The mineralized zones reported are situated at the east bank of Sungai Pinanduan. Gossan floats with several tens centimeters in diameter were found in the stream nearby the reported mineralized zones. A gossan sample (M709) indicates comparatively high assay values of Au (4.1 g.t) and Fe (57.66 %) as shown in Table II -1-4. At the surface of Tavai Plateau, pisolite shaped iron oxide gravels with 10 to several mm in diameter, and large gossan blocks with approximately one meter in diameter are found. Assay results of the gossan sample (M710) indicate 3.59 % Cr, 43.81 % Fe and 0.34 % Ni (Table II -1-4). No chromite was confirmed during the survey.

1-9-2 Soil geochemical survey

(1) Sampling

Soil and stream sediments geochemical surveys were conducetd in the Area Q. Locations of collected soil samples and their list are, respectively, shown in Fig. II -1-24 and Appendix 19. After drying up the samples, -80 mesh fractions were prepared for the chemical analyses.

(2) Statistical data treatment

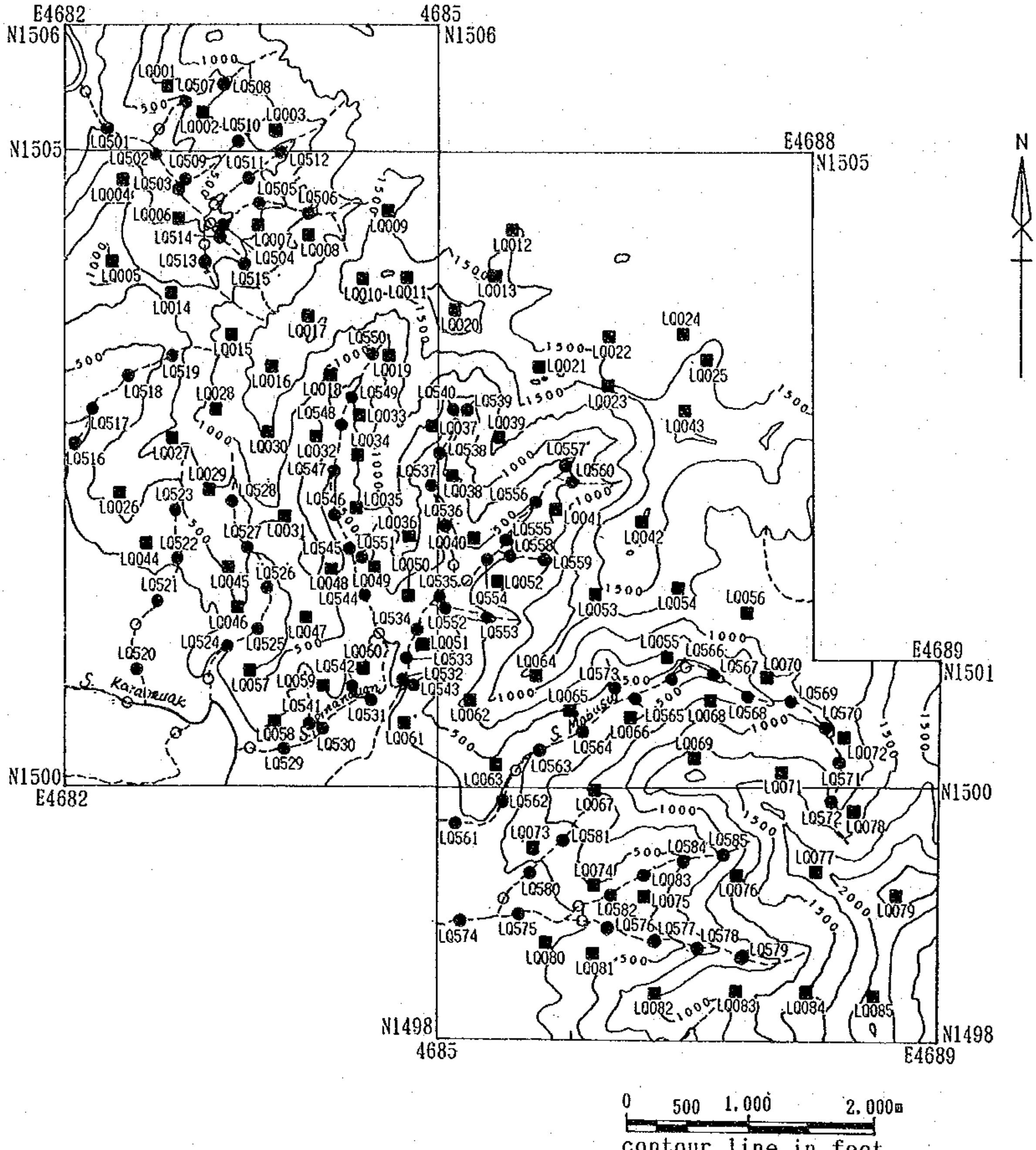
Analytical results are shown in Appendix 20. These analytical results were input to a computer and statistics were caluculated. The results of these are given in Table II -1-14.

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

Element indicating higher value: Au, Co, Cr, Cu, Hg, Mn, Ni, S
Element indicating lower value : Ba, K, Pb, U, Sr

The elements including Co, Cr and Ni show high values reflecting the distribution of the ultra-basic rocks in the area. The elements, Au, Cu, Hg and S, which directly related to mineralization also show high values. The values of Au and Cu show the highest values among the semi-detailed survey areas. The maximum and average values of Au and Cu are 276 ppb Au and 4.2 ppb Au and 4,726 ppm and 145.2 ppm Cu respectively. Analytical results of Mo and W for whole the samples indicate less than the detection limit. Concentrations of Pb indicate less than the detection limit for nearly whole samples.

In order to clarify relationships between the elements, correlation coefficients were also calculated. The results show following pairs of element to



LQ501 Location of stream sediment samples and sample number.

LQ001 Location of soil samples and sample number.

o Location of stream sediment samples collected in phase III.

Fig. II-1-24 Location map of geochemical samples in Area Q

Table II-1-14 Statistics of soil geochemical survey in Area Q

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	29.4	60	< 1	6.9	0.785	—	14.0	33.0	—
Au (ppb)	17.6	276	< 1	4.2	0.649	83.2	5.0	14.0	—
Ba (ppm)	—	101	4	17.6	0.259	58.0	18.0	26.0	75.2
Co (ppm)	—	1,526	100	405.6	0.277	1,452.8	458.0	737.0	—
Cr (ppm)	—	7,307	427	6,047.6	0.164	—	6,802.0	6,844.0	7,186.1
Cu (ppm)	—	4,726	25	145.2	0.413	971.3	129.0	301.0	1,182.2
Hg (ppb)	—	5,656	133	289.0	0.226	817.7	257.0	364.0	629.9
K (%)	—	0.15	0.04	0.058	0.131	0.106	0.050	0.080	0.116
Mg (%)	—	14.83	0.04	0.393	0.649	7.824	0.280	1.850	—
Mn (ppm)	—	9,703	496	3,065.6	0.318	—	3,382.0	6,131.0	—
Mo (ppm)	100.0	< 1	< 1	0.5	—	—	0.5	—	—
Na (%)	—	1.91	0.01	0.131	0.380	0.756	0.160	0.240	1.121
Ni (ppm)	—	4,316	134	3,197.5	0.192	—	3,951.0	4,006.0	—
Pb (ppm)	96.5	5	< 2	1.0	0.096	1.6	1.0	1.0	1.0
S (%)	—	0.181	0.017	0.037	0.212	0.098	0.033	0.058	0.134
Sb (ppm)	1.2	171.0	< 0.2	59.25	0.368	—	65.50	95.80	—
Sr (ppm)	10.6	46	< 1	1.9	0.330	8.6	2.0	3.0	15.6
Ti (%)	—	2.81	0.20	0.128	0.354	0.654	0.110	0.290	1.920
U (ppm)	74.1	0.8	< 0.2	0.13	0.218	0.35	0.10	0.20	0.10
W (ppm)	100.0	< 2	< 2	1.0	—	—	1.0	—	—
Zn (ppm)	—	270	13	138.9	0.221	—	160.0	194.0	—

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

be comparatively good (correlation coefficient: more than 0.500) correlations.

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

The blanket (-) indicate negative relationship. Good correlation is found between Au and Cu and these elements show negative relation with Mg. The elements including Cr, Ni and Zn show good correlations each other.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 21) using the values obtained by EDA method. Distribution of each element is summarized as follows;

As: Anomalous zones are found along Sungai Nobusu. Anomalous and high value zones are also found in the area of ultra-basic rocks from Sungai Pinanduan to Sungai Nobusu.

Au: Anomalous zones are found at the lower and upper stream of Sungai Pinanduan covering the known mineralized zones in the area of gabbros. The zone extends further west and covers the area where a gossan sample indicating 4.1 g/t Au was collected.

Ba: Anomalous and high value zones are restricted at the northwest side of Sungai Pinanduan.

Co: Anomalous and high value zones are found in the upper stream of Sungai Pinanduan and the zones extend further west.

Cr: Anomalous and high value zones are restricted in the area of southeast side of Sungai Nobusu. Small high value zones are scattered in the other area.

Cu: The distribution tendencies are similar to those of As. Anomalous and high value zones are found in the lower and upper stream. The anomalous zones at the lower stream include a sample indicating the maximum value (4,726 ppm) and extends the further west of Sungai Pinanduan.

Hg: High value and anomalous zones are found from Sungai Pinanduan to Sungai Nobusu in the sentral part of the area.

K Anomalous and high value zones are restricted at the northwest side of Sungai Pinanduan. No characteristic distribution feature is recognized.

Mg: High concentrations are found along Sungai Nobusu

Mn: High value and anomalous zones are found at the upper stream of Sungai Pinanduan. Other zones are scattered in the southeastern part of the area.

Na: High value and anomalous zones are found in the northeastern part of the area. The zones of small scale are found at the lower stream Sungai Pinanduan.

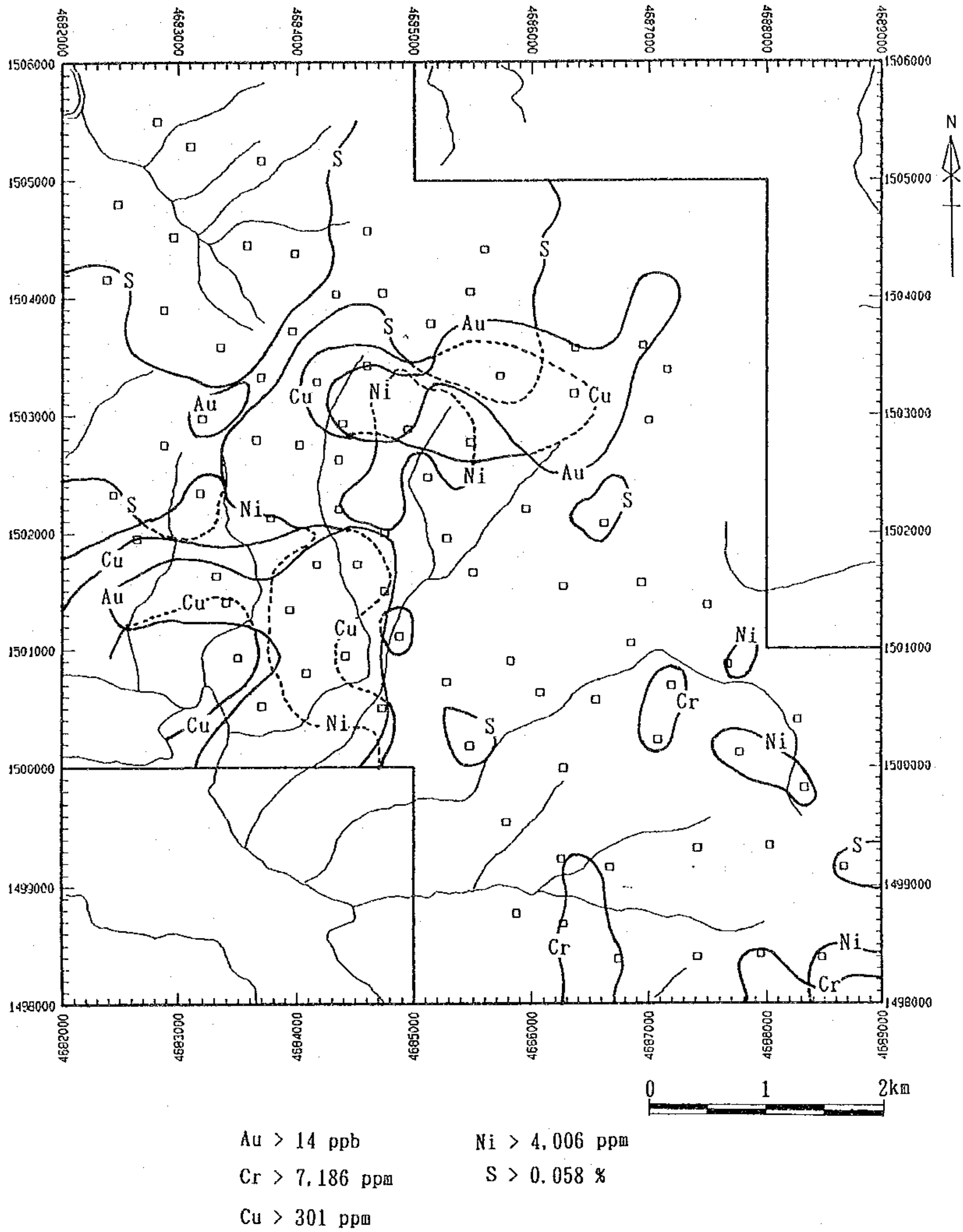


Fig. II-1-25 Distribution of geochemical anomalous zones of soil in Area Q

Ni: Anomalous zones are found from the upper stream of Sungai Pinanduan to the southwestern part of the area. Anomalous samples are scattered along Sungai Nobusu.

Pb: Only three samples indicate more than the detection limit.

S : High value zones are found in Tavai Plateau, and the zones extend for southwest along the ridge. Other than these, high value samples are scattered.

Sb: High value and anomalous zones occur at Tavai Plateau in the central part of the area. The distribution tendencies are similar to S.

Sr: High value zones occur in the lower stream of Sungai Pinanduan. Other than this, no clear distribution tendency is recognized.

Ti: High value and anomalous zones are restricted in the southern part of the area and are found along Sungai Nobusu.

U Absolute values are low and most the samples indicate less than the detection limit. Slightly high value samples are recognized at the south.

Zn: High value and anomalous zones mainly occur in the upper stream of Sungai Pinanduan, Tavai Plateau and the southern part of the area.

Considering the distribution maps and geological environment of the area, the elements, which are possibly useful for investigating the area, were choosen and an anomaly map for these elements was prepared (Fig. II-1-25). Anomalous zones of Au and Cu are overlapped and are found in the areas from Tavai Plateau to the upper stream of Sungai Pinanduan, lower stream of Sungai Pinanduan and the western part of the area. Anomalous zones of Ni are found nearby the anomalous zones of Au and Cu. Anomalous zones of Cr are isolated and are found in the southern part of the area.

(4) Multi element analysis

Factor analysis was examined as the multi element analysis in this survey. The results of facter analysis are given in Table II-1-15. Following relationships between elements and factors extracted by the factor analysis.

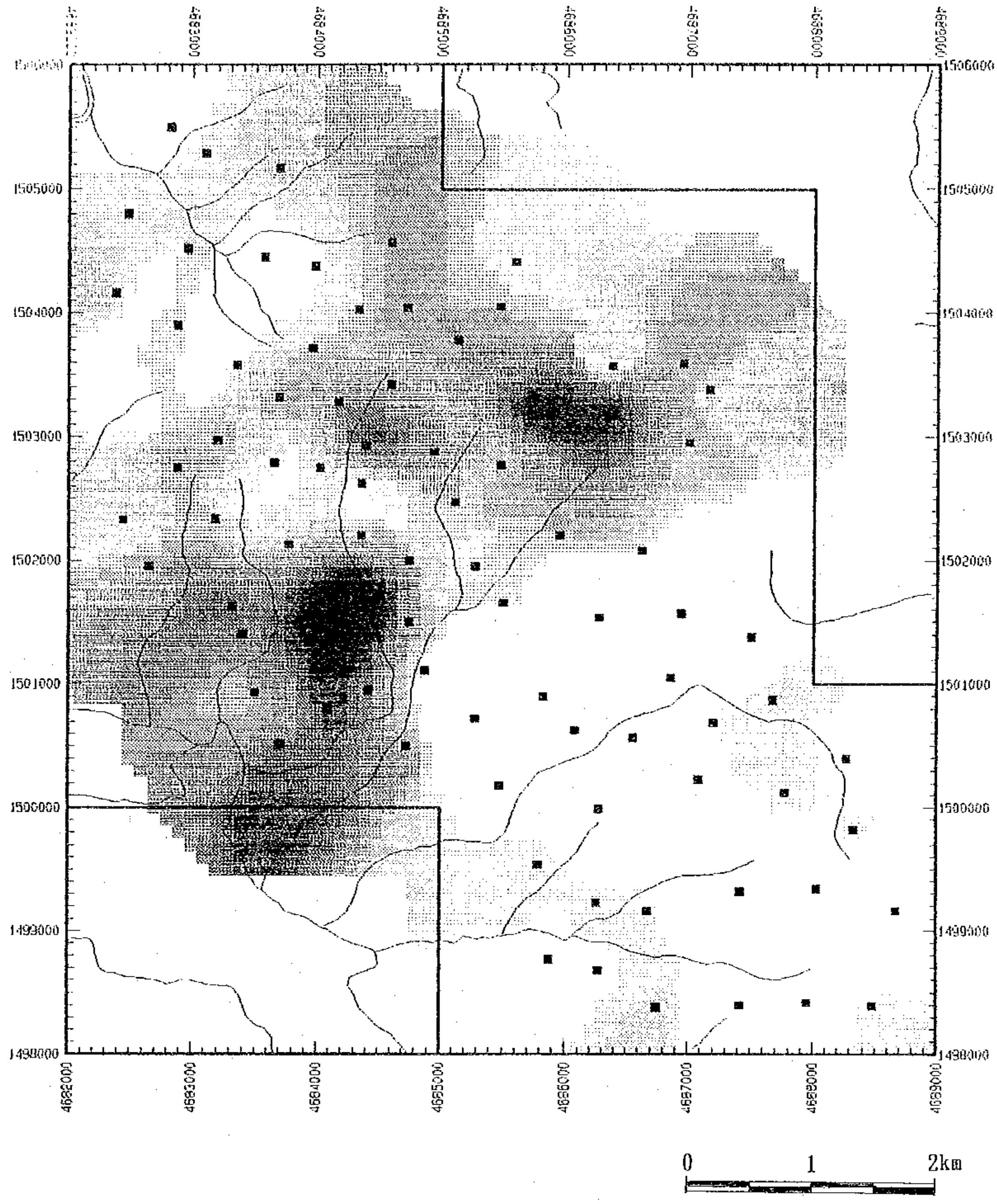
Factor 1 : Cr - Ni - Sb - Zn
Factor 2 : Ba - K - Na - Sr
Factor 3 : Co - (Mg) - Mn - (-)S
Factor 4 : Au - Cu - (-)Mg
Factor 5 : (As) - (Ti) - U
Factor 6 : (Pb)

Factor 1, to which a group of many elements are related, is probably reflecting a nature of ultra-basic rocks. Factor 4 is possibly indicates the mineralization.

Table II-1-15 Results of factor analyses for soil samples in Area Q

Element	Factor loading (Varimax rotation)						Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	
As	0.092	-0.237	0.297	-0.364	0.405	0.093	0.4581
Au	-0.035	0.166	0.046	0.832	-0.119	-0.115	0.7510
Ba	-0.182	0.656	-0.350	0.209	-0.023	0.249	0.6916
Co	-0.352	-0.018	-0.829	-0.004	-0.249	-0.172	0.9024
Cr	-0.888	-0.125	0.005	-0.003	0.155	-0.063	0.8327
Cu	-0.203	0.025	-0.093	0.788	0.063	0.011	0.6748
Hg	-0.056	-0.039	-0.274	0.042	0.099	0.033	0.0927
K	0.077	0.839	0.204	0.158	0.080	0.115	0.7955
Mg	0.296	0.000	-0.456	-0.651	0.003	-0.064	0.7240
Mn	-0.094	0.068	- 0.899	-0.033	-0.230	-0.145	0.8971
Na	0.071	0.785	0.257	0.040	-0.081	-0.269	0.7670
Ni	-0.782	-0.210	-0.175	0.100	-0.147	0.066	0.7225
Pb	0.063	0.051	0.075	-0.030	-0.056	0.357	0.1440
S	-0.293	0.261	0.509	0.283	0.059	-0.002	0.4971
Sb	-0.660	0.146	0.032	0.280	0.150	-0.081	0.5655
Sr	0.330	0.684	-0.164	-0.138	0.254	0.147	0.7082
Ti	0.372	0.265	0.194	-0.451	0.434	-0.295	0.7242
U	-0.089	0.092	0.029	0.011	0.536	-0.089	0.3128
Zn	-0.652	-0.021	-0.258	0.228	-0.076	-0.119	0.5642
F.C.*[1]	24.8 %	21.5 %	21.5 %	20.2 %	7.9 %	4.1 %	—

*[1]: Factor contribution



Factor 1 factor score : Blue

Factor 3 factor score : Yellow

Factor 4 factor score : Red

Fig. II-1-26 Distribution of factor scores of soil in Area Q

Among these factors, three factors, Factor 1, 3 and 4, were selected and a distribution map of factor score was prepared allocating three different colors for each factor (Fig. II-1-26). Three factors are shown by following colors.

Factor 1 : blue Factor 3 : yellow Factor 4 : red

Distribution tendencies of these factors are summarized as follows;

Factor 1: High factor score zones are found in Tavai Plateau and the north western extensions and are surrounded by high factor score zones of Factor 4. Comparatively high score zones are also found in the southeastern part of the area where high factor zones of Factor 3 are also found.

Factor 3: Zones of factor score are concentrated in the south side of Sungai in the southeastern part of the area. Other than these, small scale high factor zones are found in the upper stream of Sungai Pinanduan.

Factor 4: Conspicuous high factor score zones occur in the areas from Tavai Plateau to the upper stream of Sungai Pinanduan, the lower stream of Sungai Pinanduan and the western extensions. The high factor score zones Factor 1 and 3 do not overlap the high factor score zones of Factor 4.

From the results of factor analyses, Factor 4 seems to reflect the mineralization of copper and gold. Since, gossans are found in the high factor score zones of Factor 4, the high factor score zone should be investigated. Factor 1 and 3 may have some relation with laterite and chromite deposits.

1-9-3 Stream sediment geochemical survey

(1) Sampling

A Stream sediment geochemical survey was also conducted in Area Q. Locations of collected samples and their list are, respectively, shown in Fig. II-1-24 and Appendix 22. After drying up, these samples were sent for the chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 23. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-16.

The statistical figures of the stream sediments show following tendencies comparing with other areas of similar geological environment.

Element indicating higher value: Au, Co, Cr, Cu, Ni, Sb, Zn

Element indicating lower value : Ba, K, Na, Pb, Sr, U

Table II-1-16 Statistics of stream sediments geochemical survey in Area Q

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	8.2	50	< 1	13.0	0.562	—	19.0	35.0	—
Au (ppb)	41.2	1,200	< 1	2.3	0.761	78.2	2.0	12.0	158.11
Ba (ppm)	—	41	3	8.7	0.259	28.7	8.0	14.0	33.94
Co (ppm)	—	631	66	305.8	0.145	596.9	325.0	394.0	—
Cr (ppm)	—	7,338	4,527	6,897.5	0.024	—	6,925.0	7,115.0	—
Cu (ppm)	—	1,117	21	86.2	0.402	549.4	88.0	189.0	—
Hg (ppb)	—	190	40	78.4	0.130	142.6	76.0	97.0	159.2
K (%)	—	0.15	0.03	0.043	0.132	0.079	0.040	0.050	0.040
Mg (%)	—	11.97	0.21	3.259	0.292	—	3.380	6.030	—
Mn (ppm)	—	4,914	368	2,163.6	0.159	4,495.5	2,295.0	2,841.0	—
Mo (ppm)	96.5	3	< 1	0.5	0.110	0.9	0.5	0.5	0.5
Na (%)	—	0.96	0.01	0.051	0.433	0.375	0.050	0.130	—
Ni (ppm)	—	4,392	1,167	2,944.0	0.129	—	2,989.0	3,880.0	—
Pb (ppm)	98.8	9	< 2	1.0	0.104	1.7	1.0	1.0	1.0
S (%)	—	0.030	0.008	0.014	0.118	0.024	0.014	0.018	0.025
Sb (ppm)	—	850.0	31.5	341.89	0.226	—	372.40	533.70	—
Sr (ppm)	38.8	19	< 1	1.4	0.438	10.3	1.0	3.0	—
Ti (%)	—	1.92	0.03	0.154	0.341	0.740	0.170	0.280	1.523
U (ppm)	92.9	1.2	< 0.2	0.11	0.146	0.21	0.10	0.10	0.10
W (ppm)	100.0	< 2	< 2	1.0	—	—	1.0	—	—
Zn (ppm)	—	661	43	346.8	0.157	—	359.0	463.0	—

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

The elements indicating higher values are reflecting the distribution of ultra-basic rocks in the area. The maximum values of Au and Cu give 1,200 ppb and 1,117 ppm respectively, and these elements generally indicate high values. Cr indicate lower values compare to the values of Cr in Area P. Among 21 elements analyzed in this survey, W indicates less than the detection limit for whole the samples, and the elements of Mo, Pb and U show the values less than the detection limit for nearby whole samples. In order to clarify relationships between the elements, correlation coefficients were also calculated. The results show following pairs of elements to be comparatively good (correlation coefficient: more than 0.500) correlations.

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

A parenthesis of (-) indicates negative correlation each other. Au and Cu show a fairly good correlation and among the elements of Co, Mn and Ni also show good correlation each other.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 21) using the threshold and median values. Distributions of each element are summarized as follows;

As: Conspicuous anomalous zones are found at the upper stream of Sungai Pinanduan. Other anomalous zones are scattered in the southwestern and northwestern parts of the area.

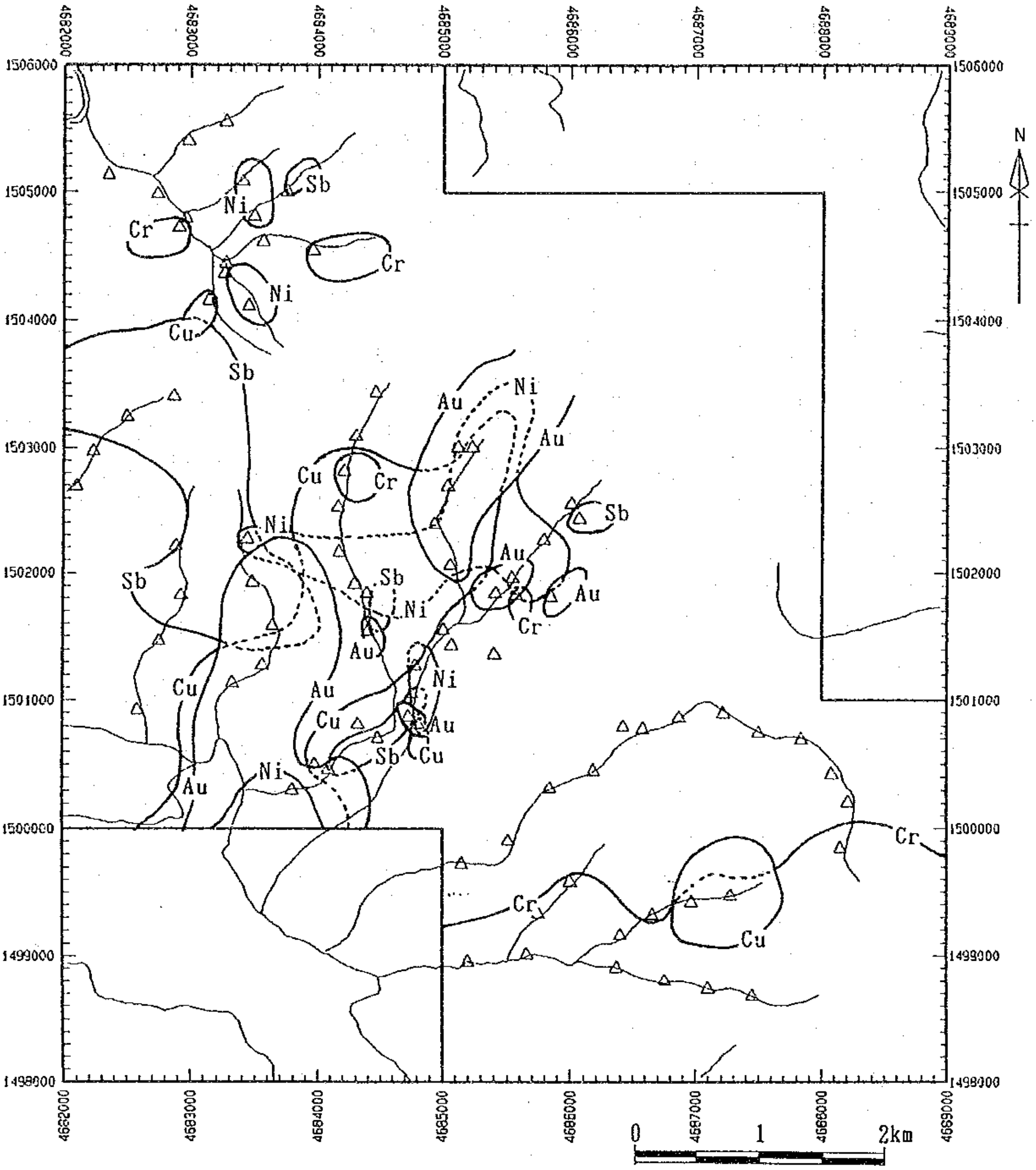
Au: High value and anomalous zones are found at the upper and lower stream of Sungai Pinanduan and the western adjacent stream of Sungai Pinanduan. The sample with the maximum values of 1,200 ppb was found in the western adjacent stream of Sungai Pinanduan. A gossan sample indicating 4.1 g/t was also confirmed in this adjacent stream.

Ba: High value samples are distributed at upper the stream of Sungai Nobusu and are scattered in the western part of the area.

Co: Anomalous zones are found in the upper stream of Sungai Pinanduan and northwestern part of the area.

Cr: The samples in the southern part of the area mostly indicate anomalous values. Other than the area, anomalous samples are scattered.

Cu: Anomalous zones are found at the upper stream of Sungai Pinanduan and the



Au > 12 ppb　　Ni > 3,880 ppm
Cr > 7,115 ppm　　Sb > 553.7 ppm
Cu > 189 ppm

Fig. II-1-27 Distribution of geochemical anomalous zones of stream sediments in Area Q western adjacent stream.

Hg: Anomalous samples are concentrated in the upper stream of Sungai Pinanduan. Other than the area, anomalous samples are scattered along Sungai Nobusu, in the southeastern and northwestern part of the area.

K : Most of the sample show low values. Slightly high value samples are found in the southern and southwestern part of the area.

Mg: Anomalous samples are mostly found along Sungai Nobusu and the southern part of the area. Other than these areas, anomalous samples are scattered in the northwestern part of the area.

Mn: High value and anomalous zones occur in the upper stream of Sungai Pinanduan and the northwestern part of the area.

Mo: Only three samples indicate more than the detection limit.

Na: Anomalous zones are distributed along Sungai Pinanduan and in the streams at the south. Small scale anomalous zones are found in the lower stream of Sungai Pinanduan and tthe western part of the area.

Ni: Ni indicates similar distribution tendencies of Mn. The high value and anomalous samples are found in the upper stream of Sungai Pinanduan and in the streams of the northwestern part of the area.

Pb: The absolute values are low. Only one sample indicates more than the detection limit.

S : High value and anomalous samples are slightly concentrated in the upper stream of Sungai Nobusu and in the streams at the southern part of the area. Other than there, high value and anomalous samples are scattered.

Sb: Samples of high value and anomaly mostly occur in the nortwestern side of Sungai Pinanduan.

Sr: High value zones are distributed in the stream of in the southern and western parts of the area. Small scale anomalous zones are found in the middle stream of Sungai Pinanduan.

Ti: High value zones are found from the middle stream of Sungai Pinanduan to the streams in the western part of the area. High value zones are also found in the upper stream of Sungai Nobusu.

U : The absolute values are low and only two samples indicates more than the detection limit.

Zn: High value zones are found in along Sungai Nobusu and southern part of the area. The high value zones are scattered in the northwestern side of Sungai Pinanduan.

The concentration of the elements show regional distribution tendencies. Concentrations of As, Co, Cu, Hg, Ni and Sb are found in the northwestern side of Sungai Pinanduan. In the areas along Sungai Nobusu and south side of Sungai Nobusu, the elements, Ba, Mg, Na and Ti are concentrated.

Considering the distribution maps, the elements, which are possibly useful for investigating the area, were choosen and an anomaly map for these elements was prepared (Fig. II-1-27). Anomalous zones of Au, Cu and Ni, overlapping each other, are found in the upper stream of Sungai Pinanduan and in the streams of the western part of the area. Anomalous zones of Cr are isolated and are found in the southeastern part of the area.

(4) Multi element analysis

Factor analysis was examined as a multi element analysis in this survey. The results of facter analysis are given in Table II-1-17. Following relationships between elements and factors were extracted by the factor analysis.

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

Considering the relationship between the factor and elements, Factor 2, 3 and 6 have some relation with mineralization. Among these factors, three factors, Factor 2, 3 and 6, were selected and a distribution map of factor scores was prepared allocating three different colors for each factor (Fig. II-1-28). Three factors are shown by following colors.

Factor 2 : blue   Factor 3 : red   Factor 6 : yellow

Distribution tendencies of these factors are summarized as follows;

Factor 1: Zones of high factor score are found along Sungai Pinanduan and southwestern side of Sungai Pinanduan. In the lower stream of Sungai Pinanduan, the high factor score zones overlap the high factor score zones of Factor 3.

Factor 3: High factor score zones are lestricted in the northwestern part of Sungai Pinanduan and conspicuous high score zones are found in the down stream of Sungai Pinanduan.

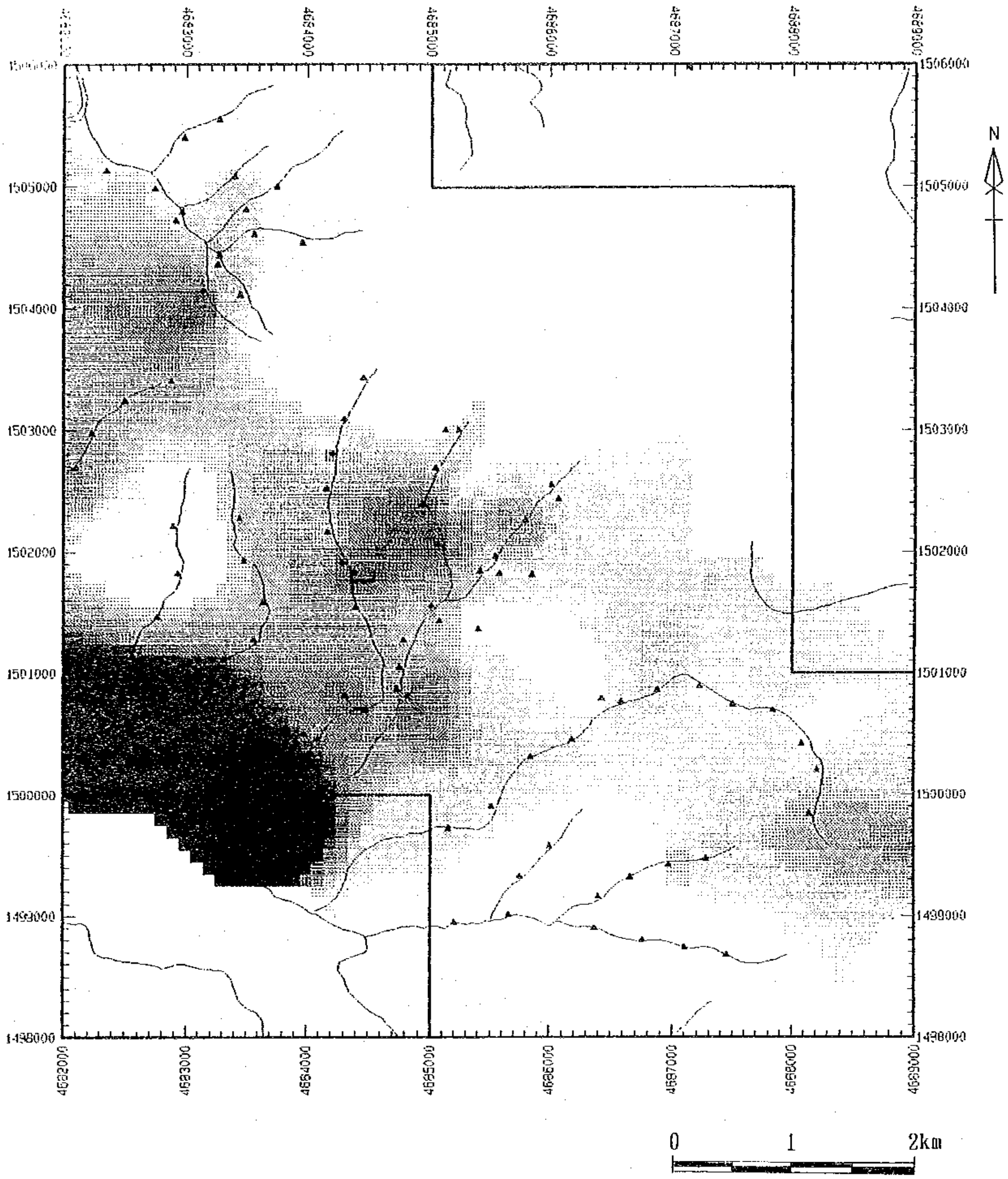
Factor 6: High factor score zones in the surrounding aseas of Tavai Plateau and the western central part of the area.

Judging from the results, Factor 3 reflects the mineralization of Au and Cu. Therefore the high factor score zones of Factor 3 in important for the further exploration work. Factor 6 may have some relation with laterite. Factor 2 have some relation with nickel and chromite, but is not conspicuous.

Table II-1-17 Results of factor analyses for stream sediments samples in Area Q

Element	Factor loading (Varimax rotation)						Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	
As	0.112	0.021	-0.228	-0.003	0.054	0.682	0.5331
Au	0.322	-0.122	-0.506	0.185	0.169	0.247	0.4981
Ba	- 0.704	0.174	0.035	-0.356	-0.006	-0.133	0.6710
Co	0.050	0.862	-0.234	0.177	-0.066	0.227	0.8874
Cr	0.224	0.520	0.376	0.167	-0.565	-0.114	0.8223
Cu	0.226	0.158	-0.799	0.005	0.013	0.199	0.7541
Hg	0.047	0.337	-0.522	-0.281	-0.239	0.044	0.5267
K	-0.814	-0.225	0.091	-0.143	-0.007	-0.048	0.7444
Mg	0.096	0.051	0.838	0.199	-0.226	0.043	0.8059
Mn	-0.029	0.935	0.001	0.121	-0.014	-0.022	0.8895
Mo	0.047	-0.181	-0.148	0.309	0.102	-0.292	0.2480
Na	-0.623	0.077	0.156	-0.039	-0.512	-0.405	0.8463
Ni	0.289	0.545	-0.191	0.028	-0.025	0.627	0.8112
Pb	-0.312	-0.513	-0.236	-0.567	0.391	0.002	0.8907
S	-0.272	0.029	0.036	-0.118	-0.704	-0.034	0.5875
Sb	0.221	0.093	-0.074	0.841	0.229	0.071	0.8287
Sr	-0.766	-0.208	0.126	-0.117	-0.235	-0.347	0.8346
Ti	-0.451	-0.016	-0.037	0.068	-0.144	-0.654	0.6581
U	-0.264	-0.397	-0.198	-0.653	0.193	-0.211	0.7744
Zn	0.067	0.190	0.278	0.783	-0.018	-0.235	0.7866
F.C.*1	20.6 %	20.6 %	16.7 %	17.8 %	10.8 %	13.5 %	—

*1: Factor contribution



Factor 2 factor score : Blue

Factor 3 factor score : Red

Factor 6 factor score : Yellow

Fig. II-1-28 Distribution of factor scores of stream sediments in Area Q

1-10 Area R

1-10-1 Geology and mineralization

(1) Survey area

From the regional geochemical survey results, high value and anomalous zones of Au and Cu were delineated in this area. In order to clarify these potentials, soil and stream sediment geochemical surveys were carried out in this area.

Area R is located between Sungai Karamuak and Sungai Milian in the south central part of the Labuk area. Sungai Karamuak flows southeastward in the northern part of the area. Sungai Milian flows eastward in the southern adjacent of this area. The area shows steep topography. Ridges upto the 600 m in elevation streach with a direction of NW-SE in the southern central part of the area. Sungai Kelugu and Numatoi are the tributaries of Sungai Karamuak, and Sungai Bangkulat is the tributary of Sungai Milian. Flat low lands are found along Sungai Karamuak and the southwestern part of the area. The area is mostly covered by secondary jungle. Camp was established within the area and the survey was conducted.

(2) Geology

Geology in Area R consist of metamorphic rocks (Gs), ultra-basic rocks (Pr) and gabbros (Gb) of Cretaceous to Tertiary age, Chert-Spilite formation (Csch, Csba) Cretaceous to Eocene age, and Crocker formation (P_2Cr) of Eocene to Oligocene age. Terrace deposits (Q_1) and Alluvium deposits (Q_2) are found along rivers. The geological map of Area R is given in Fig. Ⅱ-1-29.

Metamorphic rocks consist of amphibolite and green schist and are found in the central part of the area. The ultra-basic rocks (Pr) consisting of harzburgite and serpentinized rocks, occur along the ridge with a direction of NW-SE in the central part of the area. Gabbros (Gb) are found in visinity of basalt in the southwestern part of the area and form small bodies. The Chert-Spilite consists of dolerite and basalt (Csba) and chert (Csch). Dolerite and basalt are dark greenish gray in color and chrolitized, and are surrounded by thrust faults. These rocks are found under the ultra-basic rocks. The chert is found in a small area in the northwestern part of the area.

(2) Mineralization

No conspicuous mineralized and/or altered zone was recognized in this survey.

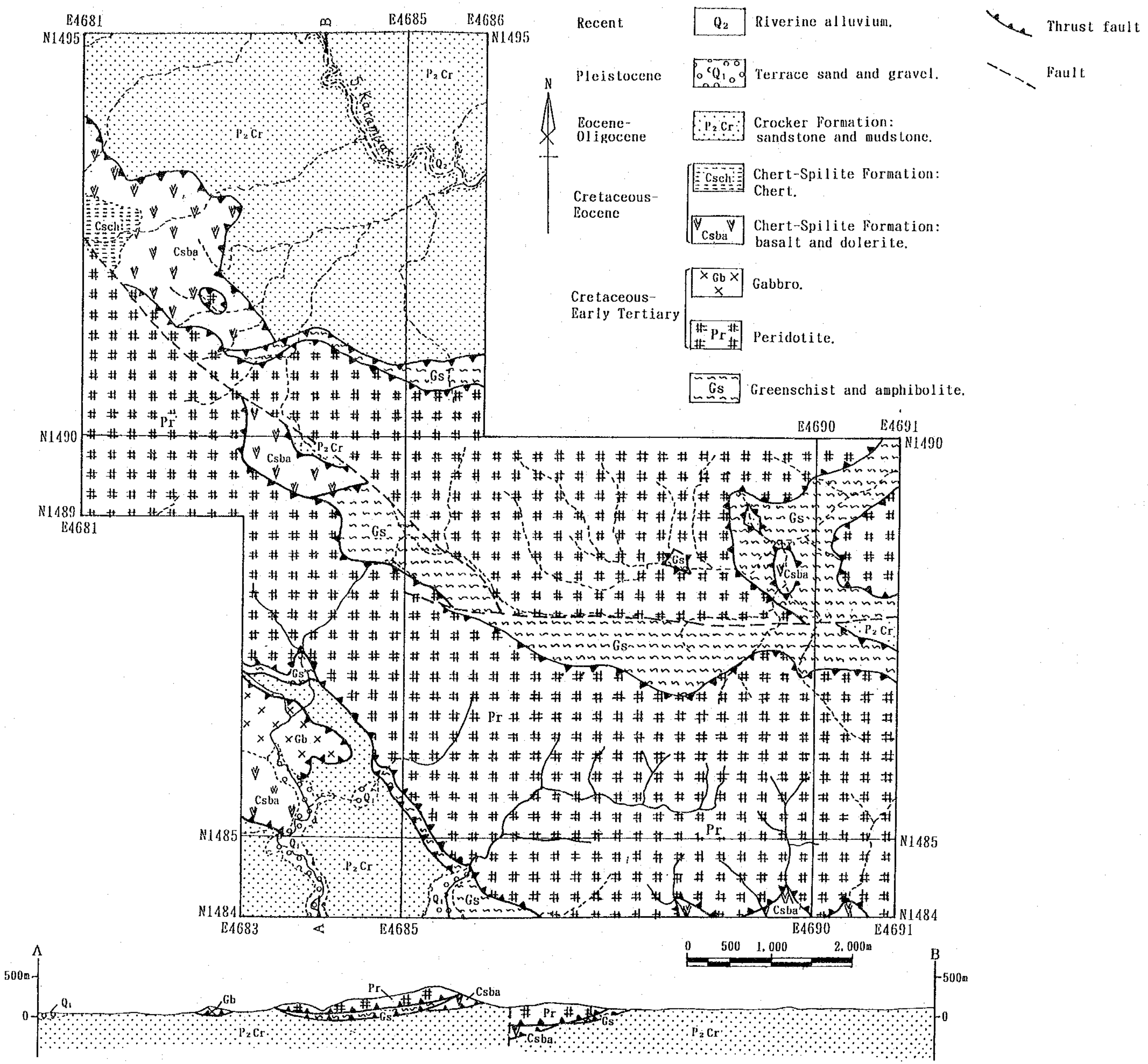


Fig. II-1-29 Geologic map and cross sections of Area R

1-10-2 Soil geochemical survey

(1) Sampling

Soil and stream sediments geochemical surveys were conducetd in the Area R. Locations of collected soil samples and their list are, respectively, shown in Fig. II-1-30 and Appendix 24. After drying up the samples, -80 mesh fractions were prepared for the soil samples and the samples were chemically analized.

(2) Statistical data treatment

Analytical results are shown in Appendix 25. These analytical results were input to a computer and statistics were caluculated. The results of these are given in Table II-1-18.

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

Element indicating higher value: Co, Cr, Mg, Ni, Sb

Element indicating lower value : Ba, K, Pb, Sr, U

Among the 21 elements analyzed, Au, Mo and W indicate less than the detection limits nearby whole samples.

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

Co-Cr, Co-Mn, Co-Ni, Co-Sb, Co-U(-), Co-Zn, Cr-Mn, Cr-Ni, Cr-Sb,
Cr-U(-), Cr-Zn, K-U, Mg-Mn, Mn-Ni, Mn-U(-), Mn-Zn, Ni-Sb, Ni-U(-)
Ni-Zn, Pb-u, S-U(-), Sb-U(-), Sb-Zn

The blanket (-) indicate negative relationship. Good correlation is found among the elements of Co, Cr, Mn, Ni, Sb and Zn. U has negative relationship with these elements.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 26) using the values obtained by EDA method. Distribution of each element is summarized as follows;

As: Anomalous zones are found in the southeastern part of the area where ultra-basic rocks are distributed. Other than those, anomalous zones are scattered.

Au: Absolute values are low and most of the samples indicates less than the

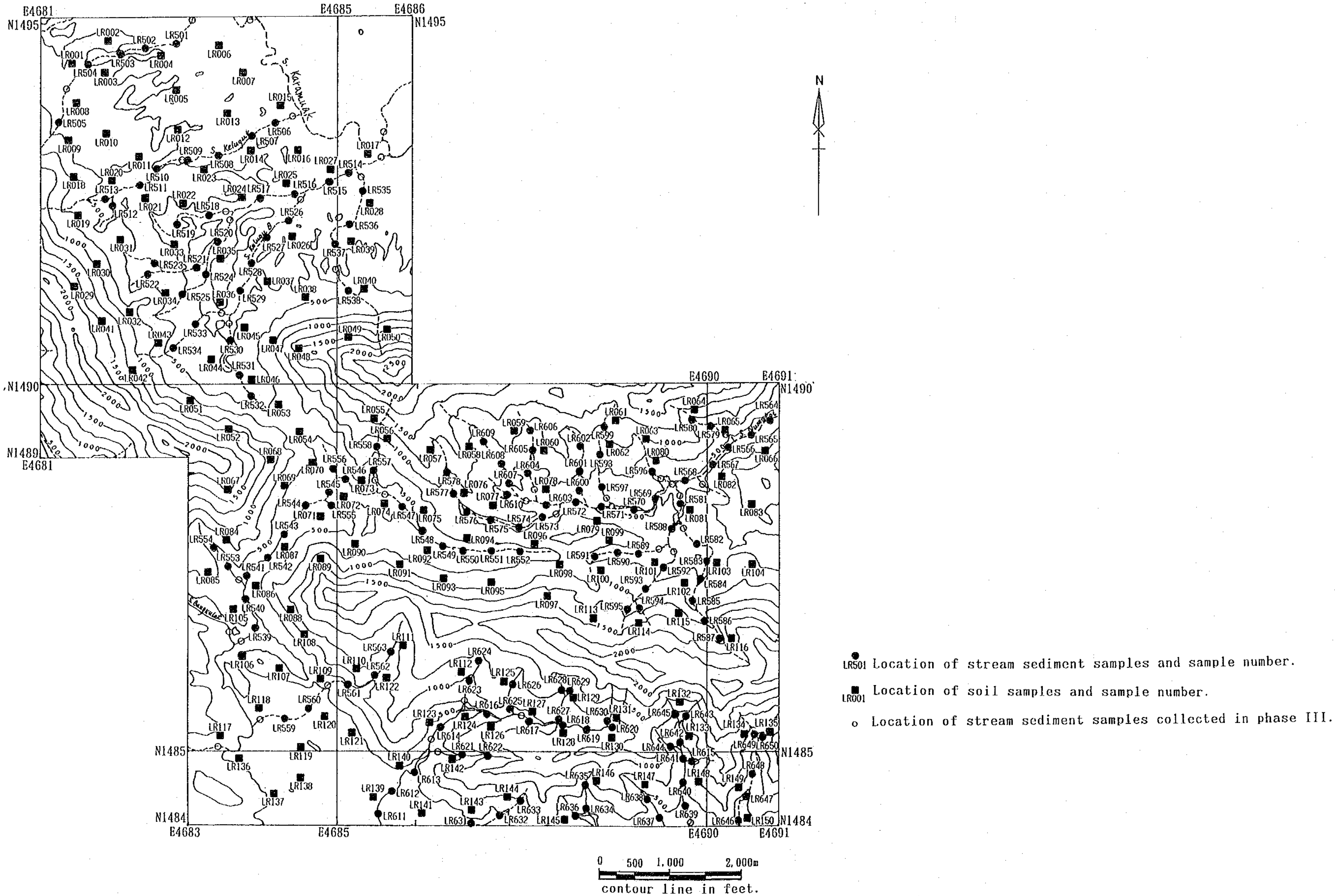
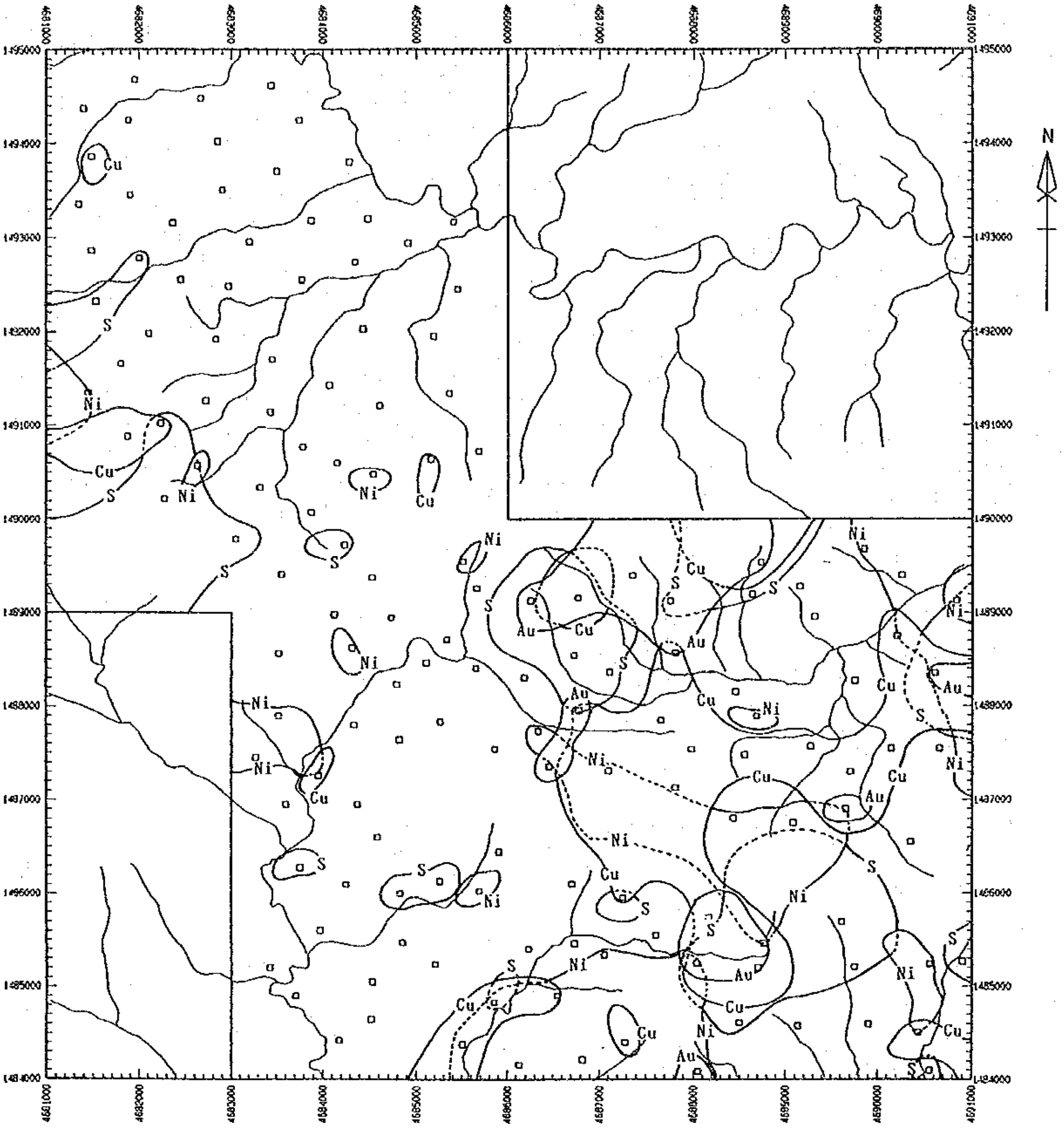


Fig. II-1-30 Location map of geochemical samples in Area R

Table II-1-18 Statistics of soil geochemical survey in Area R

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	32.0	94	< 1	5.0	0.786	—	7.5	31.0	—
Au (ppb)	77.3	6	< 1	0.7	0.282	2.5	0.5	1.0	0.5
Ba (ppm)	—	2,238	4	37.7	0.528	428.7	43.0	88.0	869.2
Co (ppm)	2.0	983	< 1	85.7	0.769	—	136.0	404.0	—
Cr (ppm)	—	7,450	48	1,636.4	0.678	—	3,205.9	6,814.0	—
Cu (ppm)	—	241	3	42.6	0.396	—	50.5	91.0	—
Hg (ppb)	—	495	41	105.4	0.207	273.5	106.0	164.0	413.0
K (%)	—	1.17	0.04	0.126	0.434	0.928	0.105	0.360	—
Mg (%)	—	10.81	0.06	1.098	0.609	—	1.139	5.020	—
Mn (ppm)	—	9,157	21	1,113.2	0.672	—	1,805.4	4,433.0	—
Mo (ppm)	76.0	3	< 1	0.6	0.204	1.6	0.5	1.0	0.5
Na (%)	—	4.04	0.01	0.180	0.453	1.445	0.200	0.380	1.982
Ni (ppm)	—	4,527	9	643.7	0.788	—	1,299.4	3,252.0	—
Pb (ppm)	52.7	27	< 2	2.7	0.499	26.7	1.0	10.0	—
S (%)	—	0.092	0.006	0.022	0.236	0.066	0.024	0.035	—
Sb (ppm)	0.7	159.7	< 0.2	21.18	0.534	—	27.05	57.00	—
Sr (ppm)	2.0	94	< 1	9.7	0.519	—	11.0	27.0	—
Ti (%)	—	1.84	0.09	0.435	0.282	1.592	0.430	0.780	—
U (ppm)	30.0	2.8	< 0.2	0.40	0.527	—	0.40	1.80	—
W (ppm)	99.3	3	< 2	1.0	0.039	1.2	1.0	1.0	1.0
Zn (ppm)	7.3	221	< 1	50.9	0.682	—	92.5	130.0	—

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



0 1 2km

Au > 2.5 ppb
Cr > 6.814 ppm
Cu > 91 ppm
Ni > 3.252 ppm
S > 0.035 %

Fig. II-1-31 Distribution of geochemical anomalous zones of soil in Area R detection limit. Slightly high value samples are restricted in the southeastern part of the area along Sungai Numatoi.

Ba: High value zones are found along Sungai Kelugu in the northwestern part and along Sungai Bankulat in the southwestern part where the Crocker formation occurs. The high value zones are also found in the area of Sungai Numatoi.

Co: Anomalous zones are found in the southern central part of the area. Other than these, anomalous and high value zones are scattered in the area of ultra-basic rocks.

Cr: Distribution tendencies are similar to those of Co. Anomalous zones are found in the southeastern part of the area. Other than these, anomalous and high value samples are scattered in the area of ultra-basic rocks.

Cu: Anomalous zones are found in the areas along Sungai Numatoi and southern part of the area. These anomalous areas are correspond to the area of the ultra-basic rocks and metamorphic rocks.

Hg: High value zones are found in the area centering the upper stream of Sungai Numatoi. High value samples are scattered in the area of the ultra-basic rocks.

K : Anomalous and high value zones are found in the area along Sungai Numatoi and the Crocker formation.

Mg: High value zones are found in the area of the ultra-basic rocks, and the anomalous zones are scattered within these zones.

Mn: Distribution tendencies are similar to those of Mg. High value zones are found in the area of the ultra-basic rocks. Anomalous zones are scattered within these high value zones.

Na: High value and anomalous zones are found in the areas of the Crocker formation, basalt and metamorphic rocks.

Ni: Distribution tendencies are similar to those of Co and Cr, and anomalous zones are found in the southeastern part of the area. Other than these, the high value and anomalous zones are scattered in the area of ultra-basic rocks.

Pb: The absolute values are low and around a half of the samples indicates less than the detection limit. Slightly high value samples are found in the area of the Crocker formation.

S : Distribution of high value and anomalous zones are correspond to the area of ultra-basic rocks.

Sb: Anomalous samples are found in the area of ultra-basic rocks in the southwest of the area. Anomalos zones are found along a stream in the southwestern part of the area.

Sr: High value and anomalous samples are distributed in the area of Crocker formation, crystalline basement and basalt.

Ti: Anomalous zones are found in the area of metamorphic rocks along Sungai Numatoi. Other than these, anomalous samples are scattered in the area of metamorphic rocks and basalt.

U : Anomalous and high value zones are found in the area of Crocker formation and metamorphic rocks which occur in the central part of the area.

W : Only one sample indicates more than the detection limit.

Zn: Anomalous zones are found in the area of ultra-basic rocks in the southwestern part of the area.

Considering the distribution maps and geological environment of the area, the elements, which are possibly useful for the assessment of the area, were selected and an anomaly map for these elements was prepared (Fig. II-1-31). Anomalous zones are mostly found in the southwestern part of the area. Anomalous zones of Cu and Au are found from Sungai Numatoi to southwestern part of the area and are overlapping each other, but absolue values of these elements are low.

(4) Multi element analysis

Factor analysis was examined as the multi element analysis in this survey. The results of facter analysis are given in Table II-1-19. Following relationships between elements and factors extracted by the factor analysis.

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

Judging from the relationship between the facter and the related elements, Factor 1 is probably reflecting a nature of ultra-basic rocks, basic rocks and copper mineralization. Facter 2 has some relation with copper and/or gold mineralization. Factor 4 is possibly indicates a nature of sedimentary rocks. Other than these three factors, the relationships are not clear. Among these factors, three factors, Factor 1, 2 and 3, were selected and a distribution map of factor score was prepared allocating three different colors for each factor (Fig. II-1-32). Three factors are shown by following colors.

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

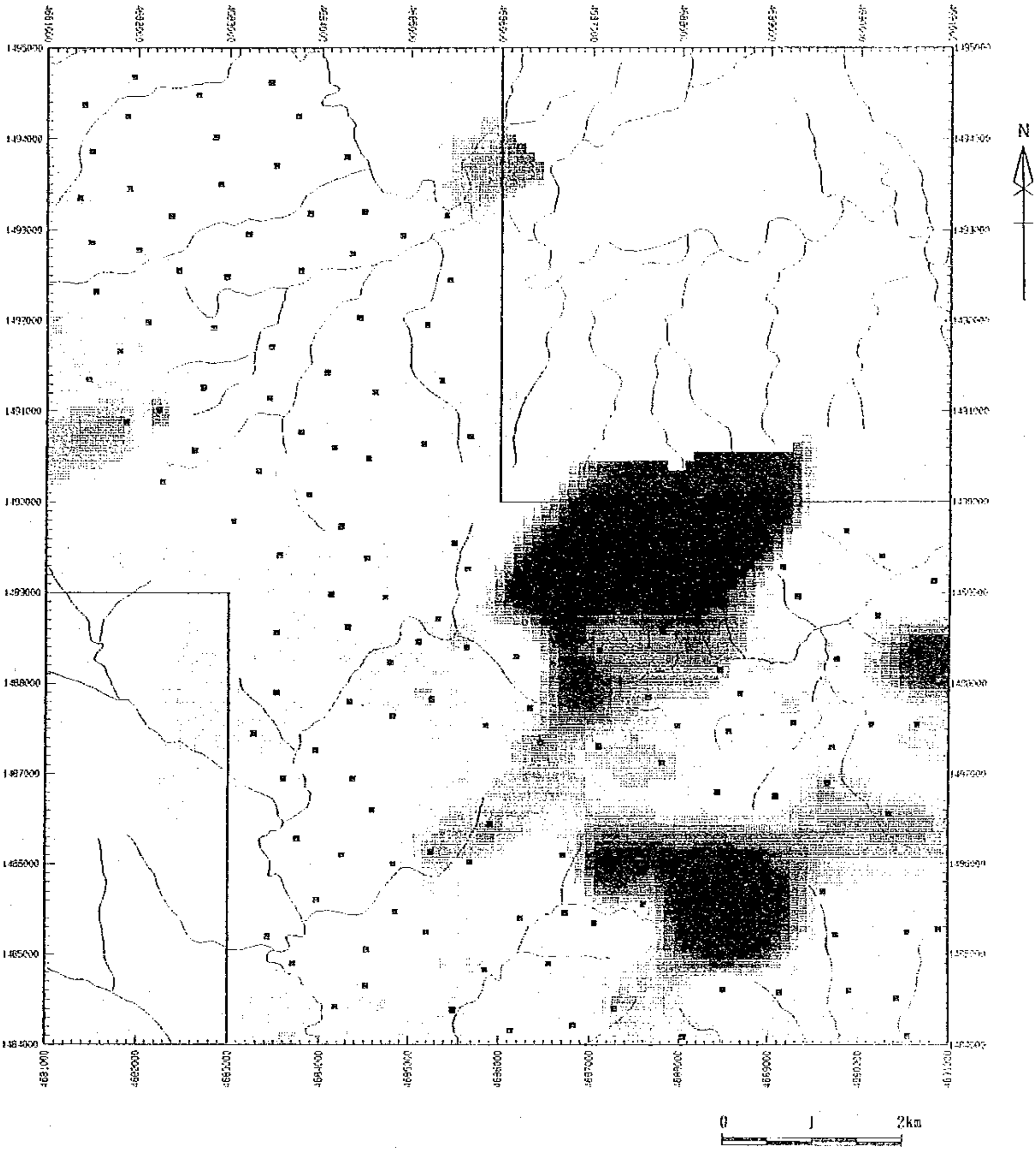
Distribution tendencies of these factors are summarized as follows;

Factor 1 Comparatively high factor score zones are found in the area of ultra-basic rocks with a NW-SE direction.

Table II-1-19 Results of factor analyses for soil samples in Area R

Element	Factor loading (Varimax rotation)					Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
As	0.215	0.355	-0.657	-0.032	-0.097	0.6142
Au	0.065	0.759	0.029	0.129	-0.136	0.6167
Ba	-0.080	-0.183	-0.005	-0.817	0.043	0.7096
Co	0.846	0.097	-0.385	0.199	-0.174	0.9433
Cr	0.683	0.388	-0.509	0.256	-0.115	0.9547
Cu	0.766	0.458	0.165	0.039	-0.171	0.8547
Hg	0.365	0.610	-0.285	0.281	-0.163	0.6915
K	-0.207	-0.186	0.414	-0.737	0.247	0.8532
Mg	0.579	-0.496	-0.454	0.033	-0.224	0.8386
Mn	0.864	-0.100	-0.225	0.172	-0.253	0.9001
Mo	-0.319	0.060	0.345	-0.297	0.058	0.3160
Na	0.503	-0.071	0.300	-0.130	-0.524	0.6399
Ni	0.757	0.326	-0.494	0.212	-0.115	0.9818
Pb	-0.387	-0.264	0.162	-0.462	0.533	0.7428
S	0.426	0.343	-0.153	0.271	-0.550	0.6973
Sb	0.673	0.399	-0.396	0.151	-0.288	0.8747
Sr	-0.134	-0.595	0.251	-0.519	-0.178	0.7363
Ti	0.060	0.069	0.705	-0.204	-0.046	0.5490
U	-0.512	-0.082	0.349	-0.473	0.501	0.8649
W	-0.178	-0.009	-0.060	-0.063	0.027	0.0399
Zn	0.885	0.238	-0.117	0.049	-0.185	0.8901
F.C.*1	38.5 %	17.3 %	17.9 %	16.0 %	10.3 %	—

*1: Factor contribution



Factor 1 factor score : Blue

Factor 2 factor score : Red

Factor 3 factor score : Yellow

Fig. II-1-32 Distribution of factor scores of soil in Area R

Factor 2 High factor score zones are along the upper stream of Sungai Numatoi and southeastern part of the area where ultra-basic rocks occur.

Factor 3 The high score samples are mostly found in the are of ultra-basic rocks.

High factor score zones of Factor 2 are clearly recognized. However, since the absolute values of Au and Cu are low, potential for copper and gold ore deposits is thought to be low.

1-10-3 Stream sediment geochemical survey

(1) Sampling

A Stream sediment geochemical survey was also conducted in Area R. Locations of collected samples and their list are, respectively, shown in Fig. II-1-30 and Appendix 27. After drying up, these samples were sent for the chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 28. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-20.

The statistical figures of the stream sediments show following tendencies comparing with other areas of similar giological environment.

Element indicating higher value: Co, Cr, Mg, Mn, Ni, Sb

Element indicating lower value : Au, Ba, K, Pb, Sr

The elements indicating higher values are reflecting the distribution of ultra-basic rocks in the area. Among 21 elements analyzed in this survey, Mo indicates less than the detection limit for whole the samples, and the elements of Au and W show the values less than the detection limit for most the samples. In order to clarify relationships between the elements, correlation coefficients were also calculated. The results show followingpairs of elements to be comparatively good (correlation coefficient: more than 0.700) correlations.

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

Good correlations are recognized among the elements of Co, Cr, Cu, Mg, Mn, Ni and Zn. Generally, U indicates negative correlation among these elements.

Table II-1-20 Statistics of stream sediments geochemical survey in Area R

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	26.7	68	< 1	4.7	0.681	—	8.0	17.0	—
Au (ppb)	90.0	2	< 1	0.5	0.122	1.0	0.5	0.5	0.5
Ba (ppm)	—	1,611	5	48.8	0.667	1,053.9	33.5	176.0	1,215.2
Co (ppm)	1.3	488	< 1	100.4	0.491	—	140.5	204.0	—
Cr (ppm)	—	7,245	190	4,581.1	0.331	—	6,799.5	7,095.0	—
Cu (ppm)	—	358	4	29.1	0.345	142.8	30.0	54.0	202.9
Hg (ppb)	—	472	21	54.8	0.261	182.7	49.0	99.0	316.6
K (%)	—	1.62	0.02	0.156	0.428	1.119	0.145	0.450	—
Mg (%)	—	16.86	0.02	3.770	0.489	—	5.100	7.970	—
Mn (ppm)	—	5,904	32	1,443.1	0.391	—	1,711.0	2,533.0	3,658.5
Mo (ppm)	100.0	< 1	< 1	0.5	—	—	0.5	—	—
Na (%)	—	0.96	0.01	0.271	0.348	—	0.325	0.460	—
Ni (ppm)	—	4,263	12	935.2	0.459	—	1,302.0	1,917.0	—
Pb (ppm)	54.0	22	< 2	2.2	0.421	15.4	1.0	6.0	—
S (%)	—	0.037	0.003	0.017	0.219	—	0.018	0.024	—
Sb (ppm)	—	308.6	3.5	54.36	0.376	307.31	57.95	121.20	—
Sr (ppm)	—	91	2	16.4	0.368	89.2	18.5	33.0	—
Ti (%)	—	6.34	0.10	0.454	0.401	2.873	0.450	1.010	5.630
U (ppm)	42.0	2.2	< 0.2	0.26	0.407	1.67	0.20	0.60	—
W (ppm)	96.7	5	< 2	1.0	0.091	1.6	1.0	1.0	1.0
Zn (ppm)	4.0	460	< 1	130.7	0.568	—	179.5	270.0	—

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

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 26) using the threshold and median values. Distributions of each element are summarized as follows;

As: Anomalous zones are found along Sungai Numatoi and a tributary of Sungai Bangkulat. Anomalous samples are scattered at the upper stream of Sungai Kelugu.

Au: The absolute values are low and are mostly less than the detection limit. Slightly high value samples are scattered in the areas of Sungai Numatoi, a tributary of Sungai Bangkulaty and southeastern part of the area.

Ba: Conspicuous high value zones are found in the area of Sungai Numatoi. Other than these, anomalous zones are found at the tributary of Sungai Bangkulat and the upper stream of Sungai Kelugu.

Co: High value and anomalous zones are found in the area of ultra-basic rocks. Conspicuous anomalous zones are found in the upper stream of Sungai Numatoi and southeastern part of the area.

Cr: High value and anomalous zones are restricted in the southeastern part of the area.

Cu: High value and anomalous zones are restricted in the areas of ultra-basic rocks and crystalline basements. Conspicuous anomalous zones are found in the lower stream of Sungai Numatoi. other than these, anomalous zones are found in the areas of upper stream of Sungai Numatoi, upper stream of Sungai Bangkulat and southwestern part of the area.

Hg: High value zones are restricted in the area of ultra-basic rocks in the south eastern part of the area.

K Anomalous zones are found in the area of metamorphic rocks in the central part of the area.

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

Mn: High value samples are restricted in the area of ultra-basic rocks and are found in the area of Sungai Numatoi. Other than these, high value samples are scattered in the southeastern and southwestern parts of the area.

Mo: Whole samples indicate less than the detection limit.

Na: Anomalous zones are distributed in the areas of the lower stream of Sungai Numatoi, upper stream of Sungai Kelugu and southwestern part of the area where metamorphic rocks occur.

Ni: High value and anomalous samples are scattered in the area of ultra-basic rocks.

Pb: The absolute values are low and a half of the samples indicates less than the

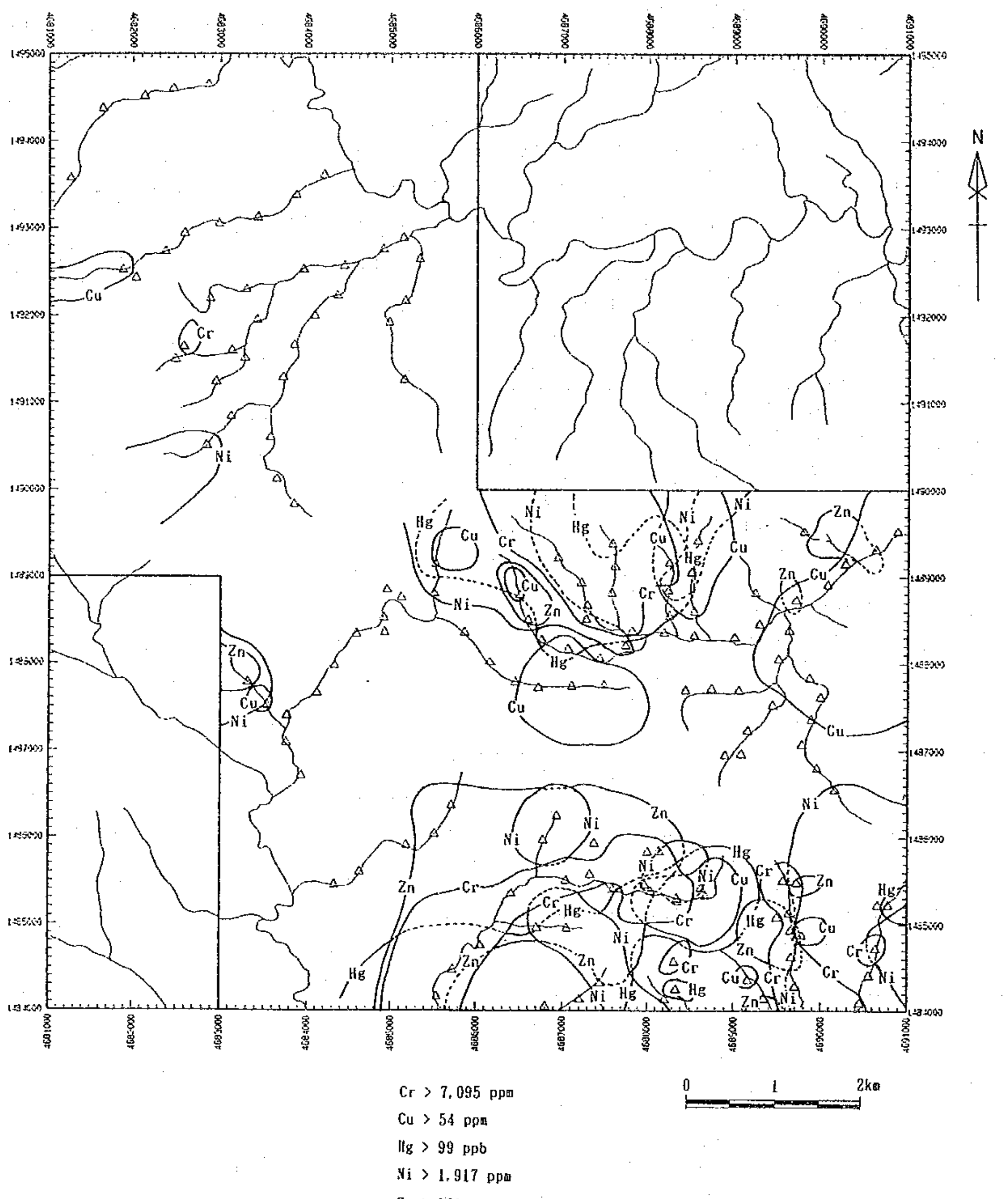


Fig. II-1-33 Distribution of geochemical anomalous zones of stream sediments in Area R detection limit. Slightly high value samples are found in the area of Sungai Numatoi.

S : Anomalous samples are in the areas of ultra-basic rocks in the southeastern part of the area and basalt in the northwestern part of the area.

Sb: Anomalous zones are found in the area of ultra-basic rocks. Other than these, anomalous samples are scattered in the area along Sungai Numatoi.

Sr: High value and anomalous samples are mostly found in the areas of metamorphic rocks and basalt.

Ti: High value zones are found in the area of ultra-basic rocks. Other than these, small in scale anomalous zones are found in the northwest and southwest of the area.

U : High value samples are found in the area of the Crocker formation and along Sungai Numatoi, but the absolute values are low.

W : The most of the samples indicate less than the detection limit

Zn: High value zones are found in the area of ultra-basic rocks at the southwest of the area. The high value samples are also scattered along Sungai Numatoi.

Considering the distribution maps, the elements, which are possibly useful for investigating the area, were choosen and an anomaly map for these elements was prepared (Fig. II-1-33). Anomalous zones of Cr, Cu, Hg, Ni and Zn overlapping each other, are found in the upper stream of Sungai Numatoi and in the southwestern part of the area.

(4) Multi element analysis

Factor analysis was examined as a multi element analysis in this survey. The results of facter analysis are given in Table II-1-21. Following relationships between elements and factors were extracted by the factor analysis.

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

Considering the relationship between the factor and elements, Factor 1 has relation with ultra-basic rocks. Factor 2 and 3 are interpreted to have some relation with sedimentary rocks and copper mineralization respectively. Among these factors, three factors of Factor 1, 2, and 3 were selected and a distribution map of factor scores was prepared allocating three different colors for each factor

Table II-1-21 Results of factor analyses for stream sediments samples in Area R

Element	Factor loading (Varimax rotation)					Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
As	0.223	0.099	-0.158	-0.578	0.066	0.4226
Au	-0.002	0.000	-0.361	-0.038	-0.026	0.1327
Ba	-0.048	0.657	-0.016	-0.445	-0.133	0.6501
Co	0.899	-0.133	-0.297	-0.145	-0.149	0.9571
Cr	0.906	-0.115	-0.087	-0.084	-0.258	0.9153
Cu	0.470	0.184	-0.675	-0.135	-0.200	0.7688
Hg	0.258	-0.391	-0.522	0.039	-0.363	0.6250
K	-0.097	0.891	-0.093	-0.051	-0.054	0.8170
Mg	0.886	-0.002	0.068	0.003	0.212	0.8338
Mn	0.828	0.142	-0.343	-0.082	-0.287	0.9128
Na	0.766	0.490	-0.175	-0.054	0.084	0.8674
Ni	0.904	-0.210	-0.282	-0.159	-0.064	0.9701
Pb	-0.412	0.447	0.038	-0.281	-0.257	0.5155
S	0.799	0.070	-0.309	0.044	0.245	0.8010
Sb	0.762	-0.312	-0.099	-0.076	-0.390	0.8451
Sr	0.059	0.884	0.123	0.061	0.053	0.8072
Ti	0.156	0.303	-0.364	0.092	-0.554	0.5637
U	-0.651	0.448	0.050	0.017	-0.115	0.6416
W	-0.146	0.037	0.185	0.042	-0.012	0.0588
Zn	0.928	0.008	-0.141	-0.088	-0.213	0.9334
F.C.*1	53.9 %	22.4 %	10.9 %	5.2 %	7.6 %	—

*1: Factor contribution

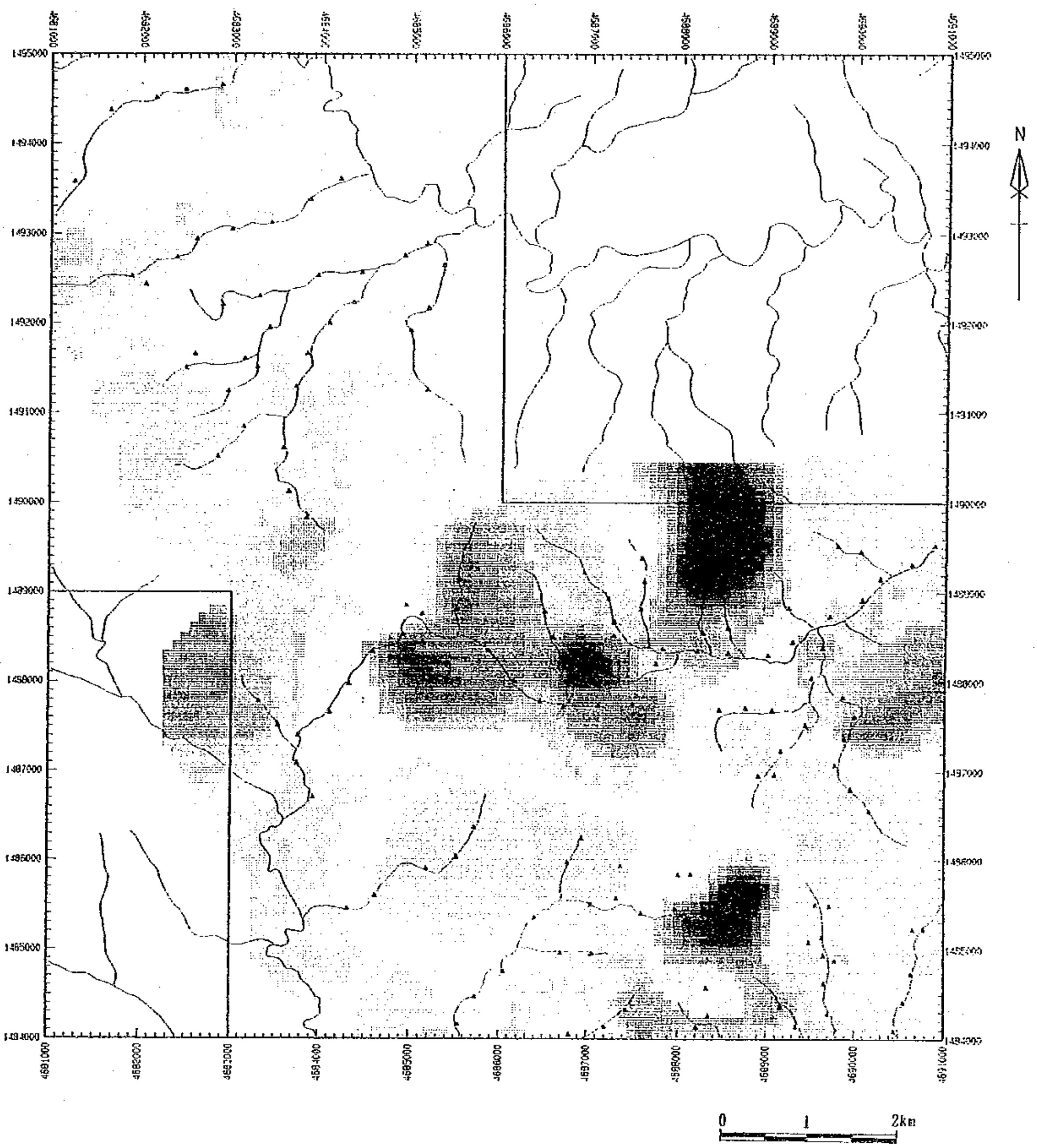


Fig. II-1-34 Distribution of factor scores of stream sediments in Area R

(Fig. Ⅱ-1-34). Three factors are shown by following colors.

Factor 1 : blue Factor 2 : yellow Factor 6 : red

Distribution tendencies of these factors are summarized as follows;

Factor 1: High factor score zones are in the area of ultra-basic rocks.

Factor 2: High factor score zones are found in the area of metamorphic rocks along Sungai Numatoi. Other tha these, high score zones are found in the area of the Crocker formation in the southwestern part and in the area of basalts in the northwestern part of the area.

Factor 3: High factor score zones are found in the upper stream of Sungai Numatoi , in the upper stream of Sungai Bangkulat and southeastern part of the area where ultra-basic rocks occur.

Judging from the results, Factor 3 reflects the mineralization of copper. However, absolute values of Cu are not high and the high factor score zones are restricted in the areas of ultra-basic rocks.

1-11 Area S

1-11-1 Geology and mineralization

(1) Survey area

From the regional geochemical survey results, high value and anomalous zones of Au was delineated in this area. In order to clarify the potential for gold ore deposits, soil and stream sediment geochemical surveys were carried out in this area.

Area S is located along a southern tributary of Sungai Imbak in the soutern part of the Labuk area. The area shows steep topography and the elevation reachs upto approximately 600 m. A tributary of Sungai Imbak forms deep valley and flow southward in the central part of the area.

(2) Geology

Geology in Area S consist of ultra-basic rocks (Pr) of Cretaceous to Tertiary age and Sapulut formation (KPSp) of late Cretaceous to Eocene age. The geological map of Area S is given in Fig. II-1-35.

The ultra-basic rocks occur in a small area of the eastern part of the area and contact with Sapult formation by thrust fault dipping eastward. The ultra-basic rocks consists of peridotite and serpentinite. The Sapulut formation widely occupies the area and consists of massive gray sandstone with subordinate mudstone.

(2) Mineralization

No conspicuous mineralized and/or altered outcrop was recognized in this survey. A float sandstone sample with quartz stockwork veinlets and pyrite disseminations was collected in the northeastern part of the area.

1-11-2 Soil geochemical survey

(1) Sampling

Soil and stream sediments sample were simultaniously collected along streams in this survey. Locations of collected soil samples and their list are, respectively, shown in Fig. II-1-36 and Appendix 29. After drying up the samples, -80 mesh fractions were prepared for the soil samples and the samples were chemically analized.

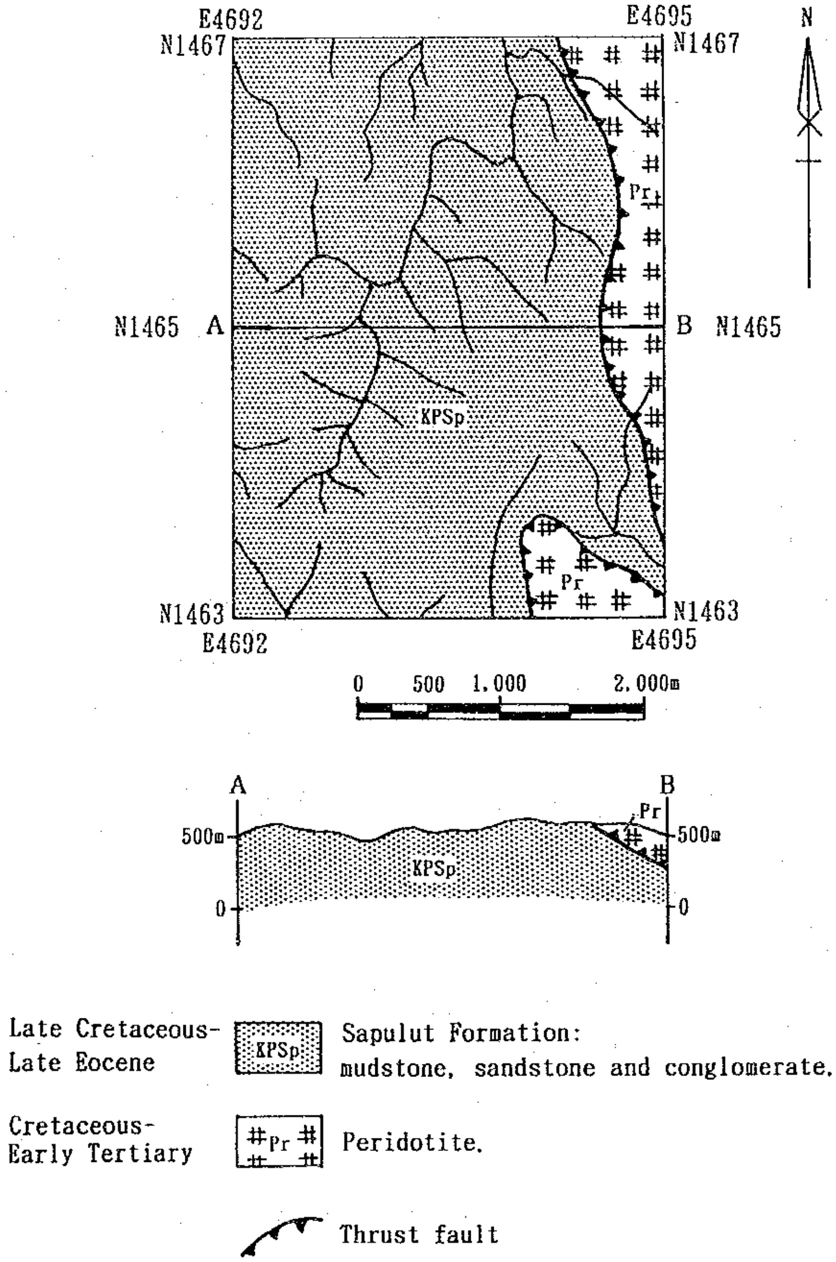
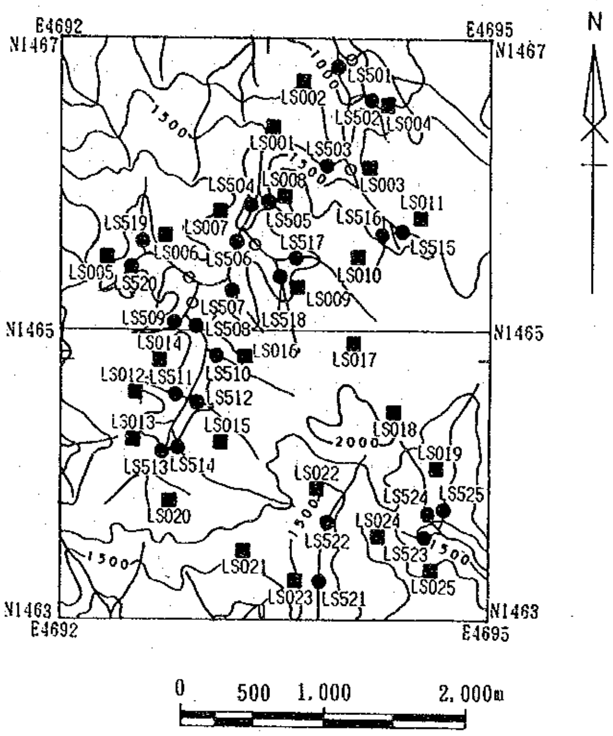


Fig. II-1-35 Geologic map and cross sections of Area S



contour line in feet.

● LS501 Location of stream sediment samples and sample number.

■ LS001 Location of soil samples and sample number.

o Location of stream sediment samples collected in phase III.

Fig. II-1-36 Location map of geochemical samples in Area S

(2) Statistical data treatment

Analytical results are shown in Appendix 30. These analytical results were input to a computer and statistics were calculated. The results of these are given in Table Ⅱ-1-22.

The calculated geometric means of the Area S give following tendencies comparing with other areas.

Element indicating higher value: Hg, K, Pb

Element indicating lower value : Co, Cr, Cu, Mg, Mn, Sb

Among the 21 elements analyzed, Au, Mo and W indicate less than the detection limits nearby whole samples.

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

Ba-K, Ba-Pb, Ba-U, Co-Cr, Co-Cu, Co-MN, Co-Ni, Co-S, Co-Sb, Co-Zn

Cr-Ni, Cr-Sb, Cr-U(-), Cu-Mn, Cu-Ni, Cu-Zn, K-Pb, K-Sr, K-U, Mg-Na

Mn-Ni, Mn-S, Mn-Zn, Ni-Sb, Pb-U, Sr-U

The blanket (-) indicate negative relationship. Good correlation is found among the elements of Co, Cr, Cu, Ni and Zn. These elements show negative relation with the elements of Ba, K, Pb and U.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 31) using the values obtained by EDA method. Distribution of each element is summarized as follows;

As: Anomalous zones are found over the Sapult formation in the northeastern part of the area. Other than those, anomalous samples are scattered in the area of Sapulut formation.

Au: Most of the samples indicates less than the detection limit. The maximum value of Au is 10 ppb.

Ba: Anomalous samples are found in the southern and northern parts of the area where the Sapulut formation occurs.

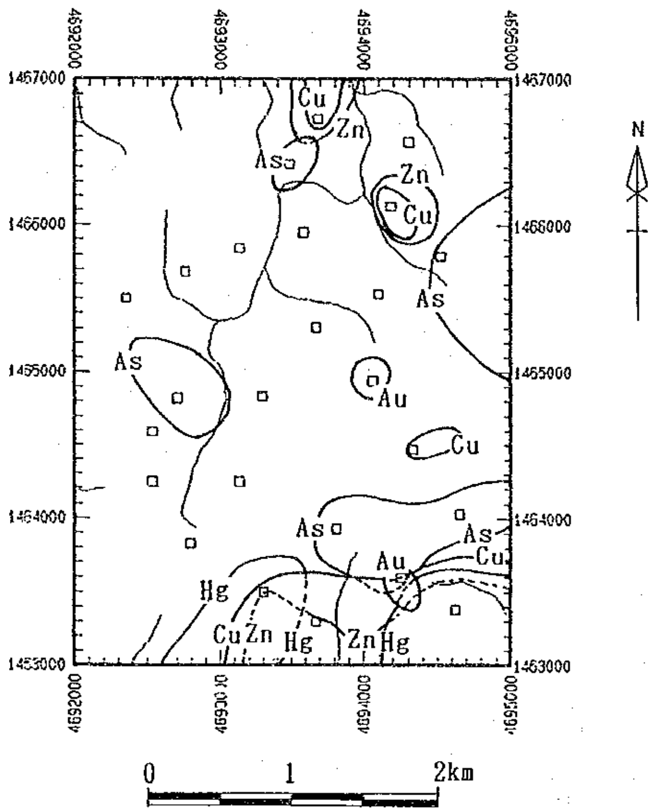
Co: High value samples are found in the area of ultra-basic rocks in the northeastern and southeastern parts of the area.

Cr: Distribution tendencies are similar to those of Co. High value samples are found in the area of ultra-basic rocks and the surroundings.

Table II-1-22 Statistics of soil geochemical survey in Area S

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	32.0	88	< 1	3.4	0.744	—	3.0	16.0	—
Au (ppb)	88.0	10	< 1	0.7	0.365	3.6	0.5	0.5	0.5
Ba (ppm)	—	274	17	134.6	0.266	—	140.0	211.0	—
Co (ppm)	12.0	656	< 1	6.8	0.641	130.0	7.0	17.0	96.0
Cr (ppm)	—	7,121	45	111.9	0.444	866.0	85.0	143.0	338.0
Cu (ppm)	—	112	4	20.6	0.327	—	21.0	34.0	—
Hg (ppb)	—	734	94	154.1	0.221	425.7	125.0	195.0	287.3
K (%)	—	2.03	0.06	0.756	0.328	—	0.910	1.280	—
Mg (%)	—	2.53	0.06	0.426	0.318	1.842	0.430	0.590	1.636
Mn (ppm)	—	2,950	17	137.9	0.593	2,114.4	121.0	364.0	—
Mo (ppm)	60.0	4	< 1	0.9	0.327	3.9	0.5	2.0	2.8
Na (%)	—	1.36	0.06	0.194	0.308	0.802	0.160	0.330	1.038
Ni (ppm)	—	4,287	14	45.2	0.538	538.0	31.0	86.0	477.5
Pb (ppm)	4.0	36	< 2	17.2	0.324	—	20.0	25.0	—
S (%)	—	0.049	0.010	0.017	0.165	0.037	0.015	0.022	0.025
Sb (ppm)	—	101.8	0.9	4.59	0.383	26.73	4.4	8.6	15.8
Sr (ppm)	—	77	2	22.8	0.362	—	25.0	40.0	—
Ti (%)	—	0.71	0.05	0.362	0.200	—	0.370	0.460	0.640
U (ppm)	4.0	6.0	< 0.2	2.00	0.340	—	2.20	2.60	3.85
W (ppm)	84.0	6	< 2	1.2	0.214	3.3	1.0	1.0	1.0
Zn (ppm)	8.0	308	< 1	25.1	0.708	—	43.0	88.0	—

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



As > 16 ppm

Au > 3.6 ppb

Cu > 34 ppm

Hg > 287 ppb

Zn > 88 ppm

Fig. II-1-37 Distribution of geochemical anomalous zones of soil in Area S

Cu: High value zones are found in the northeastern and southeastern parts of the area.

Hg: High value and anomalous zones are restricted in the southern part of the area.

K : Anomalous zones are found in the southern and northern parts of the area where the Sapulut formation occurs.

Mg: High value zones are found in the southern and northern parts of the area.

Mn: Distribution tendencies are similar to those of Co and Cr. High value zones are found in the northeastern and southeastern parts of the area where ultra-basic rocks occur.

Na: High value zones are found in the area of the Sapulut formation in the northern part of the area.

Ni: Distribution tendencies are similar to those of Co and Cr, and anomalous zones are found in the area of ultra-basic rocks.

Pb: High value samples are scattered from the northern part to the eastern part of the area.

S : Anomalous samples are scattered in the northern and southern parts of the area.

Sb: High value zones are in the northeastern and southeastern parts of the area where ultra-basic rocks occur.

Sr: Anomalous samples are scattered in the area. No clear distribution tendencies are recognized.

Ti: High value zones are found in the northern and southern parts of the area where the Sapulut formation is distributed.

U : Anomalous and high value zones are found along streams in the central part of the area.

W : The absolute values are low and the distribution tendencies are not clear.

Zn: Anomalous zones are found in the area of ultra-basic rocks and the surroundings in the northeastern and southeastern parts of the area.

Considering the distribution maps and geological environment of the area, the elements which useful for the accessment, were selected and an anomaly map for these elements was prepared as shown in Fig. II-1-37. Anomalous zones of Cu, Hg and Zn are found in the southeastern part od the area and are overlapping each other.

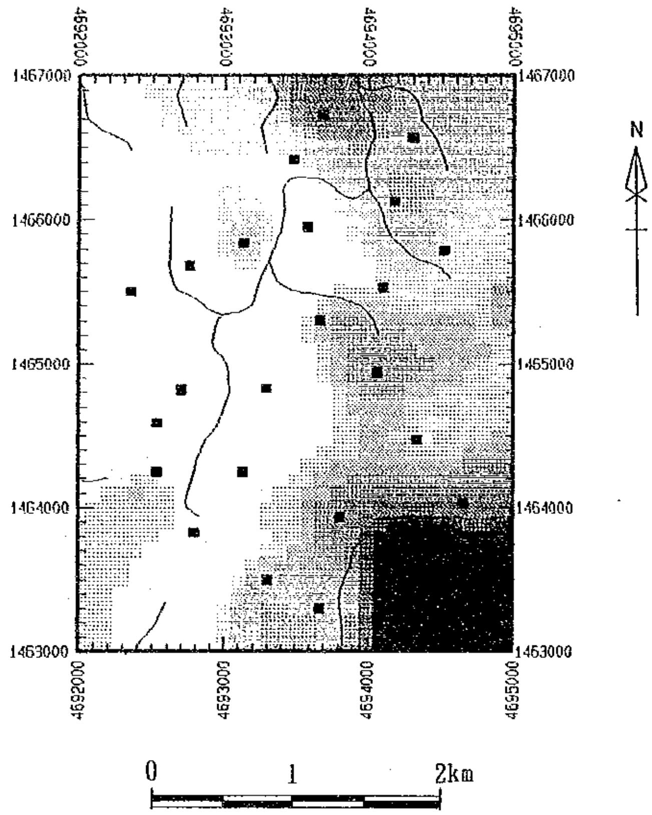
(4) Multi element analysis

Factor analysis was examined as the multi element analysis in this survey. The results of facter analysis are given in Table II-1-23. Following relationships between elements and factors extracted by the factor analysis.

Table II-1-23 Results of factor analyses for soil samples in Area S

Element	Factor loading (Varimax rotation)					Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
As	-0.033	0.606	0.335	-0.069	0.197	0.5240
Au	-0.037	-0.103	0.661	0.209	-0.007	0.4930
Ba	0.171	0.897	-0.158	-0.252	-0.210	0.9652
Co	-0.929	-0.198	0.040	-0.180	0.023	0.9369
Cr	-0.744	-0.472	0.312	-0.065	0.272	0.9523
Cu	-0.919	-0.126	-0.097	-0.177	-0.126	0.9167
Hg	-0.455	-0.259	0.482	0.302	-0.033	0.5985
K	0.112	0.897	-0.288	-0.108	-0.058	0.9142
Mg	-0.280	0.359	-0.766	0.221	0.013	0.8435
Mn	-0.949	-0.082	-0.081	0.053	-0.090	0.9240
Mo	-0.122	0.390	-0.013	-0.657	0.018	0.5994
Na	-0.694	0.319	-0.493	-0.018	0.164	0.8538
Ni	-0.815	-0.434	0.158	-0.151	0.187	0.9358
Pb	0.267	0.882	-0.217	-0.044	-0.080	0.9045
S	-0.794	-0.210	0.057	0.246	0.101	0.7491
Sb	-0.784	-0.209	0.353	-0.008	0.203	0.8242
Sr	0.115	0.718	-0.320	-0.121	0.378	0.7880
Ti	0.149	0.552	-0.566	0.028	-0.158	0.6721
U	0.373	0.818	-0.309	0.009	0.053	0.9071
W	0.261	0.039	0.194	0.270	-0.004	0.1800
Zn	-0.910	0.040	-0.113	-0.111	-0.168	0.8823
F.C.*1	43.0 %	32.2 %	15.9 %	5.8 %	3.1 %	—

*1: Factor contribution



Factor 1 factor score : Blue

Factor 2 factor score : Yellow

Factor 3 factor score : Red

Fig. II-1-38 Distribution of factor scores of soil in Area S

Factor 1 : Co - Cr - Cu - Mn - Na - Ni - S - Sb - Zn

Factor 2 : As - Ba - K - Pb - Sr - Ti - U

Factor 3 : Au - Mg(-) - Ti(-)

Factor 4 : Mo

Factor 5 : (Sr)

Among these factors, three factors, Factor 1, 2 and 3, were selected and a distribution map of the factor score was prepared allocating three different colors for each factor (Fig. II-1-38). Three factors are shown by following colors.

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

Distribution tendencies of these factors are summarized as follows;

Factor 1: High factor score zones are found in the northeastern and southeastern parts of the area where the ultra-basic rocks are distributed.

Factor 2: High factor socore zones are scattered in the northern and southern parts of the area and the distribution tendencies are not clear.

Factor 3: The high score zones are found in the southwestern part of the area and overlap the high factor score zones of Factor 1.

From the results, Factor 1 and 2 reflect the ultra-basic rocks and sedimentary rocks respectively. Factor 3 may relate to gold mineralization. However, since the absolute values of Au are low, potential for gold mineralization is thought to be low.

1-11-3 Stream sediment geochemical survey

(1) Sampling

A stream sediment geochemical survey was also conducted in Area S. Locations of collected samples and their list are, respectively, shown in Fig. II-1-36 and Appendix 32. After drying up, these samples were sent for the chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 28. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-24.

The statistical figures of the stream sediments show following tendencies comparing with other areas of similar geological environment.

Element indicating higher value: Hg

Element indicating lower value : Co, Cr, Cu, Mg, Ni, Sb

Table II-1-24 Statistics of stream sediments geochemical survey in Area S

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	12.0	20	< 1	4.0	0.493	—	4.0	11.0	—
Au (ppb)	84.0	1	< 1	0.6	0.113	0.9	0.5	0.5	0.5
Ba (ppm)	—	234	41	113.5	0.234	—	106.0	201.0	—
Co (ppm)	—	37	1	7.2	0.401	—	6.0	17.0	—
Cr (ppm)	—	2,434	186	339.8	0.278	1,222.9	269.0	444.0	575.1
Cu (ppm)	—	37	5	12.3	0.269	—	11.0	25.0	—
Hg (ppb)	—	787	34	135.5	0.370	746.1	116.0	247.0	738.7
K (%)	—	1.82	0.15	0.539	0.313	—	0.480	1.080	—
Mg (%)	—	1.50	0.07	0.324	0.401	—	0.270	0.770	—
Mn (ppm)	—	947	65	237.4	0.370	—	197.0	522.0	—
Mo (ppm)	24.0	2	< 1	1.0	0.221	—	1.0	2.0	—
Na (%)	—	0.68	0.02	0.151	0.466	—	0.130	0.490	—
Ni (ppm)	—	431	12	35.4	0.429	255.8	24.0	66.0	350.0
Pb (ppm)	12.0	45	< 2	5.9	0.426	41.7	7.0	13.0	—
S (%)	—	0.064	0.005	0.010	0.287	0.036	0.008	0.012	0.027
Sb (ppm)	—	20.0	1.5	6.03	0.249	19.00	5.60	9.70	19.3
Sr (ppm)	—	74	10	23.4	0.290	—	18.0	46.0	—
Ti (%)	—	0.54	0.11	0.212	0.180	0.485	0.210	0.310	—
U (ppm)	—	2.8	1.0	1.47	0.118	2.52	1.40	1.80	2.46
W (ppm)	84.0	72	< 2	1.4	0.421	9.8	1.0	1.0	1.0
Zn (ppm)	28.0	84	< 1	7.1	0.879	—	8.0	48.0	—

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

Among 21 elements analyzed in this survey, Au and W indicates less than the detection limit for the most of the samples. Because the survey area is mostly occupied by sedimentary rocks, the elements related to basic rocks indicate low values. Contents of Hg indicate slightly high values comparing to other areas.

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

Ba-Co, Ba-Cu, Ba-K, Ba-Mg, Ba-Mn, Ba-Na, Ba-Ni, Ba-Pb, Ba-s, Ba-Sr, Ba-Ti, Ba-Zn, Co-Cu, Co-K, Co-Mg, Co-Mn, Co-Na, Co-Ni, Co-Sb, Co-Sr, Co-Ti, Co-Zn, Cu-K, Cu-Mg, Cu-Mn, Cu-Na, Cu-Ni, Cu-Pb, Cu-Sr, Cu-Ti, Cu-Zn, K-Mg, K-Mn, K-Na, K-Pb, K-S, K-Sr, K-Ti, K-U, K-Zn, Mg-Mn, Mg-Na, Mg-Ni, Mg-Pb, Mg-Sr, Mg-Ti, Mg-Zn, Mn-Na, Mn-Ni, Mn-Sr, Mn-Ti, Mn-Zn, Na-Ti, Na-Pb, Na-S, Na-Sr, Na-Ti, Na-Zn, Ni-Sb, Ni-Sr, Ni-Ti, Ni-Zn, Pb-S, Pb-Sr, Pb-U, Pb-Zn, S-Sr, S-U, Sr-Ti, Sr-Zn, Ti-Zn

As indicated above, so many pairs of elements indicate good correlations.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 31) using the threshold and median values. Distributions of each element are summarized as follows;

As: Anomalous zones are found in the northeastern and southeastern parts of the area where ultra-basic rocks occur.

Au: The absolute values are low and the maximum value is 1 ppb.

Ba: Anomalous zones are found in the northeastern and southeastern part of the area where is the area of ultra-basic rocks and the surroundings.

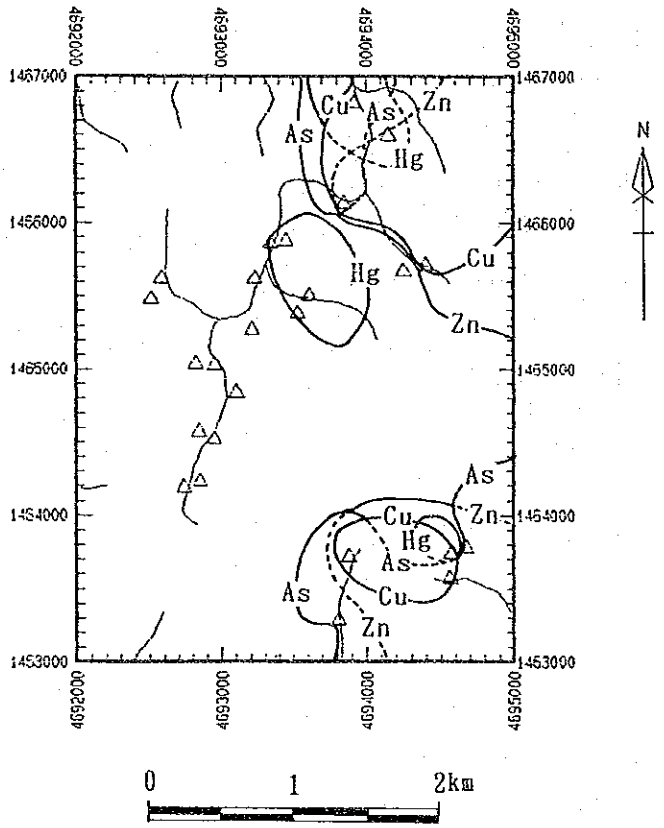
Co: Anomalous zones are found in the eastern part of area where ultra-basic rocks occur.

Cr: Distribution tendencies are similar to those of Co. High value zones are restricted in the area of ultra-basic rocks in the eastern part of the area.

Cu: Anomalous zones are found in the vicinity of the ultra-basic rocks in the northeast and southeast of the area.

Hg: High value zones are found in the central part of the area.

K : Anomalous zones are found in the northeastern and southern parts of the area.



As > 11 ppm

Cu > 25 ppm

Hg > 247 ppb

Zn > 48 ppm

Fig. II-1-39 Distribution of geochemical anomalous zones of stream sediments in Area S

Mg: Anomalous and high value samples are restricted in the area of ultra-basic rocks in the eastern part of the area.

Mn: Anomalous zones are found in the surrounding areas of ultra-basic rocks in the northeastern and southeastern parts of the area,

Mo: The maximum value is 2 ppm. Slightly high value samples are scattered in the central part of the area.

Na: Anomalous zones are distributed in the noutheastern and southeastern parts of the area. These anomalous zones are situated in the vicinity of the ultra-basic rocks.

Ni: Distribution tendancies are similar to those of Co and Mg. High value samples are found in the area of ultra-basic rocks in the eastern part of the area.

Pb: Anomalous samples are found in the central part of the area.

S : Anomalous samples are also found in the central part of the area.

Sb: High value zones are found from eastern part to southeastern part of the area where ultra-basic rocks occur.

Sr: Anomalous samples are found in the northeastern and southern parts of the area.

Ti: Distribution tendencies are similar to those of Sr. Anomalous samples are found in the northeastern and southern parts of the area.

U : High value and anomalous samples are found in the central part of the area.

W : The sample indicating the maximum value of 72 ppm is found in the northern part of the area. Other than this, the absolute values are low.

Zn: Anomalous zones are found in the area of the ultra-basic rocks.

Considering the distribution maps, the elements, which are possibly useful for investigating the area, were choosen and an anomaly map for these elements was prepared (Fig. II-1-39). Anomalous zones of As, Cu, Hg and Zn overlapping each other, are found in the northeastern and southeastern parts of the area.

(4) Multi element analysis

Factor analysis was examined as a multi element analysis in this survey. The results of facter analysis are given in Table II-1-25. Following relationships between elements and factors were extracted by the factor analysis.

Factor 1 : Ba-Co-Cu-K-Mg-Mn-Na-Ni-Pb-S-Sr-Ti-U-Zn

Factor 2 : Hg - Mo - W

Factor 3 : Co - Cr - Ni - Sb

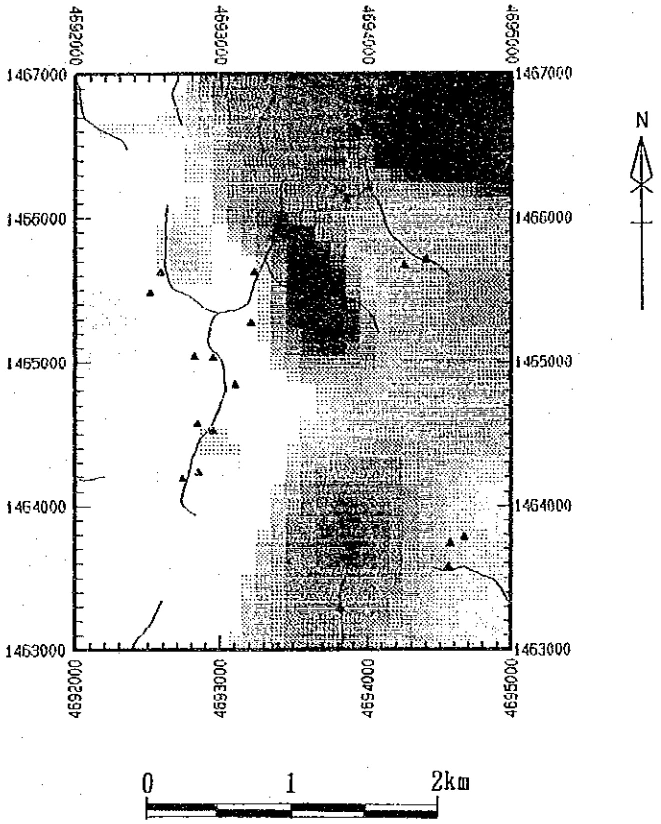
Factor 4 : Au

Factor 5 : (As)

Table II-1-25 Results of factor analyses for stream sediments samples in Area S

Element	Factor loading (Varimax rotation)					Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	
As	0.402	0.034	0.325	-0.051	0.417	0.4455
Au	0.254	0.029	0.178	0.526	-0.003	0.3738
Ba	0.928	-0.129	0.149	0.178	0.200	0.9709
Co	0.766	0.112	0.526	0.185	0.043	0.9116
Cr	0.010	0.159	0.844	0.114	-0.052	0.7536
Cu	0.950	-0.058	0.149	0.169	0.078	0.9620
Hg	0.095	-0.804	-0.152	0.129	0.018	0.6964
K	0.975	-0.102	0.077	0.029	0.123	0.9833
Mg	0.887	0.047	0.392	0.093	-0.058	0.9546
Mn	0.912	0.046	0.231	0.229	0.138	0.9584
Mo	0.063	-0.660	-0.185	-0.081	0.368	0.6165
Na	0.926	-0.155	0.222	0.056	0.096	0.9432
Ni	0.665	0.118	0.716	0.078	0.005	0.9755
Pb	0.839	-0.150	0.057	-0.313	-0.124	0.8431
S	0.724	-0.143	0.175	-0.421	0.179	0.8112
Sb	0.415	0.106	0.746	0.045	0.225	0.7920
Sr	0.939	0.133	0.138	0.032	0.140	0.9385
Ti	0.912	-0.032	0.134	0.203	0.167	0.9200
U	0.711	-0.431	-0.031	-0.393	0.045	0.8489
W	-0.048	-0.672	0.006	-0.171	-0.295	0.5704
Zn	0.879	0.069	0.312	0.204	-0.041	0.9185
F.C.*1	63.3 %	11.1 %	15.9 %	6.0 %	3.7 %	—

*1: Factor contribution



Factor 1 factor score : Blue

Factor 2 factor score : Red

Factor 3 factor score : Yellow

Fig. II-1-40 Distribution of factor scores of stream sediments in Area S

Among these factors, three factors were selected and a distribution map of factor scores was prepared allocating three different colors for each factor (Fig. II-1-40). Three factors are shown by following colors.

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

Distribution tendencies of these factors are summarized as follows;

Factor 1: High factor score zones are in the northeastern and southern parts of the area where ultra-basic rocks occur.

Factor 2: High factor score zones are found in the central part of the area where the Sapulut formation is distributed.

Factor 3: High factor score zones are found in the area of ultra-basic rocks in the eastern part of the area.

Judging from the results, Factor 1 reflects the ultra-basic rocks and sedimentary rocks. Factor 2 has possibility to reflect mineralization, but the values of Mo and W are low. Factor 3 has relation with the ultra-basic rocks.

Although high values of Au was recognized in this area in the regional survey in Phase III, no significant high value sample was confirmed in this survey. Judging from the results of the factor analysis, potential for ore deposit in this area is thought to be low.

1-12 Area T

1-12-1 Geology and mineralization

(1) Survey area

The stream sediment samples with high concentrations of Au and Hg (maximum value: Au 6,530 ppb, Hg 24,735) obtained during the regional geochemical survey of Phase III suggest the Area T to be a potential area for gold mineralization. A semi-detail geochemical survey of soil sample was conducted for further evaluating the area during this phase.

The Area T is located in Sungai Imbak area, at south end of the Labuk Area.

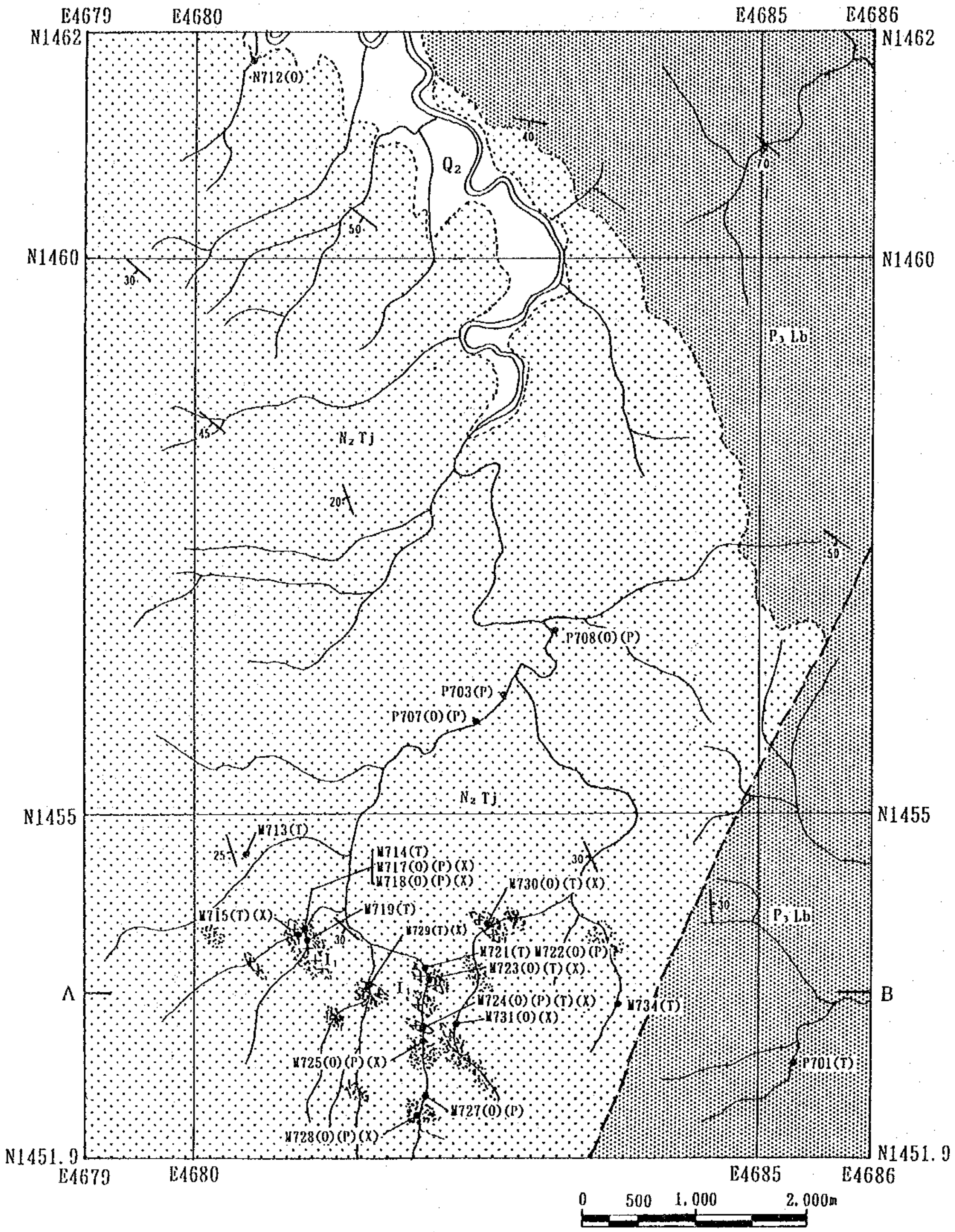
The tributary of Sungai Imbak meaderingly flows from south to north in center of the area, gathering samll tributaries from both east and west sides. The area is generally occupied by gentle, hilly topography except western and southern ends of the area where steep riges with the maximum altitude of more than 1,000 m run in N-S and E-W trends. The vegitation of the area is primary jungle and no trace of human activity such as timber logging and cultivation is found in the area. The field work was conducted establishing few camps within the area.

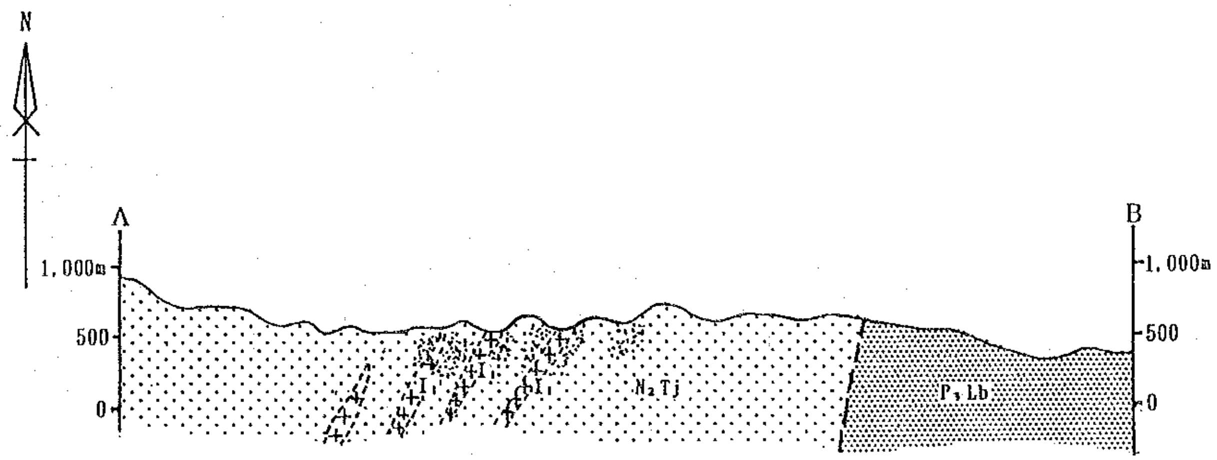
(2) Geology

The area is mainly overlain by the Tertiary sedimentary rocks. They are Labang formation (P_3Lb) of Oligocene and Tanjong formation (N_2Tj) of early to middle Miocene. In addition to them, small intrusive bodies of diorite porphyry (I_1) occur in southern part of the area and Alluvium (Q_2) is distributed along the main stream in northern part of the area. Geologic map of the area is given in Fig. II-1-41.

The Labang formation (P_3Lb), consisting of mainly mudstone with an occasional association of sandstone, is distributed in eastern part of the area from north to south. It strikes in N-S trende and dips gently toward east in the block bounded by fault in southeastern part of the area. While, in southeastern part of the area, it strikes in NW-SE and dips toward SW at 40° to 70°.

The Tanjong formation (N_2Tj) is distributed in central to western part of the area, unconformably overlying the Labang formation. It has a fault contact with the Labang formation in southeastern part of the area. Dark gray mudstone is the main constituent of the Tanjong formation and occasionally it intercalates sandstone layers. The mudstone becomes slightly coarser, similar to fine sandstone, in western and southern part of the area and this lithology constitutes the steep





Recent	Q_2	Riverine alluvium.
Early Miocene-Middle Miocene	N_2Tj	Tanjong Formation: mudstone, sandstone and conglomerate.
Oligocene	P_3Lb	Labang Formation: sandstone, shale and mudstone.
	I_1	Diorite porphyry.
		Silicified zone.
		Fault

• Location of sample for laboratorial studies and sample number.

(O); Ore assaying.
(P); Polished section.
(T); Thin section.
(X); X-ray diffraction analysis.

Fig. II-1-41 Geologic map and cross sections of Area T

topography of the area. The strike and dip of the Tanjong formation is consistent over the area of its distribution. It strikes in NW-SE and dips toward SW at 20° to 50°. Microscope observation of the mudstone shows that quartz fragment is the main constituent associated by subordinate plagioclase fragment. Alteration minerals such as sericite, calcite and quartz are, also, observed.

The Diorite porphyry (I_1) intrudes into the Tanjong formation in southern part of the area. Only one small intrusive body was found in Phase III and seven new locations of the intrusive bodies were found during this semi-detail geochemical survey. The intrusive bodies extende toward the direction similar to strike of the Tanjong formation and they have variable widths ranging from few meters to few 10 of meters. They are affected by different degree of alteraton and their appearances vary from gray color rock with clear porphyritic texture with plagioclase and hornblende phenocrysts of a few mm across to a totally argillized, white color rock consisting of quartz and sericite. Microscopic observation of the less altered rock shows clear porphyritic texture with plagioclase and hornblende phenocrysts(Table II-1-1). In addition to them, biotite and clinopyroxene phenocrysts occasionally appear. The altered rock is totally replaced by alteration minerals such as quartz, sericite, calcite, chlorite and the original texture is completely extinguished. The angular pebbles of diorite porphyry found in southeastern part of the area suggest a possible occurrences of diorite porphyry in area of Labang formation.

(3) Mineralization

The mineralization and alteration of the Area T mainly occur surrounding the area of the Diorite porphyry intrusion in southern part of the area. Silicification, argillization and weak disseminaton of pyrite and arsenopyrite with occasional appearances of quartz veinlet occur in the mudstone of the Tanjong formation in southern part of the area. Some of the intrusive bodies of the Diorite porphyry are completely argillized with dissemination of pyrite. As shown in the geologic map of Area T (Fig. II-1-41), the zone of alteration and mineralization extents over a wide area. Furthermore, altered and mineralized rocks of up to boulder size were found along streams in southern part of the area. They are strongly silicified, rusty rock with pyrite and arsenopyrite dissemination. Fragments of quartz vein with sulphides, such as pyrite and arsenopyite, were, also, found along the streams.

Microscopic observation and X-ray diffraction analysis show alteration mineral assemblages of quartz-sericite-calcite for the mudstone quartz-sericite-albite -chlorite for the altered diorite porphyry(Table II-1-1 and Table II-1-3).

The results of microscopic obervation of polished section and assaying for ore samples are given in Tables II-1-2 and II-1-4.

The mineralization of the argillized diorite porphyry is not intensive with a weak pyrite dissemination and occational pyrite veinlet and it does not show high grade assay results. Significant assay results were obtained from quartz veins in the mudstone and float found in streams. The maximum Au grade was obtained from the 10 cm wide quartz-arsenopyrite-pyrite veinlet found in silicified mudstone. It shows Au 18.4 g/t and 115.7 g/t. The main ore minerals of the mineralized boulders and pebbles found along streams are arsenopyrite and pyrite associated by chalcopyrite and sphalerite. The quartz vein fragment of cobble size found at the main stream in center of the area has aggregates of fine Ag-minerals, such as proustite, pyrargyrite, freibergite and etc., in addition to arsenopyrite, chalcopyrite and sphalerite. The assay result of this samples shows Au 15.4 g/t and Ag 931.4 g/t.

The occurences and mineral assemblages of alteration and ore minerals suggest the mineralization in the area to be an epithermal type.

1-12-2 Soil geochemical survey

(1) Sampling

A soil geochemical survey was conducted in the Area T. Locations of collected samples and their list are, respectively, shown in Fig. II-1-42 and Appendix 34. After drying up these samples, -80 mesh fractions were prepared for chemical analyses.

(2) Statistical data treatment

Analytical results are shown in Appendix 35. These analytical results were input to a computer and statistical figures were obtained. The results of these are given in Table II-1-26.

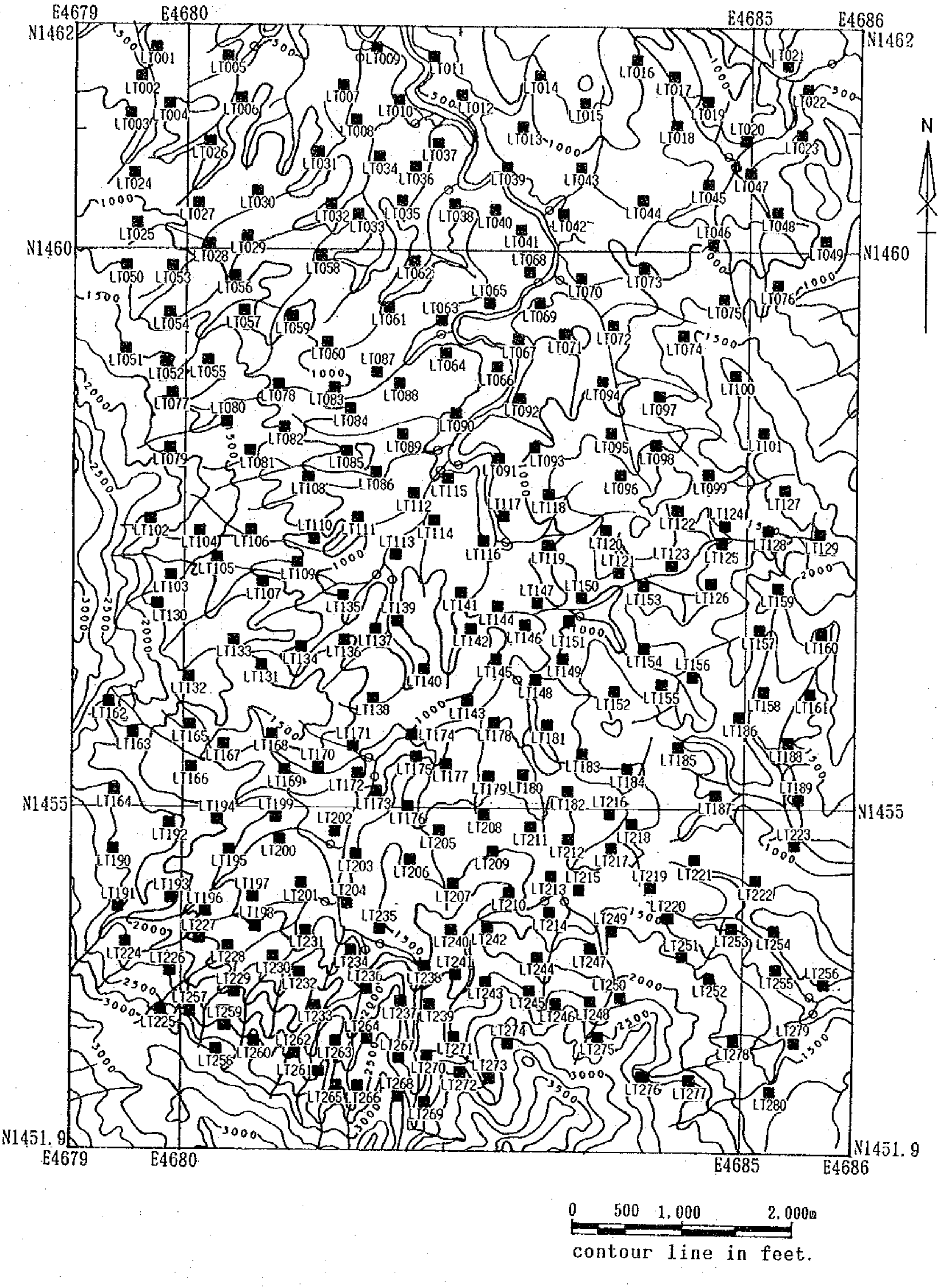
The statistical figures of the Area T show following tendencies comparing with those of other areas with similar geological environment.

Element indicating higher value: As, Hg, Pb, Sb

Element indicating lower value: Co, Mg, Mn

As and S show high maximum values of As 401 ppm and S 0.976.

In order to clarify relationships between the elements, correlation coefficients were also calculated. The results show following pairs of elements to



LT001 Location of soil samples and sample number.

o Location of stream sediment samples collected in phase III.

Fig. II-1-42 Location map of geochemical samples in Area T

Table II-1-26 Statistics of soil geochemical survey in Area T

Element	Statistics						EDA method*4		
	Below detection limit (%)	Maximum value	Minimum value	Mean*1 value (b)	Standard*2 deviation	b + 2S.D. *3	Median	Upper Wisker	Upper Fence
As (ppm)	18.6	401	< 1	6.4	0.721	177.6	7.0	28.0	362.0
Au (ppb)	68.9	43	< 1	1.0	0.509	10.1	0.5	2.0	16.0
Ba (ppm)	—	507	18	122.3	0.167	263.6	125.0	166.0	289.6
Co (ppm)	8.2	90	< 1	5.2	0.430	37.5	6.0	12.0	60.9
Cr (ppm)	—	7,092	23	86.7	0.175	194.3	83.0	100.0	133.7
Cu (ppm)	—	153	2	12.9	0.258	42.2	14.0	20.0	50.9
Hg (ppb)	—	754	45	134.4	0.203	342.9	126.0	195.0	371.5
K (%)	—	1.81	0.60	0.661	0.240	—	0.710	1.080	—
Mg (%)	0.4	0.93	< 0.01	0.313	0.247	—	0.320	0.510	—
Mn (ppm)	—	1,258	8	79.4	0.447	622.7	71.0	222.0	—
Mo (ppm)	49.6	3	< 1	0.8	0.237	2.4	1.0	2.0	2.82
Na (%)	—	1.43	0.02	0.166	0.343	0.807	0.160	0.370	—
Ni (ppm)	—	3,510	4	24.2	0.275	85.8	25.0	39.0	103.4
Pb (ppm)	—	330	3	17.4	0.292	66.5	16.0	26.0	54.6
S (%)	—	0.976	0.008	0.018	0.143	0.036	0.018	0.022	0.032
Sb (ppm)	7.5	132.5	< 0.2	2.94	0.511	30.9	4.10	6.50	25.3
Sr (ppm)	—	169	11	44.5	0.164	94.8	47.0	57.0	99.7
Ti (%)	—	0.60	0.10	0.401	0.081	0.582	0.405	0.470	—
U (ppm)	—	5.4	1.0	2.39	0.065	3.22	2.40	2.60	3.34
W (ppm)	85.7	10	< 2	1.2	0.177	2.6	1.0	1.0	1.0
Zn (ppm)	8.9	271	< 1	20.0	0.616	—	30.0	58.0	—

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

be comparatively good (correlation coefficient: more than 0.600) correlations.

As-Au, Au-Pb, Ba-Cu, Ba-K, Ba-Mg, Ba-Mn, Ba-Na, Co-Mg, Co-Mn, Co-Na, Co-Ni, Co-Zn, Cr-Cu, Cr-Ni, Cu-K, Cu-Ni, Cu-Zn, K-Mg, K-Mn, K-Na, K-Ti, Mg-Mn, Mg-Na, Mg-Sr, Mg-Ti, Mg-Zn, Mn-Na, Na-Sr, Na-Zn, Ni-Zn

Good correlations between the elements such as As, Au and Pb is probably reflecting the chemical nature of mineralization in the area.

(3) Single element analysis

Based on the results of statistical data treatment, the threshold values were determined using EDA method. Distribution maps of each element were prepared (Appendix 36) using the values obtained by EDA method. Distributions of each element are summarized as follows:

As: High value zones are distributed covering the area of alteration/mineralization zone in central south of the area and they further continuously extend toward north. Samples of high value are scattered along the main stream in northern part of the area.

Au: Similar to As distribution, high value and anomalous zones occur over the area of alteration/mineralization in central south of the area, and the area north of the alteration/mineralization zone is, also, covered by high value zone.

Ba: High value zones occur in central north of the area. Other than this, samples of high value and anomaly are scattered over the area east of the main stream.

Co: Samples of high value and anomaly are scattered over the entire area and no characteristic distribution feature is observed.

Cr: Distribution of anormaly zones are restricted in southern part of the area, one in southeastern part of the area extended in E-W trend and the other in southwest corner of the area.

Cu: High value zones occur within and close to alteration/mineralization zone in southern part of the area. Other than this, samples of high value are scattered over the center and north of the area. Cu concentration is slightly low compared with other area.

Hg: High value zones occur close to and within the alteration/mineralization zone in the central south of the area. Other than this, samples of high value and anomaly are scattered over the entire area.

K : Anomaly zones occur close to and within the area of alteration/mineralization. Other than this, samples of high value and anomaly are distributed eastern and northern part of the area.

Mg: Characteristic distribution feature is not observed except very low concentration over the area of alteration/mineralization zone.

Mn: A clear distribution tendency is not observed. However, samples of high value tend to occur in southern part of the area and east of the main stream.

Mo: Mo shows low concentration with the maximum value of 3 ppm. Samples of higher concentration tend to gather in northern and southern parts of the area.

Na: Samples of high value tend to occur along the main stream. Low concentration zone, characteristically, occurs over the area of alteration/mineralization zone.

Ni: Similar to Cr distribution, a high value zone occur in southeastern part of the area, extended in E-W direction. Other than this, samples of high value scattered over the entire area. Low concentration zone occurs over the area of alteration/mineralization zone.

Pb: High value and anomalous zones are clearly distributed over the area of alteration /mineralization zone and they further extend toward north. Other than this samples of high value are distributed in northern part of the area along the main stream.

S : High value zones occur over the area of alteration/mineralization zone in central north of the area.

Sb: Samples of high value occur in northern part of the area along the main stream and in central south of the area over the alteration/mineralization zone.

Sr: An anomalous zone occurs in the west of alteration/mineralization zone in southwestern part of the area. Samples of high value are scattered over the entire area. Samples of low concentration occur over the area of alteration/mineralization zone.

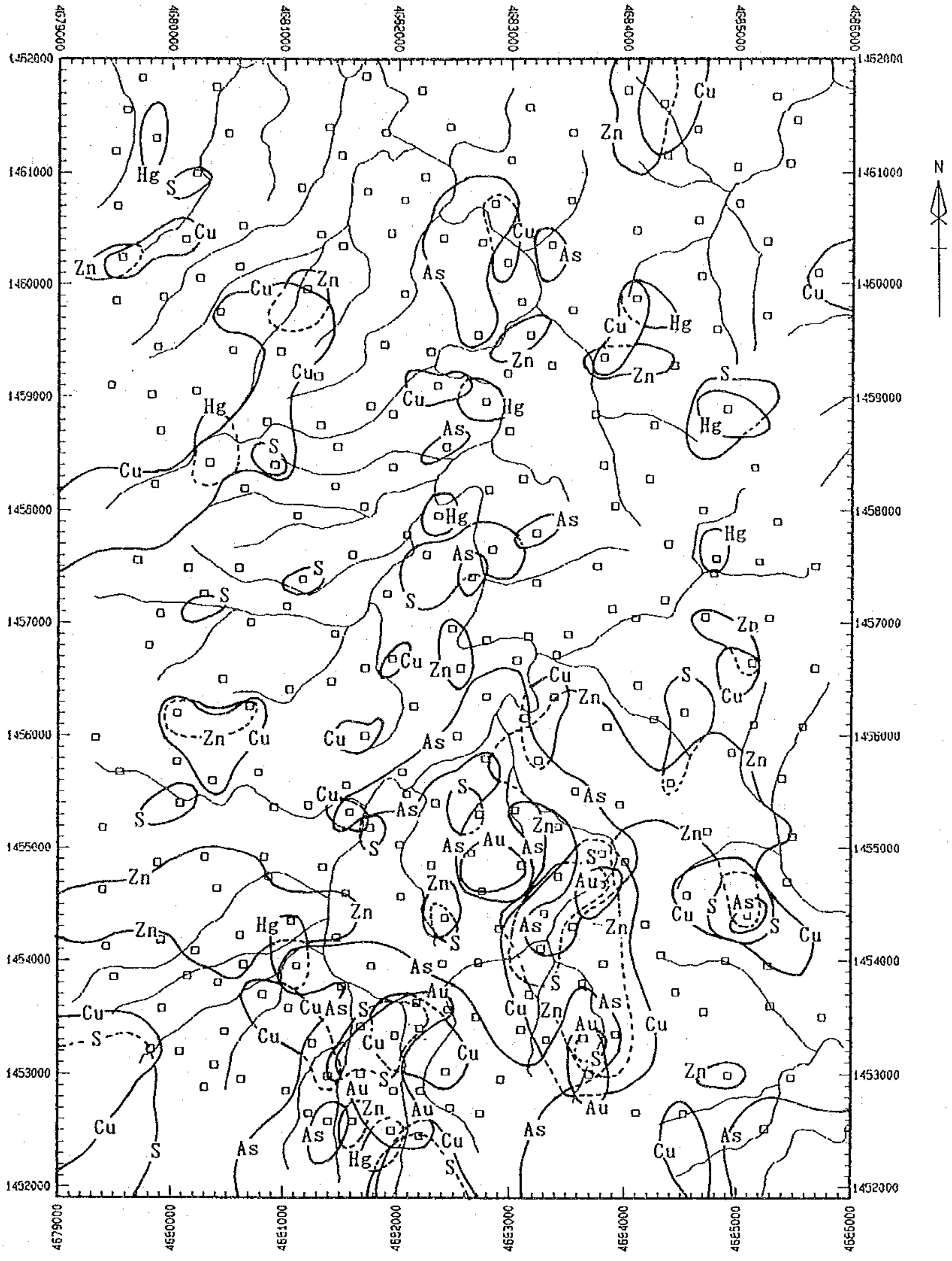
Ti: High value zones occur in southeastern part of the area. Other than these samples, high value samples are scattered over the northern part of the area.

U : High value and anomalous zones occur over southern part of the area including the alteration/mineralization zone. Other than this, high value zones occur in northwestern part of the area.

W : Nearly all the samples show the values below the detection limit. Samples of higher concentration occur in southern part around alteration/mineralization zone and norther part along the main stream.

Zn: Anomalous zones occur in southeastern and southwestern parts of the area surrounding the alteration/mineralization zone.

The alteration/mineralization zone is characterized by enrichment of As, Au, Pb and elements such as Mg, Na, Ni, Sr and Ti are depleted in the zone. Considering the distribution map and geologic environment of the area, six elements were selected for the anomaly map given in Fig. II-1-43. The anomalies of these elements occur



As > 28 ppm
Au > 16 ppb
Cu > 20 ppm
Hg > 195 ppb
Pb > 55 ppm
S > 0.022 %
Zn > 58 ppm

Fig. II-1-43 Distribution of geochemical anomalous zones in Area T closely associated with each other in southern part of the area, covering the alteration/mineralization zone and its northeastern extention. In the area overlapping anomalies of Au, Cu, Pb and S are found within the widespread anomaly of As. Zn anomalous zones tend to occur outside of the area surrounding these anomalies.

(4) Multi element analysis

Factor analysis was conducted as a multi element analysis in this survey. The results of facter analysis are given in Table II-1-27. Following relationships between elements and factors were extracted by the factor analysis.

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

Considering the relations between factors and related elements and distributions of each element, Factor 1 is related to the chemical characteristics of sedimentary rocks, possibly reflecting the chemical nature of their provenance and Factor 2 can be related to the mineralization of the Area T. Including these two factors, a distribution map of factor scores was prepared allocating three different colors for each factor (Fig. II-1-44). Three factors are shown by following colors.

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

Distribution tendencies of these factors are summarized as below;

Factor 1: Samples of high factor score are distributed over the entire area and no characteristic distribution feature is observed.

Factor 2: High factor score zones are, clearly, distributed in central south of the area covering the alteration/mineralization zone and northeast of this zone. Other than this, one sample with high facor score occurs at southeastern edge of the area and samples with relatively high factor score are distributed along the main stream to further north.

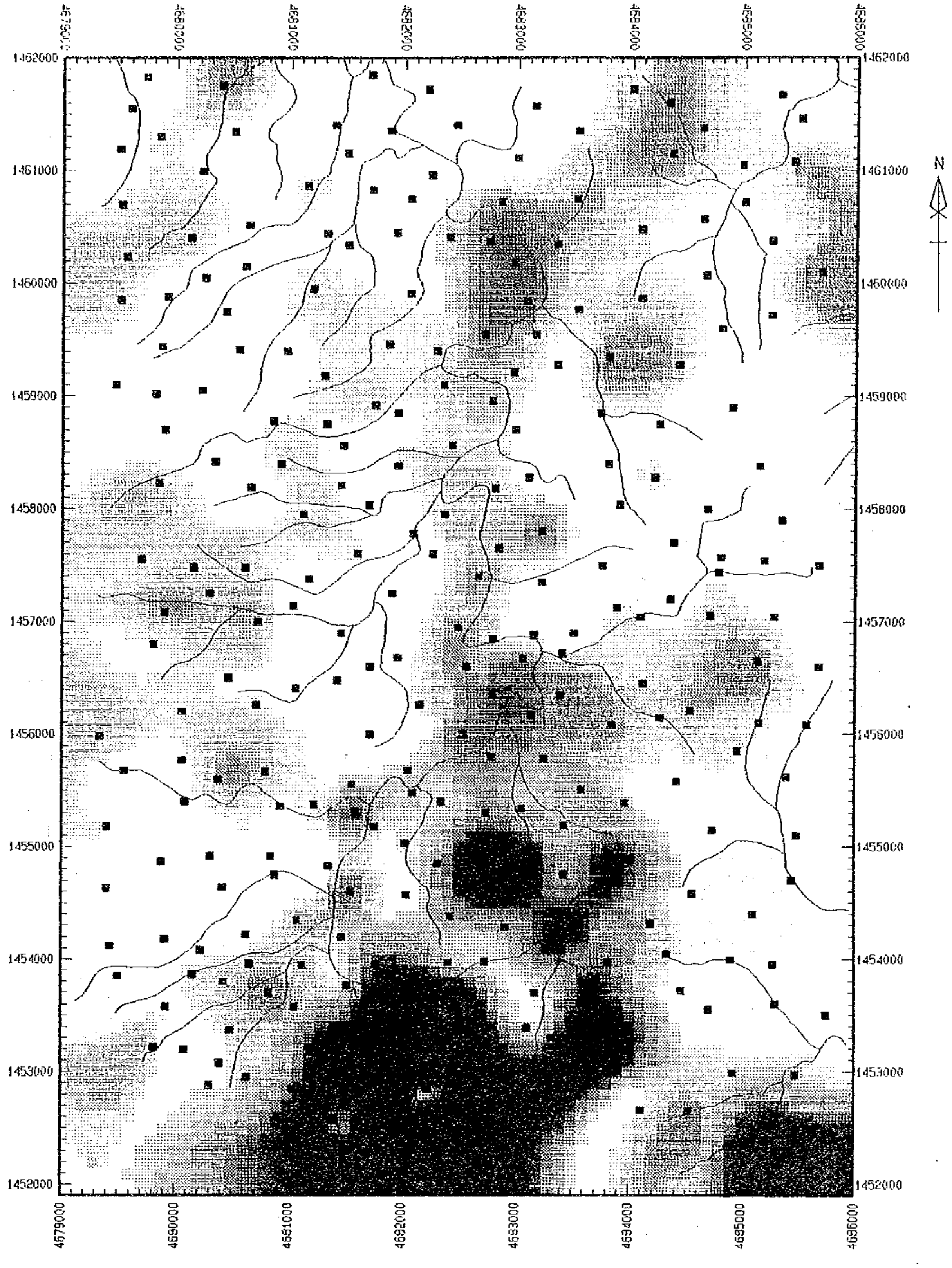
Factor 3: Samples of high factor score are distributed in southern part of the area surrounding the alteration/mineralization zone.

The factor ananlysis suggests that the mineralization in the Area T is characterized by the Factor 2 (As-Au-Pb). The alteration/mineralization zone with high Au and Ag samples was found by this semi-detailed geochemical survey and this zone is clearly characterized by high factor score of Factor 2. A detail survey over the area of this zone must be conducted in future for evaluation of the area.

Table II-1-27 Results of factor analyses for soil samples in Area T

Element	Factor loading (Varimax rotation)						Communality
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	
As	0.010	0.769	-0.094	-0.049	-0.017	0.077	0.6087
Au	-0.115	0.852	-0.055	-0.005	-0.025	-0.021	0.7437
Ba	0.707	0.133	0.016	-0.322	-0.323	-0.309	0.8215
Co	0.808	-0.074	-0.304	-0.087	-0.060	0.055	0.7651
Cr	0.090	0.178	-0.805	-0.302	-0.063	-0.147	0.8047
Cu	0.550	0.382	-0.427	-0.349	-0.158	-0.117	0.7903
Hg	-0.184	0.039	0.046	0.067	-0.145	0.451	0.2663
K	0.718	0.155	-0.052	-0.360	-0.307	-0.326	0.8719
Mg	0.748	-0.202	-0.085	-0.327	-0.149	-0.328	0.8433
Mn	0.854	0.127	-0.155	0.049	-0.120	-0.036	0.7871
Mo	0.093	0.050	-0.026	-0.241	-0.416	0.120	0.2574
Na	0.856	0.053	-0.112	-0.010	0.017	-0.147	0.7704
Ni	0.548	-0.013	-0.696	-0.192	0.051	-0.115	0.8371
Pb	0.155	0.689	-0.145	-0.254	-0.310	-0.012	0.6794
S	0.110	0.080	-0.690	0.058	-0.190	0.066	0.5382
Sb	0.107	0.092	-0.157	0.078	-0.486	0.047	0.2887
Sr	0.678	-0.368	0.021	-0.137	-0.069	0.074	0.6241
Ti	0.330	-0.027	-0.188	-0.707	-0.179	-0.149	0.6987
U	0.149	0.361	-0.135	-0.648	0.040	0.007	0.5922
W	-0.100	0.346	0.097	-0.250	-0.273	0.283	0.3564
Zn	0.643	0.042	-0.347	-0.363	0.195	-0.172	0.7348
F.C.*1	39.6 %	18.1 %	15.9 %	13.7 %	7.2 %	5.5 %	—

*1: Factor contribution



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

Fig. II-1-44 Distribution of factor scores in Area T

Chapter 2 Geological Survey (Area B)

2-1 Outline of survey

The regional geochemical survey of the Segama area in Phase II suggested a potentiality for the Cyprus type copper deposit in upper stream of Sungai Danum. The area was named Area B and the semi-detailed geochemical survey was conducted in the area during Phase III. The semi-detailed geochemical survey revealed Cu and Zn anomalies over the area of the Chert-Spilite formation in centeral and southwestern parts of Area B, and copper mineralizations of stockwork and dissemination were found within the area of the anomalies. For an evaluation of the mineralization through understanding of geological environment and scale of the mineralization, a geological survey including investigation of mineral showings was conducted over the area of central to southwestern part of Area B.

As shown in the location map of Fig. II-2-1, the Area B is located at approximately 80 km west of Lahad Datu, in the area upper stream of Sungai Danum in the Segama area. The access to the area is poor. After four or five hours drive from Lahad Datu toward west along timber logging roads, the area can be reached by approximately 30 km walk along old trail and rivers. The survey was carried out establishing few camps in the area.

The main drainage in the area is Sungai Karangan, a tributary of Sungai Danum, and it flows from west to east in the southern part of the area. The main tributaries of Sungai Karangan flow from north to south and they offer nice traverce route for the geological survey. The southern part of the area along Sungai Karangan is occupied by gentle hilly topography with elevation of 400 m to 500 m. While, a ragget moutainous topography occupies central to northern part of the area and ridges with maximum altitude more than 1,000 m run in NW-SE trend in the northern part of the area.

The geological survey was conducted mainly along streams and detailed skecthes were drawn at main mineral showings. An amount of the work is given in Tables I-1 and I-2. Thin sectoins and polish sections were prepared for typical rock and ore samples (Tables II-2-1 and II-2-2). Results of X-ray diffraction anlysis and ore assaying are, respectively, shown in Tables II-2-3 and II-2-4.

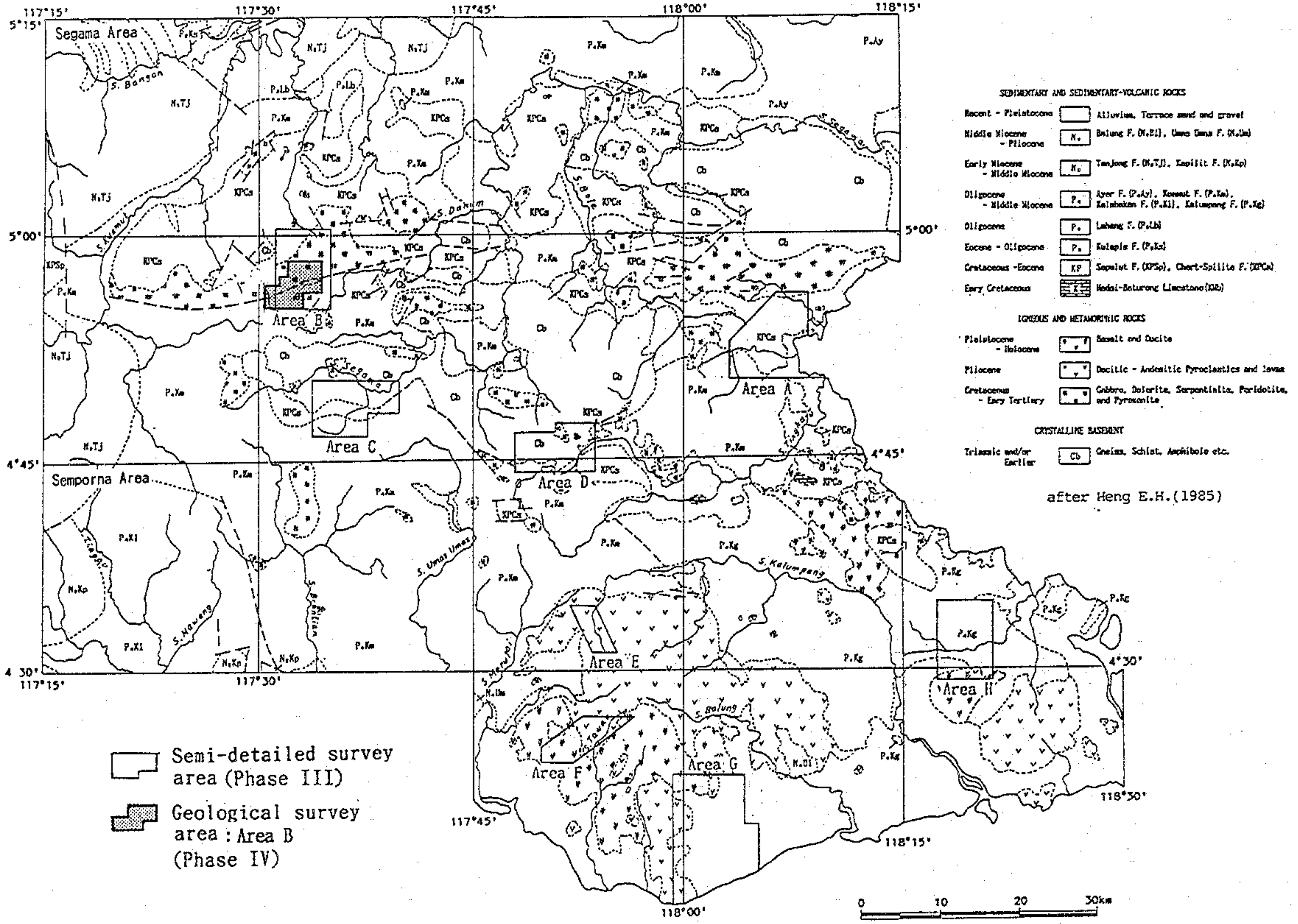


Fig. II-2-1 Location map of Area B

Table II-2-1 Descriptions of thin sections of Area B

Ser. No.	Sample No.	Area	Coordinates N	Coordinates E	Rock Name	Texture	Primary minerals: plagioclase	clinopyroxene				Secondary minerals: quartz	sericite	chlorite	epidote	calcite	montmorillonite	tremolite	prehnite	Accessory mine.: sphene	opaque mineral				Remarks
1	M739	B	1444.85	4734.90	Dolerite	granoblastic						○		◎	•					•	○				strongly altered dolerite, no primary mineral remains.
2	U721	B	1446.38	4740.20	Gabbro	hypidiomorphic granular	◎	o					o								•				plagioclace-rich leucocratic gabbro.
3	U724	B	1446.61	4740.12	Gabbro	cumulate	◎	○						o		•			o		o				orthocumulate, plagioclase is cumulate phase.
4	U730	B	1447.32	4737.34	Dolerite	ophitic	◎	○				o		o		•	o	•		•	o				relatively fresh dolerite.
5	U740	B	1445.95	4739.34	Basalt	aphyric intergranular	◎							○						○	○				fine, aphyric, chloritized basalt.

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

Table II-2-2 Descriptions of polished sections of Area B

Ser. No.	Sample No.	Area	Coordinates		Descriptions	Ore minerals							Remarks
			N	E		chalcopyrite	covellite	bornite	cubanite	sphalerite	pyrite	ganque mineral	
1	J709	B	1445.11	4734.16	qz. vein with py. and cp.	o				o	◎	◎q	
2	M739	B	1444.85	4734.90	dolerite with py. and cp. dissm.	◎					o	○q	
3	M742	B	1444.30	4733.85	qz. veinlet with py. and cp.	○	o	o			◎	◎q	
4	P710	B	1446.55	4737.15	qz. vein	o				•	◎	○q	
5	P712	B	1446.53	4737.03	qz. veinlet with py. and cp.	◎				o	○	○q	2 phases of py. generation
6	U731	B	1447.33	4737.37	qz. vein with py						◎	○q	
7	U735	B	1447.47	4737.29	qz. vein with py.						◎	○q	
8	U737	B	1447.47	4737.29	qz. vein wit py. and cp.	o			•		◎	◎q	2 phases of py. generation
9	U739	B	1447.47	4737.29	qz. veinlet with py. and cp.	◎					○	○q	
10	U743	B	1448.14	4738.70	qz. vein with py.						◎	◎	cataclastic texture
11	U744	B	1448.14	4738.70	qz. vein with py.	o				o	◎	◎q	
12	U756	B	1447.47	4737.29	qz. vein with py. and cp.						◎	◎q	
13	U761	B	1447.47	4737.29	qz. vein with py. and cp.	○	o				○	◎q	

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

Table II-2-3 Results of X-ray diffraction analyses in Area B

Ser. No.	Sample No.	Area	Coordinates N	Coordinates E	Descriptions	Detected mineral: quartz	plagioclase	K-feldspar	amphibole	chlorite	montmorillonite	calcite	pyrite	chalcopyrite	sphalerite	galena	Remarks
1	M739	B	1444.85	4734.90	dolerite with py.cp. dissm. and stwk.	o		·		◎			·	◎	·	·	
2	M742	B	1444.30	4733.85	qz.veinlet with py.cp. in dole.	◎	·			○	·		o	·	o		
3	P712	B	1446.53	4737.03	qz. veinlet with py. cp.	◎	o	·		○	·		·	o			
4	P713	B	1446.52	4736.98	brecciated dolerite with qz. veinlet.	·	○	·	o	o	·						
5	U730	B	1447.32	4737.34	altered dolerite with py. dissm.	◎	o	·		○	·		·				
6	U738	B	1447.47	4737.29	altered dolerite with py. dissm.	o	○	·	·	o			·				
7	U743	B	1448.14	4738.70	brecciated dolerite with py. dissm.	◎	o	·		o			o		o		
8	U745	B	1446.55	4737.15	altered dolerite with py. dissm.	◎	o	·		o	·		·				
9	U749	B	1446.55	4737.15	dolerite with qz. veinlet.	◎				◎	·	·					
10	U751	B	1446.53	4737.05	dolerite with py. veinlet	o	○	·		◎		·	·		·		

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

Table II-2-4 Assay results of Area B (1)

Ser. No.	Sample No.	Area	Coordinates		Descriptions	Assay results							Remarks and sampling width (m)
			N	E		Au (g/t)	Ag (g/t)	Cu (ppm)	Mo ppm)	Pb (ppm)	Zn (ppm)	S (%)	
1	J704	B	1445.80	4736.84	sili. dolerite with py.	< 0.1	0.3	297	< 1	7	142	19.45	float, w.0.2
2	J709	B	1445.11	4736.11	quartz vein with py. and cp.	< 0.1	0.8	5,019	13	4	6,222	11.45	w.0.3
3	J712	B	1445.14	4734.12	qz.veinlet with py.cp. in basalt	< 0.1	0.5	5,104	< 1	3	69	6.22	w.1.2
4	J713	B	1445.33	4735.19	basalt with py. dissm.	< 0.1	0.2	25	< 1	5	84	0.48	w.0.2
5	M735	B	1444.39	4735.43	qz. vein with py. cp.	< 0.1	0.5	1,819	< 1	< 1	586	14.69	w.0.3
6	M738	B	1444.85	4734.90	dole.with py.cp.dissm.& stwk.	< 0.1	4.0	28,017	1	8	981	7.56	w.0.2
7	M739	B	1444.85	4734.90	dole.with py.cp.dissm.& stwk.	< 0.1	5.5	59,041	< 1	4	1,231	11.28	w.0.1
8	M740	B	1444.85	4734.90	dole.with py.cp.dissm.& stwk.	< 0.1	4.2	37,207	4	2	546	7.36	w.0.1
9	M742	B	1444.30	4733.85	qz.veinlet with py.cp. in dole.	< 0.1	0.9	11,603	< 1	< 1	53	12.72	w.0.2
10	M744	B	1444.20	4734.35	sili.dolerite with py.dissm.	< 0.1	12.6	1,628	7	28	5,095	3.38	w.0.2
11	P710	B	1446.55	4737.15	quartz vein	< 0.1	0.3	378	< 1	2	4,869	14.20	w.0.2
12	P711	B	1446.53	4737.05	sheared dole. with py veinlet	< 0.1	0.6	4,091	< 1	5	154	13.80	w.0.2
13	P712	B	1446.53	4737.03	qz. veinlet with py.cp.	< 0.1	31.2	101,016	7	52	20,240	21.52	w.0.1
14	P713	B	1446.52	4737.98	qz. vein with py.	< 0.1	0.7	950	2	3	75	16.65	w.0.1
15	P714	B	1447.04	4737.05	dolerite with py. dissemination	< 0.1	0.4	528	< 1	2	115	8.86	w.1.0
16	P718	B	1445.99	4737.42	qz.vein with py.cp.mal.az.	< 0.1	2.7	12,702	< 1	5	126	6.13	w.0.1
17	P719	B	1446.05	4737.10	quartz vein with py.	< 0.1	1.9	8,525	< 1	6	173	10.93	w.0.1
18	P723	B	1445.70	4736.12	qz.stockwork with py.in dolerite	< 0.1	< 0.1	204	< 1	< 1	65	22.41	w.0.2
19	P724	B	1445.70	4736.12	qz.stockwork with py.in dolerite	< 0.1	< 0.1	63	< 1	< 1	60	19.25	w.0.2
20	U728	B	1447.32	4737.34	qz.vein with py.	< 0.1	< 0.1	23	4	4	109	15.46	w.0.3

Table II-2-4 Assay results of Area B (2)

Ser. No.	Sample No.	Area	Coordinates		Descriptions	Assay results							Remarks and sampling width (m)
			N	E		Au (g/t)	Ag (g/t)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	S (%)	
21	U729	B	1447.32	4737.34	qz. vein with py.	< 0.1	0.4	152	1	16	218	6.53	w. 0.1
22	U731	B	1447.33	4737.37	qz. vein with py.	< 0.1	< 0.1	110	< 1	2	76	19.35	w. 0.6
23	U732	B	1447.33	4737.37	qz. veinlet in dolerite	< 0.1	0.3	31	< 1	5	291	10.56	w. 0.1
24	U733	B	1447.33	4737.37	qz. stockwork with py. in dole.	< 0.1	0.5	879	< 1	3	147	5.76	w. 0.3
25	U734	B	1447.47	4737.29	qz. vein with py.	< 0.1	< 0.1	374	< 1	< 1	213	14.85	w. 1.0
26	U735	B	1447.47	4737.29	qz. stockwork with py.	< 0.1	< 0.1	61	< 1	2	69	18.30	w. 1.0
27	U736	B	1447.47	4737.29	qz. vein with py. cp.	< 0.1	2.0	1,579	10	3	62	19.71	w. 0.7
28	U737	B	1447.47	4737.29	qz. vein with py. cp.	< 0.1	4.6	26,642	21	1	300	21.92	w. 0.6
29	U739	B	1447.47	4737.29	qz. veinlet with py. cp.	< 0.1	26.4	124,513	< 1	2	1,234	25.12	w. 0.03
30	U743	B	1448.14	4738.70	qz. vein with py.	< 0.1	0.5	775	< 1	4	1,094	21.74	w. 1.0
31	U744	B	1448.14	4738.70	qz. vein with py.	< 0.1	1.8	7,088	4	5	4,438	6.84	w. 0.1
32	U745	B	1446.55	4737.15	qz. stockwork with py. in dole.	< 0.1	< 0.1	360	< 1	3	127	2.42	w. 1.0
33	U746	B	1446.55	4737.15	qz. stockwork with py. in dole.	< 0.1	< 0.1	13	< 1	4	109	20.85	w. 1.0
34	U748	B	1446.55	4737.15	qz. vein with py. in dole.	< 0.1	0.2	44	< 1	4	539	6.24	w. 1.0
35	U749	B	1446.55	4737.15	qz. stockwork in dolerite	< 0.1	< 0.1	11	6	2	163	3.51	w. 0.15
36	U750	B	1446.55	4737.15	qz. stockwork in dolerite	< 0.1	< 0.1	64	4	2	72	0.33	w. 0.3
37	U751	B	1446.53	4737.05	sheared dolerite with py dissm.	< 0.1	0.3	581	1	4	494	4.09	w. 1.0
38	U752	B	1446.53	4737.05	sheared dolerite with py dissm.	< 0.1	0.3	398	< 1	6	168	2.16	w. 1.0
39	U753	B	1446.53	4737.05	sheared dolerite with py dissm.	< 0.1	0.1	249	< 1	5	360	4.78	w. 1.0
40	U754	B	1446.53	4737.05	sheared dolerite with py dissm.	< 0.1	0.3	245	< 1	5	97	1.11	w. 1.0

Table II-2-4 Assay results of Area B (3)

Ser. No.	Sample No.	Area	Coordinates		Descriptions	Assay results							Remarks and sampling width (m)
			N	E		Au (g/t)	Ag (g/t)	Cu (ppm)	Mo (ppm)	Pb (ppm)	Zn (ppm)	S (%)	
41	U755	B	1447.47	4737.29	qz.veins with py.cp.in dole.	< 0.1	0.2	518	< 1	7	181	3.90	w.1.0
42	U756	B	1447.47	4737.29	qz.veins with py.cp.in dole.	< 0.1	< 0.1	328	< 1	3	100	12.87	w.1.0
43	U757	B	1447.47	4737.29	qz.veins with py.cp.in dole.	< 0.1	0.2	227	< 1	4	178	3.24	w.1.0
44	U758	B	1447.47	4737.29	qz.veins with py.cp.in dole.	< 0.1	0.3	29	< 1	6	158	2.99	w.1.0
45	U759	B	1447.47	4737.29	qz.veins with py.cp.in dole.	< 0.1	0.2	116	< 1	7	158	2.01	w.1.0
46	U760	B	1447.47	4737.29	qz.veins with py.cp.in dole.	< 0.1	0.4	325	< 1	6	160	4.57	w.1.0

2-2 Survey Results

2-2-1 Geology

Geology in the area consists of Gabbro(Gb), Dolerite (Do) and Basalt (Ba) of Cretaceous to early Tertiary and Kuamut formation (P_4Km) of Oligocene to middle Miocene. Although a geological unit of the Chert-spilite formation (Csba) was used including basalt and dolerite in semi-detailed geochemical survey during Phase III, Dolerite (Do) and Basalt (Ba) were separated into two units in this survey. Geological maps and cross sections of at 1/50,000 and 1/10,000 are, respectively, given in Fig. II-2-2 and Plate II-2-1. A schematic lithological succession is given in Fig. II-2-3

The gabbro, dolerite and basalt constitute a dismembered ophiolite block and they are distributed in central to northern part of the area forming mountainous topography. While, the Kuamut formation is distributed over the flat area in southern part of the area. Both of them are separated by the E-W trending thrust fault running near the topographic boundary of low land and mountain. The block of ophiolite sequence rocks thrust up to south onto the Kuamut formation.

The Gabbro (Gb), distributed mainly along the thrust fault in eastern and western parts of the area, constitutes the lowest unit of ophiolite sequence rocks in the area. It, generally, is a pale greenish gray, medium grain size rock with pyroxene and rare hornblende. A sheared hornblende gabbro occurs along the thrust in southwestern part of the area. Layered gabbro occurs near the thrust in western part of the area. The thin section of this layered gabbro shows a cumulate texture with plagioclase as a cumulate phase surrounded by interstitial clinopyroxene. The layered gabbro grades into massive gabbro toward north and dolerite dikes appear in the gabbro in further north close to the area of dolerite.

The Dolerite (Do), extensively, occurs in central to northern part of the area occupying steep slop of mountain. Occasional occurrences of chilled margin stripes in the dolerite suggest that this unit corresponds to sheeted dike complex of the typical ophiolite sequence. The dolerite is commonly chloritized and it is a massive, dark greenish gray rock. The less altered dolerite consists of equigranular pyroxene and plagioclase. Chilled margins of a few cm wide, occasionaly, occur at approximately 1 m interval in the dolerite and they generally trend in E-W directin with steep dips close to vertical. The dolerite is, often, brecciated to few cm to 10 cm size, probably, due to tectonic movements such as fault. Microscopic observation of the less altered rock show a ophitic texture consisting

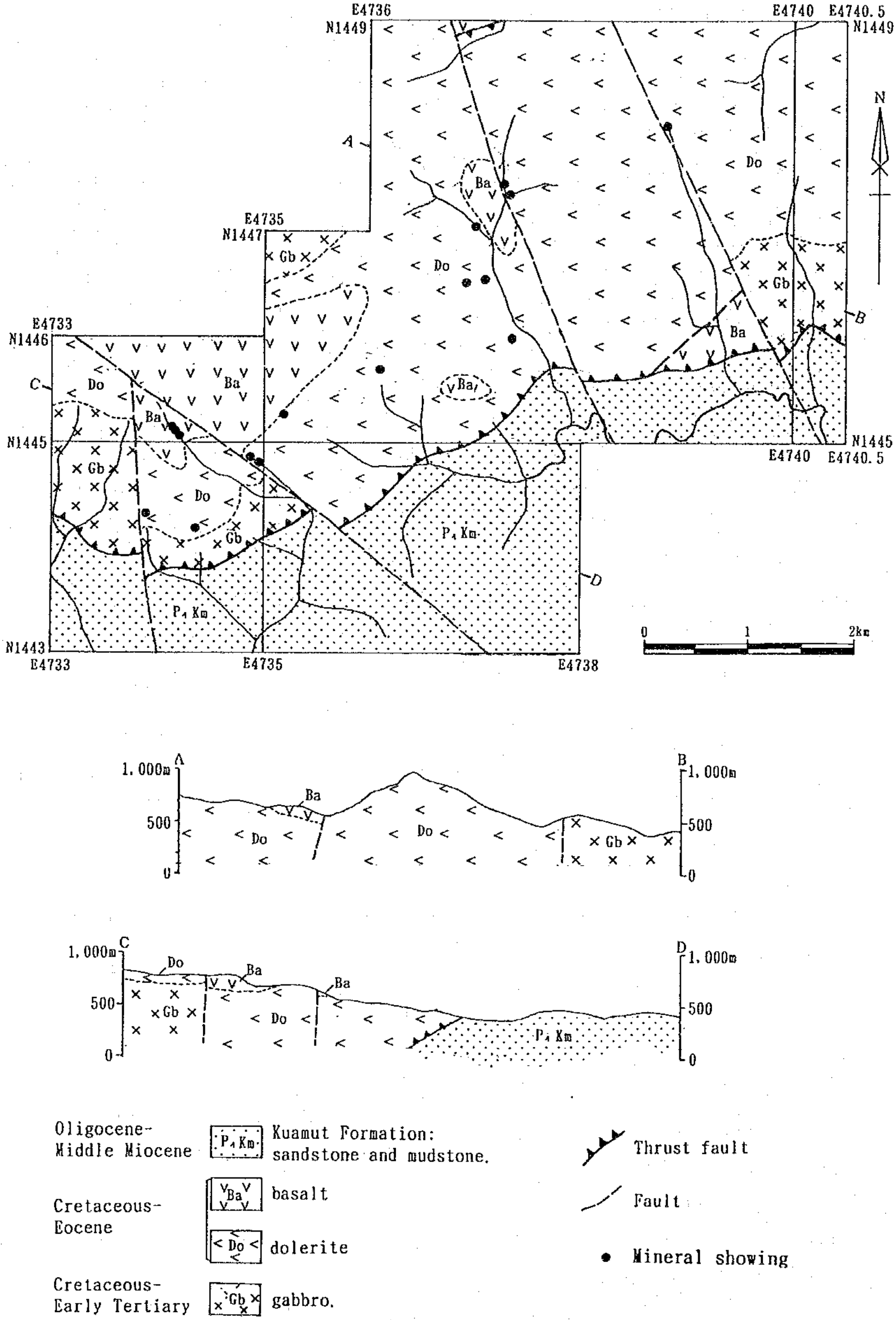


Fig. II-2-2 Geologic map and cross section of Area B

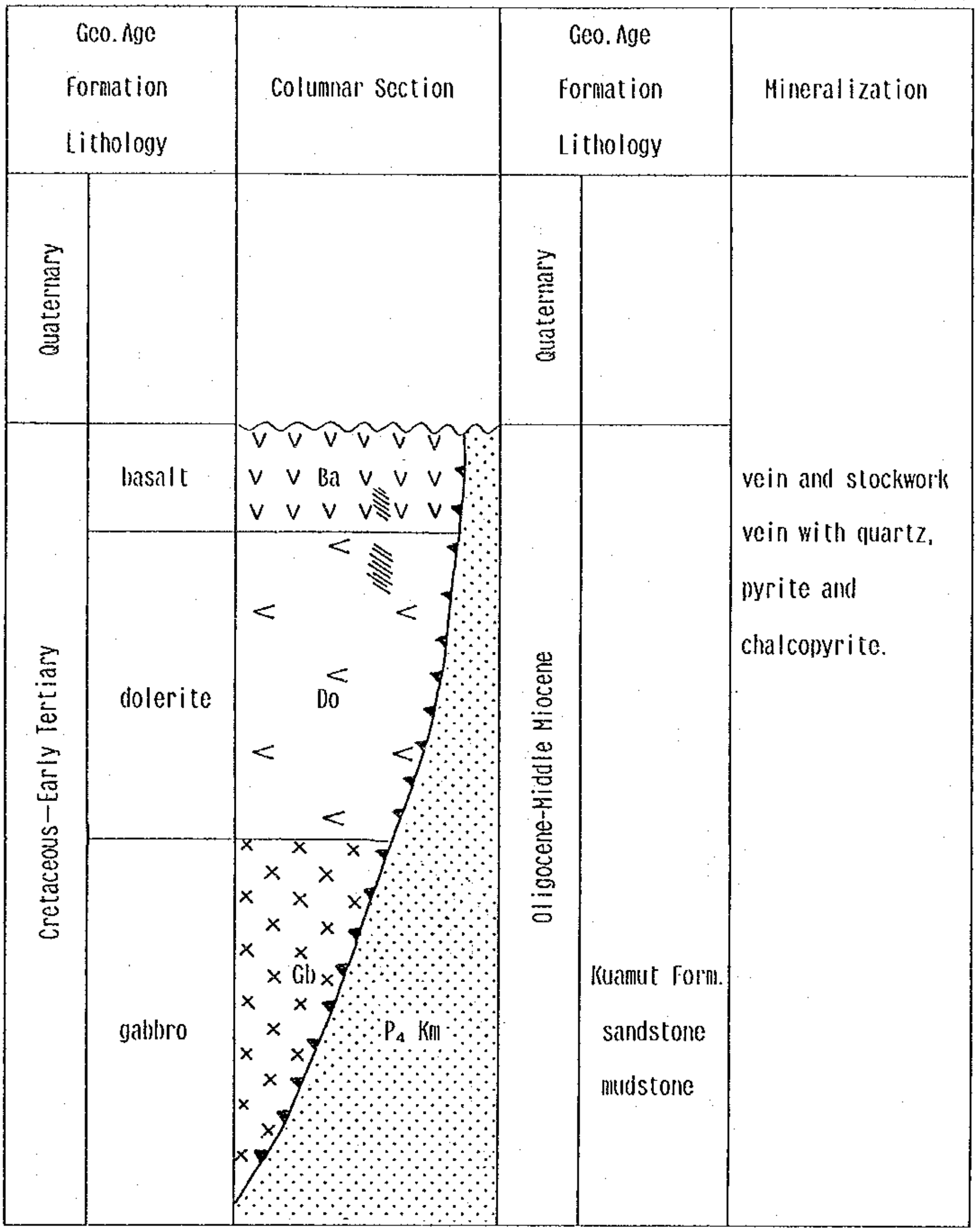


Fig. II-2-3 Schematic lithological succession of Area B of clinopyroxene and plagioclase. While, the altered rock collected close to one of mineral showing is composed of secondary quartz, chlorite and epidote, and original minerals and texture are not preserved.

Basalt (Ba) tend to occur at higher elevation on the mountain in the central and northern parts of the area except in western part of the area where basalt is surrounded by faults. It is a dark greenish gray, aphyric rock with clear pillow structure of 50 cm to 1 m across. The basalt is commonly brecciated with preserving pillow structure and is generally chloritized. Microscopic observation shows that it is an aphyric rock with groundmass of intregranular texture consisting plagioclase and secondary chlorite.

The southern part of the area is underlain by the Kuamut formation (P_4Km) consisting of mainly pale gray, massive sandstone and subordinate, gray to brown mudstone. The structure of the Kuamut formation is not clear because the laminas of mudstone do not show consistent dip and strikes through the area. The Kuamut formation is generally sheared in the vicinity of the thrust fault.

The structural feature of the area is characterized by the E-W trending thrust fault separating the ophiolite sequence rocks and the Kuamut formation. The block of dismembered ophiolite thrust up toward south and overlies the Kuamut formation. The faults trending NW-SE to NNW-SSE cut the thrust faults. Compared to the typical succession of ophiolite sequence, the dismembered ophiolite block of the Area B corresponds to layered gabbro, sheeted dike complex and pillow lava. The restricted occurrences of basaltic pillow lava in the area suggest that the upper limit of the dismembered ophiolite block in the area is close to the boundary between sheeted dike complex and pillow lava.

2-2-2 Mineralizaton

Many mineral showings were found mainly in the dolerite and only few locations of mineral showings were found in the basalt. The distribution of these mineral showings are aligned in WSW-ENE trend parallel to the thrust fault. The occurrences of the mineralization in the area are divided into three types. They are quartz vein with pyrite and chalcopyrite, stockwork zone of quartz-pyrite-chalcopyrite veinlets and disseminations of pyrite-chalcopyrite. Numbers (B-1 to B-15) were given to each of the mineral showing and they were described. At the same time, samples were collected for laboratorial work such as polished section, ore assaying and X-ray diffraction analysis. The distribution and description of the mineral