### 1-2-3 Stream sediment geochemical survey

#### (1) Element

The stream sediment samples collected in the area were chemically analyzed for 21 elements. Results of statistical processing conducted for the analytical results shown in Appendix 2 are given in Table II-1-1. Analytical results of Au, Mo and W give the values of less than the detection limits for most the samples. The maximum values of Cr (59,548 ppm), Hg (14,767 ppb), Sb (3,488.0 ppm) and Ti (51.07 %) indicate relatively high values. Correlation coefficient between the elements was calculated to clarify relationship among the elements. Correlation matrix is shown in Table II-1-2. Pairs of elements which has good correlation (more than 0.600 correlation coefficient) are as follows;

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

Pairs of element with significantly high correlation coefficient are Ba-K (0.827), Co-Ni(0.803), Mg-Ni(0.843) and Na-Sr(0.869). Au has not good correlation with other elements. Cu has good correlation (more than 0.500) with K, Mg, Na, Ni, S, Sr, Ti and Zn.

#### (2) Single element analysis

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

As : High value samples are mainly found in the areas of sedimentary rocks ($P_1Ts$, $P_2Cr$). Especially, samples in the Trusmadi formation ($P_1Ts$) show higher values of As. The anomalous samples are distributed in the area of the Sungai Melaut at south of Ranau and Sungai Sugut at north of Ranau. Mamut mine is located in the area of Sungai Melaut.

Au : The high value samples are found in the area of surroundings of Ranau,

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

| Element | Statistics | | | | | | EDA method*3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Below detection limit (%) | Maximum value | Minimum value | Mean*1 value (b) | Standard deviation | b + 2S.D. *2 | Median | Upper Wisker | Upper Fence |
| As (ppm) | 36.8 | 118 | < 1 | 2.8 | 0.643 | 54.9 | 4.0 | 13.0 | — |
| Au (ppb) | 70.6 | 1,395 | < 1 | 1.0 | 0.566 | 13.4 | 0.5 | 2.0 | 2.8 |
| Ba (ppm) | 0.2 | 1,478 | 3 | 117.4 | 0.293 | 451.9 | 116.0 | 213.0 | 741.2 |
| Co (ppm) | 7.1 | 442 | < 1 | 5.6 | 0.506 | 57.7 | 6.0 | 14.0 | 77.2 |
| Cr (ppm) | — | 59,548 | 50 | 259.0 | 0.381 | 1,498.1 | 221.0 | 386.0 | 1,062.1 |
| Cu (ppm) | 0.0 | 3,632 | < 1 | 12.0 | 0.349 | 60.0 | 10.0 | 23.0 | 85.0 |
| Hg (ppb) | 16.0 | 14,767 | < 10 | 33.3 | 0.522 | 584.1 | 26.0 | 107.0 | 1,110.0 |
| K (%) | 0.3 | 2.51 | < 0.01 | 0.481 | 0.329 | 2.187 | 0.480 | 1.020 | — |
| Mg (%) | 0.4 | 18.06 | < 0.01 | 0.281 | 0.554 | 3.607 | 0.220 | 0.760 | 7.966 |
| Mn (ppm) | 19.7 | 7,555 | < 1 | 53.3 | 0.839 | 2,542.3 | 74.0 | 302.0 | — |
| Mo (ppm) | 70.6 | 54 | < 1 | 0.7 | 0.270 | 2.4 | 0.5 | 1.0 | 2.8 |
| Na (%) | 0.9 | 2.36 | < 0.01 | 0.124 | 0.524 | 1.384 | 0.130 | 0.430 | — |
| Ni (ppm) | — | 4,193 | 3 | 31.7 | 0.493 | 306.1 | 23.0 | 65.0 | 260.7 |
| Pb (ppm) | 26.4 | 587 | < 2 | 4.2 | 0.447 | 33.0 | 5.0 | 10.0 | 243.0 |
| S (%) | — | 6.128 | 0.005 | 0.019 | 0.343 | 0.091 | 0.018 | 0.032 | 0.104 |
| Sb (ppm) | 12.6 | 3,488.0 | < 0.2 | 1.90 | 0.619 | 32.96 | 2.60 | 5.40 | 37.23 |
| Sr (ppm) | 0.0 | 213 | < 1 | 24.0 | 0.265 | 81.3 | 22.0 | 45.0 | 143.3 |
| Ti (%) | — | 51.07 | 0.02 | 0.201 | 0.219 | 0.553 | 0.180 | 0.290 | 0.593 |
| U (ppm) | 1.0 | 49.2 | < 0.2 | 1.56 | 0.231 | 4.50 | 1.60 | 2.20 | 4.30 |
| W (ppm) | 85.0 | 58 | < 2 | 1.2 | 0.215 | 3.3 | 1.0 | 1.0 | 1.0 |
| Zn (ppm) | 12.2 | 448 | < 1 | 17.4 | 0.689 | 416.8 | 22.0 | 69.0 | — |

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

## Table II-1-2 Coorelation matrix of elements for stream sediments in Kinabalu area

| | As | Au | Ba | Co | Cr | Cu | Hg | K | Mg | Mn | Mo | Na | Ni | Pb | S | Sb | Sr | Ti | U | W | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| As | 1.000 | | | | | | | | | | | | | | | | | | | | |
| Au | .102 | 1.000 | | | | | | | | | | | | | | | | | | | |
| Ba | .181 | .086 | 1.000 | | | | | | | | | | | | | | | | | | |
| Co | -.019 | .161 | .258 | 1.000 | | | | | | | | | | | | | | | | | |
| Cr | -.027 | .142 | -.102 | .575 | 1.000 | | | | | | | | | | | | | | | | |
| Cu | .124 | .392 | .386 | .677 | .346 | 1.000 | | | | | | | | | | | | | | | |
| Hg | .148 | .313 | .275 | .315 | .024 | .498 | 1.000 | | | | | | | | | | | | | | |
| K | .147 | .117 | .865 | .363 | -.098 | .522 | .358 | 1.000 | | | | | | | | | | | | | |
| Mg | .023 | .217 | .366 | .827 | .565 | .752 | .343 | .488 | 1.000 | | | | | | | | | | | | |
| Mn | .021 | .177 | .202 | .668 | .449 | .603 | .302 | .282 | .685 | 1.000 | | | | | | | | | | | |
| Mo | .052 | .234 | .239 | .142 | .015 | .409 | .263 | .273 | .145 | .097 | 1.000 | | | | | | | | | | |
| Na | .050 | .153 | .618 | .631 | .270 | .609 | .331 | .670 | .760 | .491 | .185 | 1.000 | | | | | | | | | |
| Ni | .030 | .206 | .154 | .803 | .772 | .660 | .264 | .223 | .843 | .630 | .123 | .538 | 1.000 | | | | | | | | |
| Pb | .112 | .054 | .285 | -.024 | -.138 | .179 | .130 | .268 | -.055 | -.039 | .366 | .051 | -.027 | 1.000 | | | | | | | |
| S | .142 | .213 | .276 | .461 | .217 | .661 | .334 | .343 | .565 | .323 | .301 | .495 | .518 | .197 | 1.000 | | | | | | |
| Sb | .045 | .153 | .051 | .381 | .404 | .340 | .206 | .049 | .423 | .340 | .080 | .254 | .455 | -.038 | .284 | 1.000 | | | | | |
| Sr | .082 | .169 | .699 | .514 | .068 | .602 | .368 | .742 | .645 | .403 | .185 | .869 | .395 | .108 | .499 | .213 | 1.000 | | | | |
| Ti | -.020 | .193 | .337 | .559 | .152 | .588 | .361 | .445 | .607 | .512 | .087 | .607 | .416 | -.055 | .289 | .311 | .644 | 1.000 | | | |
| U | .165 | .017 | .528 | -.107 | -.296 | .030 | .199 | .546 | -.079 | -.065 | .173 | .124 | -.180 | .272 | -.024 | -.141 | .219 | -.002 | 1.000 | | |
| W | -.009 | .070 | .059 | .064 | -.008 | .151 | .147 | .089 | .066 | .034 | .219 | .004 | .067 | .185 | .166 | .050 | .076 | .036 | .101 | 1.000 | |
| Zn | .049 | .089 | .358 | .638 | .357 | .590 | .186 | .485 | .651 | .447 | .190 | .585 | .553 | .038 | .410 | .249 | .508 | .477 | .037 | .055 | 1.000 |

northeastern part of the area, lower stream of Sungai Sugut in the central east and southeastern margin of the area. The most significant zones are found in the area of Mamut mine. The sample indicating the maximum value (1,395 ppb) is situated 5 km east of Mamut mine.

Ba : High value samples are found in the area of Trusmadi formation, surroundings of Mt. Kinabalu and northern marginal part of the area where Chert-Spilite (KPCs) formation occurs. Among these area the significant anomalous zone are found along Sungai Liwagu and its tributary in the south of Ranau.

Co : Samples with high and anomalous values are restricted in the area of ultra-basic and basic rocks.

Cr : Samples with high and anomalous values are restricted in the area of ultra-basic and basic rock. The distribution tendency of Cr reflects the distribution of ultra-basic rocks. The sample with the maximum value (59,548 ppm) is found at the upper stream of Sungai Sugut, and indicate close relation ship with ultra-basic rocks.

Cu : The most significant anomalous samples are found in the area of Mamut mine. The sample with the maximum value (3,632 ppm) is also situated in this area. Other than the Mamut mine area, high value samples are found in the northern marginal part of the area where Chert-Spilite formation occurs and the area along Sungai Sugut. The maximum Cu value in the northern marginal part is 88 ppm. This value is not significant. In the lower stream of Sungai Sugut, many samples with more than 100 ppm Cu (maximum 225 ppm) are distributed and form significant anomalous zones.

Hg : High value samples are found from the surroundings of Mamut mine to the area of Trusmadi formation. The maximum value of Hg is 14,767 ppb. This sample is situated in the upper stream of Sungai Kinaram in the northern part of the area.

K : High value samples are found in the area of Trusmadi formation. Some high value samples are also found in the lower stream of Sungai Sugut where high value of Cu samples are distributed.

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

Mn : High value samples are found in the area of ultra-basic and basic rocks and show similar distribution tendencies of Mg.

Mo : A large number of samples indicate the value less than the detection limit. Comparatively high value samples are found in the surroundings of Mamut mine, south of Mamut mine and lower stream of Sungai Sugut.

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

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

Pb : High value samples are mainly found in the surroundings of Mamut mine, the area of Trusmadi formation and lower stream of Sungai Sugut. The sample with maximum value (587 ppm) is found in the middle stream of Sungai Liwagu.

S : High value samples are found in the surroundings of Mamut mine, the area of Trusmadi formation and the area of ultra-basic to basic rocks in northwestern part of the area. As the results of geologic survey, pyrite dissemination was confirmed in the Mamut mine area and primary fine-grained pyrite layer was confirmed in the Trusmadi formation.

Sb : High value samples are mostly found in the area of Chert-Spilite formation except Mamut mine area where high value samples are also distributed.

Sr : High value samples are limitedly found in the area of Trusmadi formation. Some high value samples are also found over the area of Chert-Spilite formation in the northeastern margin of the area.

Ti : High value samples have weak relationship with ultra-basic to basic rocks and Chert-Spilite formation.

U : High value samples are restricted in the area of Trusmadi formation and Pinosuk gravels ($Q_1$), but the values are comparatively low.

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

Zn High value samples are found in the area of Chert-Spilite formation and Trusmadi formation. This distribution tendencies are similar to those of Co, Ni and Ti. A sample with the maximum value (448 ppm) is found in the area of Sungai Mindahuon which is the tributary of Sungai Liwagu.

Judging from the distribution patterns of the anomalous and high value samples, distribution of some elements well corresponds to the geology but distributions of some elements are not related with the geology. The elements including Co, Cr, Mg, Mn, Na, Ni, Sb, Ti and Zn show higher values in the area of the ultra-basic to basic rocks. The elements of As, Ba, K, Pb, S, Sr and U show high concentration in the area of Trusmadi formation. The element including Au, Cu, Hg, Mo and W show no distinct relationship with the geology.

Judging from the distribution pattern of the elements, the elements reflecting the gold and copper mineralization are As, Au, Co, Cu, Hg, S and Zn. Locations of anomalous sample for above-mentioned seven elements are shown in Fig. II-1-4.

(3) Multi elements analysis

Cluster analysis being a method of the multi elements analysis is conducted to clarify the relationship among the elements. Dendrograms of element obtained from the cluster analysis (nearest neighbor method and Ward method) are shown in Fig. II-1-5. In the dendrogram by the Ward method, following groups of elements form clusters;

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

These elements making a group show the similar distribution tendencies as shown

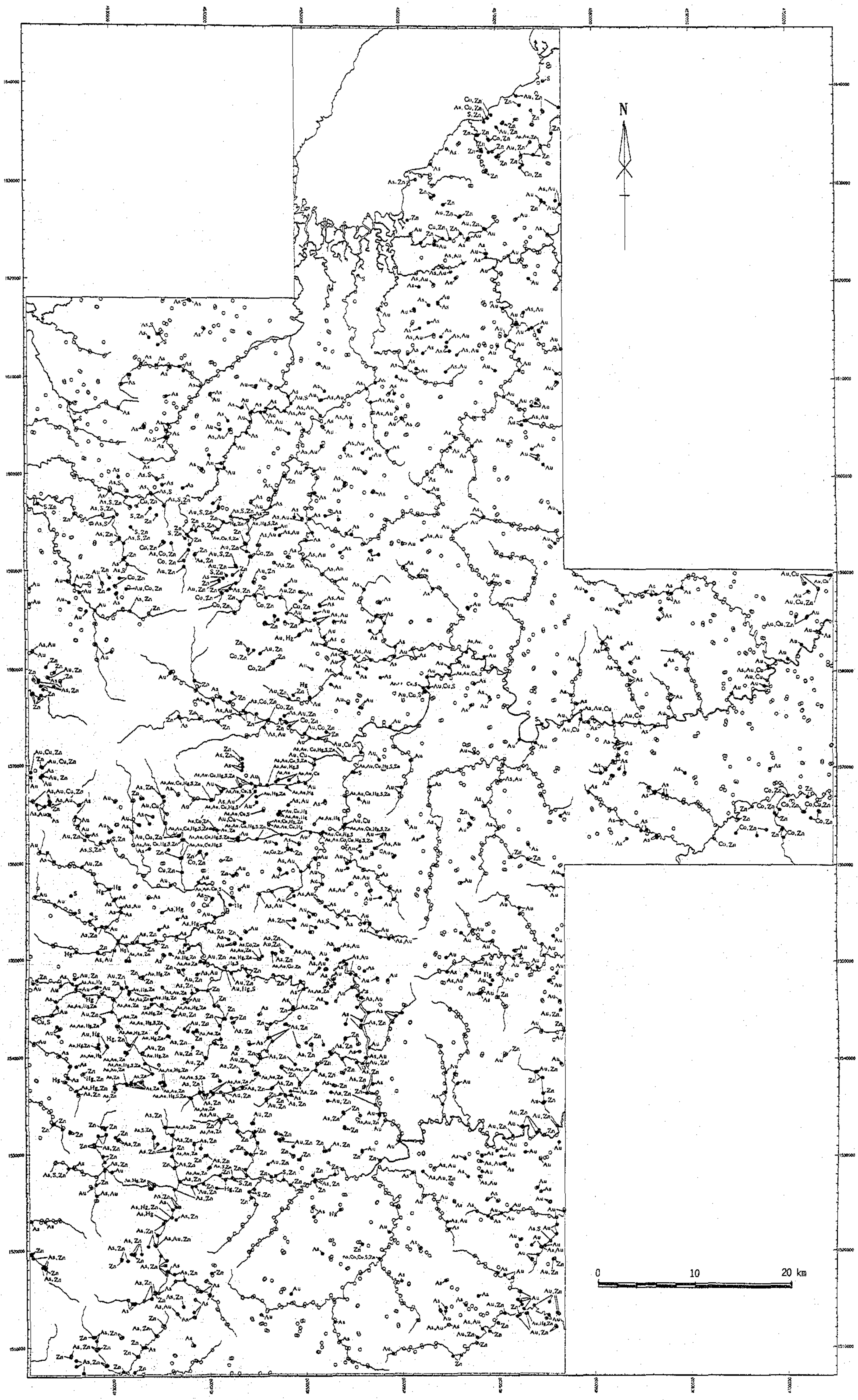
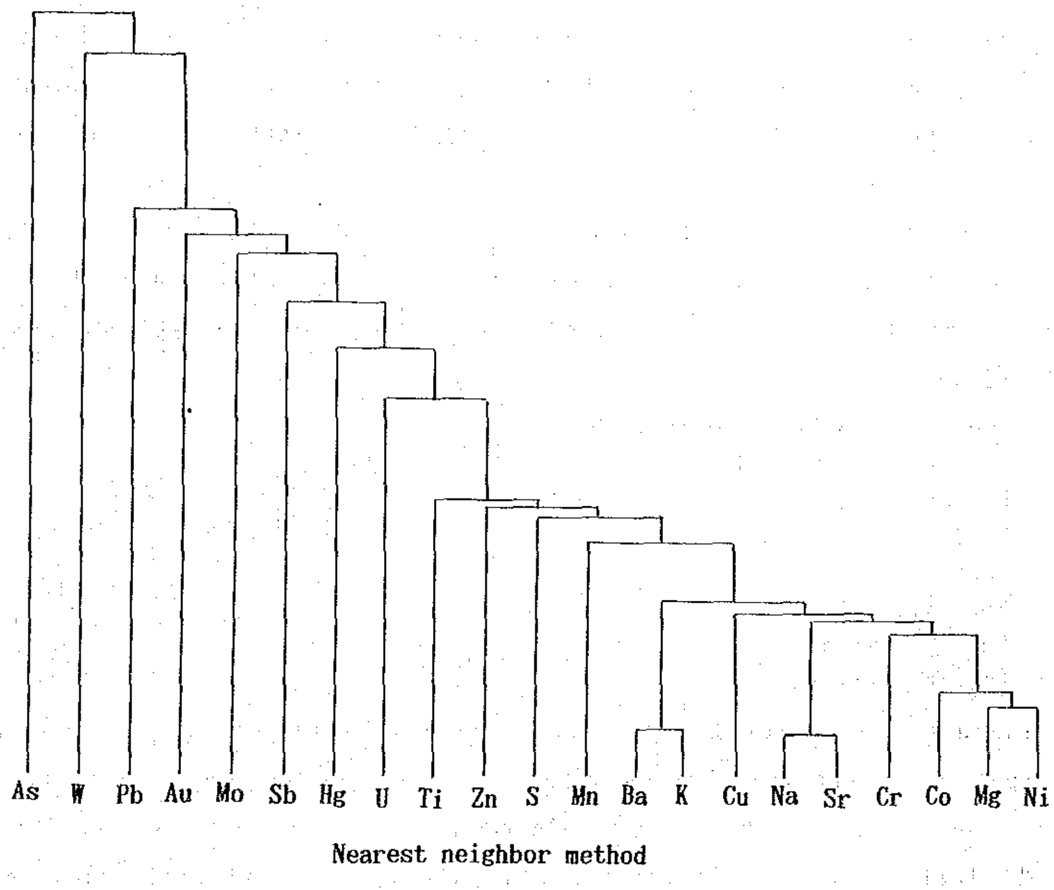



Fig. II-1-4 Distibution map of anomalous stream sediment samples for major elements in Kinabalu area



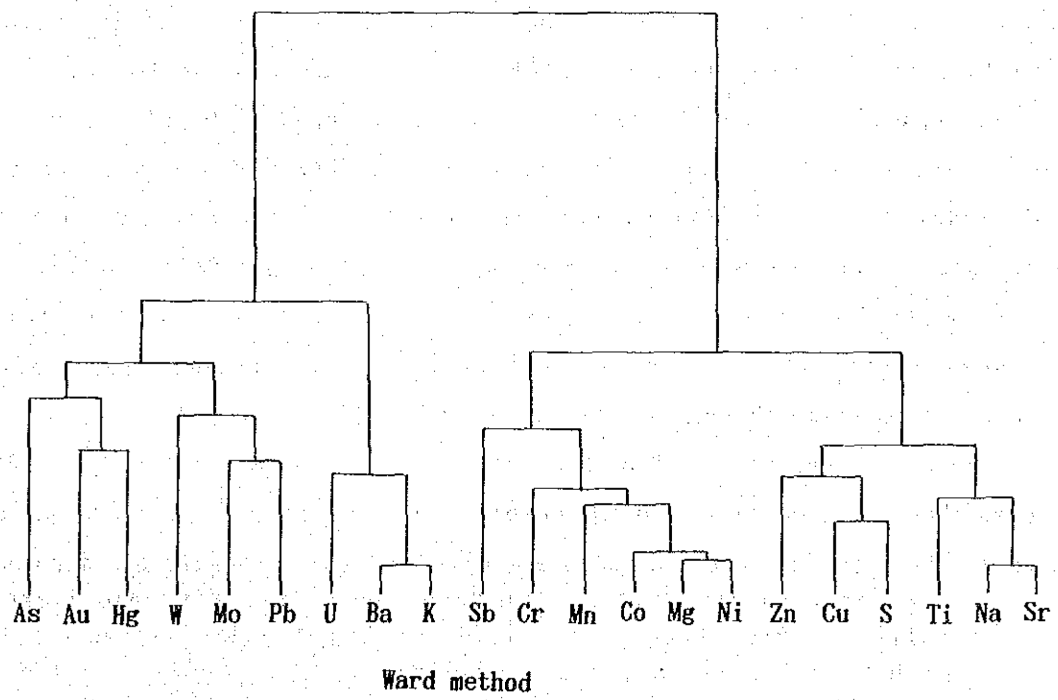




Fig. II-1-5 Dendrogram of elements for stream sediments in Kinabalu area in the distribution maps of each element. Judging from the results of the cluster analysis, the cluster of Sb-Cr-Mn-Co-Mg-Ni and Ti-Na-Sr correspond to the ultra-basic and basic rocks, the cluster of U-Ba-K corresponds to the sedimentary rocks.

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

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

Among these factors, Factor 2, 3 and 4 show negative relationship with above-mentioned elements. The elements indicating ( ) have weak relation with the factor. Judging from the elements related to the factor and distribution of each element, factor 1 have relationship with ultra-basic and basic rocks and weak relationship with copper mineralization. Factor 2 may have relation with Chert-Spilite formation and sedimentary rocks. Factor 3 is interpreted to be related with intrusives. Factor 4 is thought to be weakly related with gold mineralization. Factor 5 related with S has relationship with muddy sedimentary rocks and/or mineralization. Factors 6, 7 and 8 are not clear the relationship. Distribution map of factor scores were prepared using three factors including factor 1, 3 and 4 which may have some relation with mineralization. Distribution map of factor scores presented by three colors are shown in Fig. II-1-6. The relationship between the facter and the color on the map are as following.

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

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

Factor 1 The high factor score zones are distributed in the northern marginal part, southeastern part and the surroundings of Mt. Kinabalu where Chert-Spilite formation and ultra-basic and basic rocks are distributed. The high factor zone in the surroundings of Mt. Kinabalu includes Mamut mine area. Comparatively high score zones are found in the area of Trusmadi formation but no high score zones are confirmed in the area of Crocker formation.

Factor 3 Zones of high factor score (negative factor) are scattered in the

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

| Element | Factor loading (Varimax rotation) | | | | | | | | Commu-nality |
|---|---|---|---|---|---|---|---|---|---|
| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | Factor 7 | Factor 8 | |
| As | -0.009 | -0.092 | -0.036 | -0.086 | 0.031 | 0.000 | 0.012 | 0.400 | 0.1782 |
| Au | 0.135 | -0.024 | -0.112 | -0.593 | 0.034 | 0.027 | 0.039 | 0.099 | 0.3958 |
| Ba | 0.092 | -0.872 | -0.190 | -0.014 | -0.066 | -0.032 | 0.003 | 0.226 | 0.8616 |
| Co | 0.850 | -0.223 | -0.048 | -0.065 | 0.088 | 0.157 | 0.025 | -0.077 | 0.8184 |
| Cr | 0.780 | 0.184 | 0.084 | -0.085 | -0.057 | -0.314 | 0.197 | -0.029 | 0.7974 |
| Cu | 0.624 | -0.299 | -0.306 | -0.374 | 0.251 | 0.222 | -0.018 | 0.100 | 0.8350 |
| Hg | 0.188 | -0.218 | -0.223 | -0.387 | 0.027 | 0.359 | 0.130 | 0.222 | 0.4784 |
| K | 0.195 | -0.859 | -0.227 | -0.046 | -0.034 | 0.125 | -0.126 | 0.184 | 0.8967 |
| Mg | 0.826 | -0.352 | 0.008 | -0.138 | 0.205 | 0.111 | 0.100 | -0.003 | 0.8898 |
| Mn | 0.700 | -0.152 | 0.018 | -0.141 | -0.055 | 0.298 | 0.055 | -0.003 | 0.6283 |
| Mo | 0.090 | -0.133 | -0.574 | -0.261 | 0.063 | -0.034 | -0.066 | 0.016 | 0.4335 |
| Na | 0.496 | -0.714 | 0.030 | -0.132 | 0.282 | 0.036 | 0.080 | -0.071 | 0.8662 |
| Ni | 0.903 | -0.060 | -0.042 | -0.109 | 0.122 | -0.066 | 0.157 | 0.071 | 0.8814 |
| Pb | -0.083 | -0.164 | -0.548 | -0.007 | 0.005 | -0.069 | -0.055 | 0.147 | 0.3637 |
| S | 0.419 | -0.187 | -0.317 | -0.126 | 0.541 | 0.061 | 0.070 | 0.232 | 0.6822 |
| Sb | 0.425 | 0.008 | -0.043 | -0.106 | 0.065 | 0.069 | 0.463 | 0.032 | 0.4177 |
| Sr | 0.313 | -0.792 | -0.041 | -0.140 | 0.312 | 0.166 | 0.125 | -0.038 | 0.8891 |
| Ti | 0.424 | -0.429 | 0.062 | -0.218 | 0.117 | 0.422 | 0.118 | -0.205 | 0.6633 |
| U | -0.211 | -0.490 | -0.257 | 0.025 | -0.315 | 0.046 | -0.091 | 0.305 | 0.5543 |
| W | 0.034 | 0.004 | -0.408 | -0.012 | 0.014 | 0.085 | 0.080 | -0.027 | 0.1827 |
| Zn | 0.628 | -0.364 | -0.103 | 0.022 | 0.147 | 0.065 | -0.163 | -0.049 | 0.5919 |
| FC*1 | 38.7 % | 27.5 % | 9.3 % | 6.7 % | 5.7 % | 5.0 % | 3.1 % | 4.1 % | — |

*1: Factor contribution

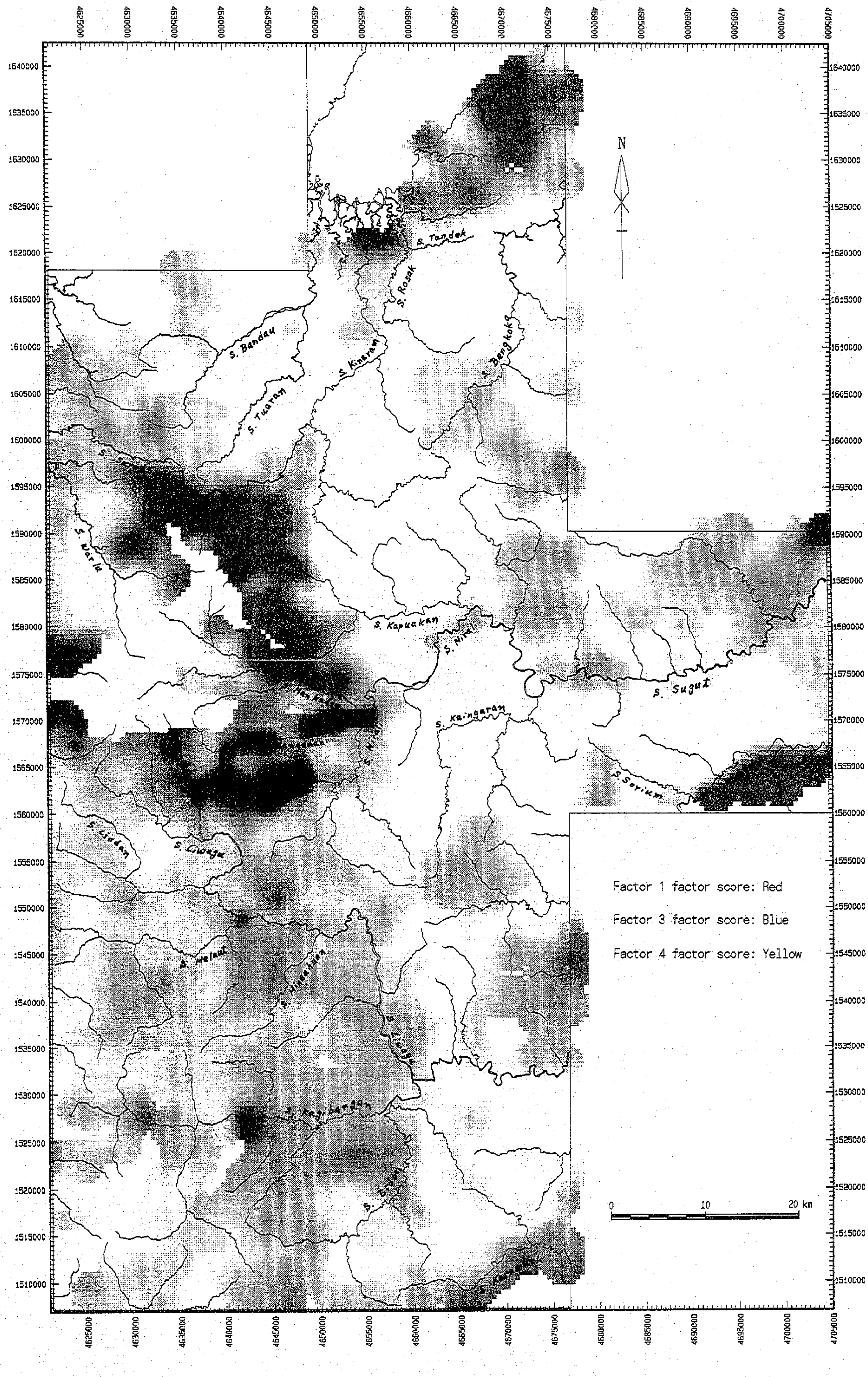



Fig. II-1-6 Distribution map of factor scores for stream sediment samples in Kinabalu area

survey area. Among these high score zone, significant high score zone were confirmed in the area of Mamut mine, the down stream of Sungai Sugut, northen marginal part of the area and the middle stream of Sungai Kagibangan in the south.

Factor 4 The high factor score (negative factor) are found in a area of NE-SW direction centering the Mamut mine and the area of Chert-Spilite formationin the southeastern part of the area.

High factor score zones of these three factors are overlap over the Mamut mine and delineated this ore deposit very clearly. Overlap of these three factors are also found in the middle and lower stream of Sungai Sugut.

### 1-2-4 Pan concentrate survey

#### (1) Sampling

Pan concentrates of 193 samples were collected in this area. Descriptions of the samples are shown in Appendix 4. The maximum weight of the pan concentrate sample is 127 grams. The weight of the samples collected in the area of the sedimentary rocks are extremely light.

#### (2) QME analyses

Results of the qualitative mineral examination (QEM) analyses of pan concentrate samples are shown in Appendix 5. According to the examination, magnetite, chromite, hematite, ilmenite, leucoxene, goethite and pyrite were observed as the main minerals. Small amounts of zircon were also observed. Some pan concentrate samples contain a large amount of pyroxene and hornblende. The samples with a small amount of pan concentrates are mainly composed of quartz and feldspar. Relationship between main minerals and geology is as follows;

Magnetite Magnetite was observed in the most of the samples. Large amount of magnetite was collected in the area of ultrabasic and basic rocks and Chert-Spilite formation.

Chromite Chromite was restricted in the streams where ultra-basic rocks are distributed.

Ilmenite Ilmenite was detected in many samples. But the amount is limited.

Goethite More than half of the samples contains goethite. The samples collected in the area of sedimentary rocks contain more volume of goethite.

Pyrite Small amounts of pyrite were detected in area of sedimentary rocks and Chert-Spilite formation. Significant amounts of pyrite was confirmed in the surroundings of Mamut mine.

1-2-5 Rock geochemical survey

Fifty two representative rock samples were analyzed for 21 elements. The list of samples is shown in Appendix 6. Locations of sample are shown in Fig. II-1-3. Analytical results are shown in Appendix 7.

According to the analytical results, more than 80 % of samples show Au contents less than its detection limit. Relationship between each element and rocks is as follows;

As : The maximum value of 25 ppm is detected in peridotite. High values are detected in the sedimentary rocks such as shale and sandstone.

Au : More than 80 % of samples show the value less than the detection limit. The maximum value of 4 ppb is detected in sandstone. Because of the low value, no significant tendencies are observed.

Ba : Intrusives show the maximum value of 1,620 ppm and have comparatively high values. Ultra-basic rocks are characterized with low contents of Ba.

Co : The maximum value of 119 ppm is detected in peridotite. Basic rock indicate higher value and sedimentary rocks show lower values.

Cr : The maximum value of 1,815 ppm is detected in peridotite. High values are restricted in the ultra-basic rocks.

Cu : The maximum value of 86 ppm is detected in gabbro. Basic rocks and intrusives indicate comparatively high values.

Hg : The maximum value of 2,142 ppb is detected in phyllite. Muddy sediment have comparatively high values.

K : The maximum value of 2.12 % is detected in intrusives. Intrusives and sedimentary rocks indicate comparatively high values. Peridotite show very low contents of K.

Mg : The maximum value of 25.21 % is detected in peridotite. High values are restricted in the ultra-basic rocks.

Mn : The maximum value of 2,471 ppm is detected in sandstone. A distinct relationship between Mn and rocks was not obtained.

Mo : The maximum value is 4 ppm. Because of low contents, a distinct relationship between Mo and rocks was not obtained.

Na : The maximum value of 3.12 % is detected in basalt. Ultra-basic rocks show lower values.

Ni : The maximum value of 3,177 ppm is detected in serpentinite. High values are restricted in the ultra-basic rocks.

Pb : The maximum value of 51 ppm is detected in phyllite. Sedimentary rocks generally indicate higher value.

S : The maximum value of 0.546 % is detected in phyllite. Sedimentary rocks generally indicate high value. Some gabbro sample also indicate higher values.

Sb : The maximum value of 14.7 ppm is detected in gabbro. A distinct relationship between Sb and rocks was not obtained.

Sr : The maximum value of 616 ppm is detected in gabbro. Peridotite indicate low value.

Ti : The maximum value of 1.53 % is detected in gabbro. No clear tendencies are found between the contents and rocks. But, ultra-basic rocks indicate low values.

U : The maximum value of 3.6 ppm is detected in intrusives. High values are detected in intrusives and sedimentary rocks. Ultra-basic rocks indicate low values.

W : The maximum value of 463 ppm is detected in sandstone. High values are generally detected in sandstone.

Zn : The maximum value of 463 ppm is detected in harzburgite. High values are detected in the basic rocks.

Judging from the relationship between elements and rocks, high values of Co, Cr, Mg, Ni and Zn are detected in the ultrabasic rocks. High values of Cu, Ba, K and Ti are detected in the basic rocks and intrusive rocks. The elements including As, Hg, Pb and U have the close relationship with the sedimentary rocks such as sandstone and shale. The relationship between elements and rocks in the area indicates the same characteristics as the general feature obtained in the typical rocks.

1-2-6 Soil geochemical survey

Forty eight soil samples were analyzed for 6 elements of Al, Co, Cr, Fe, Ni and Pt. The samples are collected in the area of the ultra-basic and basic rocks where lateritic soil is developed. All these samples were collected from upper part of B horizon. List and analytical results are shown in Appendix 8. As the results of data treatment for the analytical results, the following statistics were obtained.

| Element | Minimum value | Maximum value |
|---|---|---|
| Al | 1.26 % | 10.83 % |
| Co | 21 ppm | 1,212 ppm |
| Cr | 118 ppm | 13,594 ppm |
| Fe | 4.42 % | 45.78 % |
| Ni | 80 ppm | 10,797 ppm |
| Pt | < 5 ppb | 60 ppb |

The maximum value of Ni (10,797 ppm) shows high value. This sample (N502) was collected 4km northeast of Ranau. This sample also show the maximum value of Co (1,212 ppm). One sample (U554) collected in a north western part of the area show comparatively high value of Ni (7,229 ppm). other samples are less than 5,000 ppm Ni. Samples with high value of Cr are recognized in the northern part of the area. In this area, six samples (H508～H513) show high value of Cr ranging from 7,932 ppm to 13,594 ppm. These sample also indicate high value of Fe ranging from 31.96 % to 45.78 %.

### 1-2-7 Results of laboratorial studies

#### (1) Observation of thin sections

Thin section observation was carried out for four igneous rocks and one green schist samples. Results of the observation are shown in Table II-1-4.

As the results of the observation, the igneous rocks are acidic to intermediate intrusives. These samples were collected near Ranau and Mt. Kinabalu in the central part of the area. The sample of green schist was collected from Trusmadi formation. Observation results indicated that this sample is strongly metamorphosed. Possibly intrusion of granite in Mt. Kinabalu area affected to this metamorphism.

#### (2) Observation of polished sections

One sample (U535) was collected for observation of polished section from mineralized zone. The results of observation are given in Fig. II-1-5. This sample is quartz vein sample collected in the area of Chert-Spilite formation. As the results of the observation pyrite and minor chalcopyrite were confirmed in this section.

#### (3) Ore assaying

Six samples collected in the mineral showings were assayed for the elements of Au, Ag, Cu, Pb, Zn, Mo and S. The assay results are shown in Table II-1-6. The samples consist of two pyrite sample in mudstone and four quartz vein samples. The assay results give no significant values.

## Table II-1-4 Observation results of thin sections collected in Kinabalu area

| Ser. No. | Sample No. | Location Coordinates N | Location Coordinates E | Geologic Units | Rock Name | Texture |
|---|---|---|---|---|---|---|
| 1 | N644 | 1576.76 | 4638.49 | $I_1$ | Dacite Porphyry | Porphyritic |
| 2 | U542 | 1578.28 | 4623.86 | Ub | Greenschist | Cataclastic |
| 3 | U543 | 1577.95 | 4623.00 | $I_1$ | Adamellite | Hypidiomorphic granular |
| 4 | D527 | 1560.80 | 4646.02 | $I_1$ | Dacite porphyry | Porphyritic and intersertal |
| 5 | P515 | 1567.05 | 4659.85 | $I_1$ | Andesite porphyry | Porphyritic |

**Phenocrysts, big minerals**

| Ser. No. | quartz | K-feldspar | plagioclase | biotite | hornblende | garnet |
|---|---|---|---|---|---|---|
| 1 | | ○ | ◯ | ○ | | |
| 2 | | | | | | |
| 3 | ◎ | ◯ | ◯ | ◯ | ◯ | |
| 4 | ◯ | | ◯ | ○ | | ○ |
| 5 | | | ◯ | ○ | ◯ | |

**Groundmass and accessory minerals**

| Ser. No. | quartz | K-feldspar | plagioclase | biotite | hornblende | garnet | sphene | sphene | zircon | apatite | opaque minerals |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ◯ | ◯ | ◎ | ◯ | | | ● | ● | | ● | ● |
| 2 | | | | | | | | | | | |
| 3 | | | | | | | ● | ● | ● | ● | ● |
| 4 | ◯ | ◯ | ◯ | ○ | | ● | | | ● | ● | ● |
| 5 | ○ | | ◎ | ○ | ○ | | | | | | |

**Metamorphic and altered minerals**

| Ser. No. | quartz | plagioclase | epidote | chlorite | prehnite | pumpellyte | sericite | calcite | opaque minerals |
|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | ○ | | | | ● | |
| 2 | ◯ | ◎ | ◯ | ◯ | ○ | ○ | | | ● |
| 3 | | | | | | | ● | | |
| 4 | | | ○ | ◯ | | | ○ | | |
| 5 | | | ○ | ○ | | | | | ● |

◎ :abundant, ◯ :common, ○ :a little, ● :rare.

Table II-1-5 Observation results of polished section collected in Kinabalu area

Kinabalu

| Ser. No. | Sample No. | Coordinates | | Descriptions | Detected mineral | | | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | E | | Chalcopyrite | Bornite | Chalcocite | Pyrite | Sphalerite | Hematite | Limonite/ Goethite | Malachite | Gangue minerals | |
| 1 | U535 | 1623.45 | 4673.12 | Pyrite dissemination | • | | | o | • | | • | | ◎ | Partly weathered |

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

## Table II-1-6 List of ore samples and their assay results in Kinabalu area

| Ser. No. | Sample No. | Coordinates | | Descriptions | Assay results | | | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | N | E | | Au (g/t) | Ag (g/t) | Cu (ppm) | Pb (ppm) | Zn (ppm) | Mo (ppm) | S (%) | |
| 1 | U534 | 1623.90 | 4673.20 | Fine-grained pyrite nodule in shale | < 0.1 | < 0.1 | 12 | 20 | 32 | 17 | 1.71 | |
| 2 | U535 | 1623.45 | 4673.12 | Quartz veinlet in basalt with pyrite disseminations. | < 0.1 | < 0.1 | 148 | 16 | 67 | 17 | 1.56 | |
| 3 | Y623 | 1516.87 | 4636.65 | Quartz vein in sandstone. | < 0.1 | < 0.1 | 5 | 18 | 16 | 12 | 0.03 | |
| 4 | Y625 | 1518.33 | 4631.50 | Quartz vein in phylite. | < 0.1 | < 0.1 | 5 | 20 | 32 | 10 | 0.08 | |
| 5 | P504 | 1534.15 | 4654.60 | Fine-grained pyrite nodule in shale | < 0.1 | < 0.1 | 35 | 179 | 31 | 12 | 25.89 | |
| 6 | N555 | 1518.60 | 4668.22 | Quartz vein in sandstone | < 0.1 | < 0.1 | 8 | 16 | 28 | 12 | 0.06 | |

## 1-3 Survey results of Labuk area

### 1-3-1 Geology and mineralization

Geology of Labuk area consists of ultra-basic rocks (Ub) and sedimentary rocks with basic effusives (KPCs) of Cretaceous to Eocene, sedimentary rocks consisting mainly mudstone (KPSp) of late Cretaceous to late Eocene, and sedimentary rocks after Eocene. During the sampling work, geologic survey was simultaneously carried out. Geologic map (Fig.II-1-7) of this area was prepared using existing data (Y.E. Heng; 1985) and the present survey results.

Ultra-basic rock(Ub) bodies are found in the central part of the area with a direction of N-S. Width of the body is 10 km to 30 km. The ultra-basic rocks consist of serpentinite, serpentinized peridotite and gabbros. These rocks occur with close relationship each other. The Chert-Spilite formation (KPCs) mainly consisting of basaltic pillow lavas occurs in the west side of the ultra-basic rock bodies with a direction of NE-SW. Small bodies of Chert-Spilite formation are also found in the vicinity of the ultra-basic rocks. These two units may form a part of ophiolite. In the southern part of the area, Sapulut formation (KPSp) of late Cretaceous to late Eocene in age is distributed in a direction of WNW-ESE. This formation mainly consists of sandstone, chert and conglomerate.

The eastern part of this area is widely covered with Kulapis formation ($P_2Ks$) of Eocene to Oligocene in age. This formation consists mainly of massive sandstone. Crocker formation ($P_2Cr$) of Eocene to Oligocene in age is distributed over the Kulapis formation in the northern to eastern part of this area. This formation consists of calcareous sandstone with subordinate shale and siltstone and minor pyroclastics and limestone.

Covering the Eocene to Oligocene sedimentary rocks, Labang formation ($P_3Lb$) and Kudut formation ($P_3Kd$) are distributed in this area. The Labang formation occurs in a limited area of the southwestern part of the area and consists of sandstone, shale, mudstone, siltstone and conglomerate. The kudut formation is found at a limited area in the northern part of the area and consists of sandstone, shale, mudstone, siltstone and conglomerate.

In the eastern central part of the area, Garinono formation ($P_4Gr$) of Oligocene to middle Miocene is distributed. This formation contains characteristically slump breccia and consists of mudstone, tuff, sandstone and shale. Comparatively wide area in the southern part is occupied by Tanjong formation ($N_2Tj$) of early to middle Miocene in age. This formation consists of

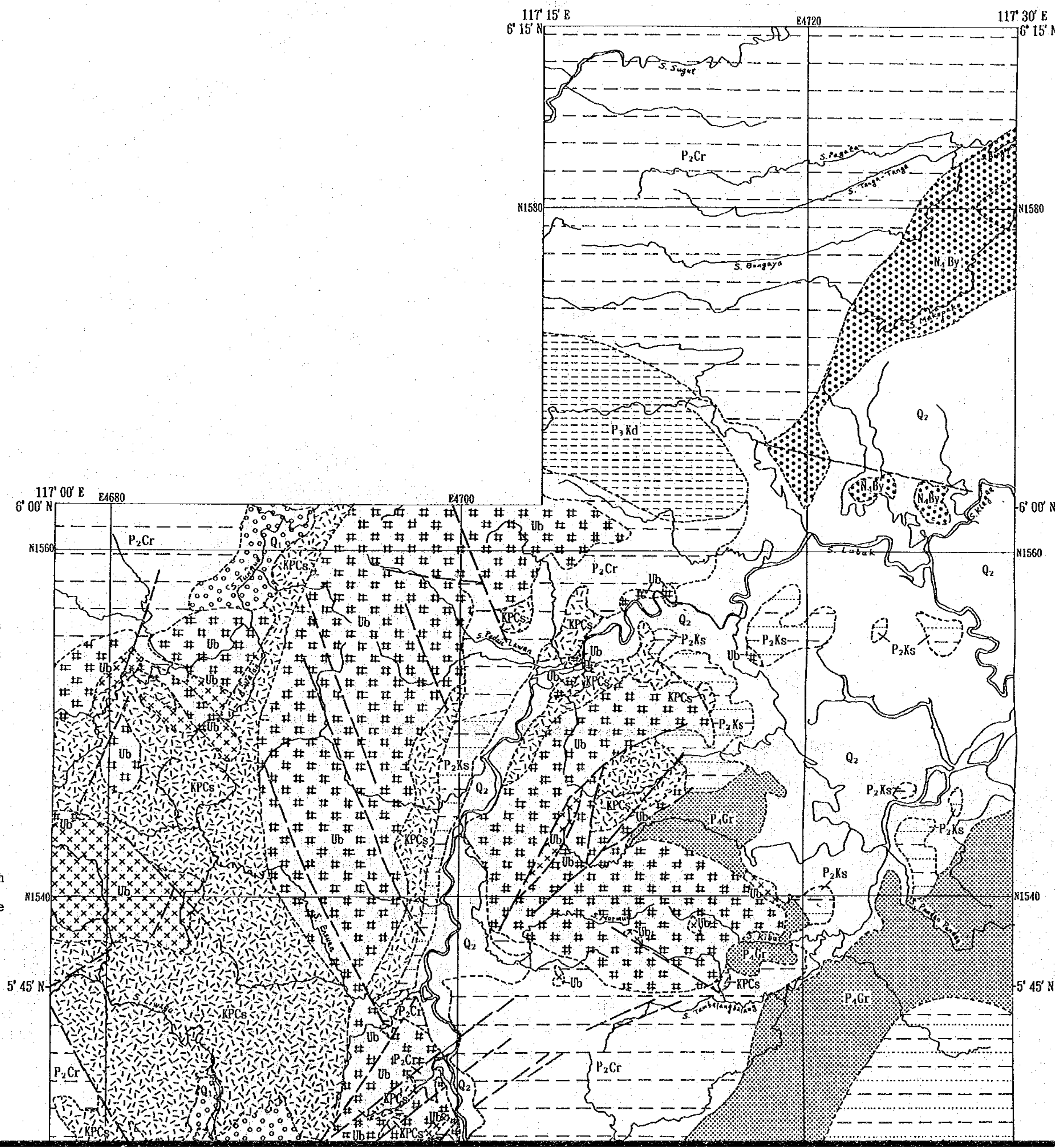
# L E G E N D

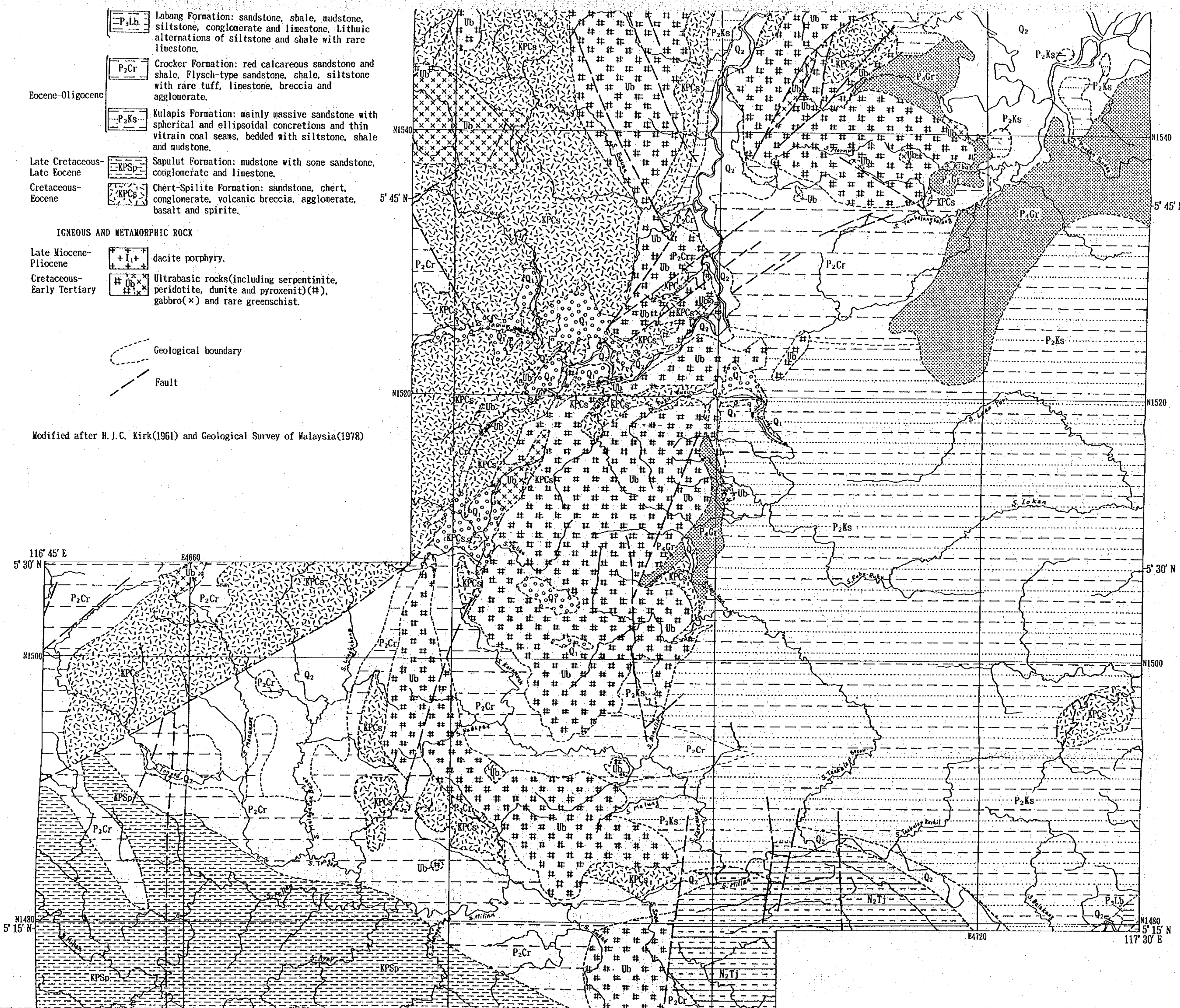
## SEDIMENTARY AND SEDIMENTARY-VOLCANIC ROCKS

| | | |
|---|---|---|
| Recent | $Q_2$ | Coastal and riverine alluvium |
| Pleistocene | $Q_1$ | Terrace sand, gravel and coral |
| Middle Miocene-Pliocene | $N_4By$ | Bongoya Formation: sandstone, mudstone, siltstone, conglomerate and lignite with minor limestone and tuff. |
| Earlj Miocene-Middle Miocene | $N_2Tj$ | Tanjong Formation: mudstone, sandstone, siltstone, conglomerate, minor limestone and lignite. |
| Oligocene-Middle Miocene | $P_4Gr$ | Garinono Formation: slump breccia and sequences of interbedded mudstone, tuff, tuffaceous sandstone, shale, conglomerate with minor chert and limestone. |
| Oligocene | $P_3Kd$ | Kudat Formation: sandstone, shale, mudstone, siltstone, conglomerate and limestone. Lithmic alternations of siltstone and shale with rare limestone. |
| | $P_3Lb.$ | Labang Formation: sandstone, shale, mudstone, siltstone, conglomerate and limestone. Lithmic alternations of siltstone and shale with rare limestone. |
| Eocene-Oligocene | $P_2Cr$ | Crocker Formation: red calcareous sandstone and shale. Flysch-type sandstone, shale, siltstone with rare tuff, limestone, breccia and agglomerate. |
| | $P_2Ks$ | Kulapis Formation: mainly massive sandstone with spherical and ellipsoidal concretions and thin vitrain coal seams, bedded with siltstone, shale and mudstone. |
| Late Cretaceous-Late Eocene | KPSp | Sapulut Formation: mudstone with some sandstone, conglomerate and limestone. |
| Cretaceous-Eocene | KPCs | Chert-Spilite Formation: sandstone, chert, conglomerate, volcanic breccia, agglomerate, basalt and spirite. |

## IGNEOUS AND METAMORPHIC ROCK

| | | |
|---|---|---|
| Late Miocene-Pliocene | $I_1$ | dacite porphyry. |
| Cretaceous-Early Tertiary | Ub | Ultrabasic rocks(including serpentinite, peridotite, dunite and pyroxenit)(#), gabbro(×) and rare greenschist. |





P3Lb
Labang Formation: sandstone, shale, mudstone, siltstone, conglomerate and limestone. Lithmic alternations of siltstone and shale with rare limestone.
P2Cr
Crocker Formation: red calcareous sandstone and shale. Flysch-type sandstone, shale, siltstone with rare tuff, limestone, breccia and agglomerate.
Eocene-Oligocene
P2Ks
Kulapis Formation: mainly massive sandstone with spherical and ellipsoidal concretions and thin vitrain coal seams, bedded with siltstone, shale and mudstone.
Late Cretaceous-Late Eocene
KPSp
Sapulut Formation: mudstone with some sandstone, conglomerate and limestone.
Cretaceous-Eocene
KPCs
Chert-Spilite Formation: sandstone, chert, conglomerate, volcanic breccia, agglomerate, basalt and spirite.
IGNEOUS AND METAMORPHIC ROCK
Late Miocene-Pliocene
I1
dacite porphyry.
Cretaceous-Early Tertiary
Ub
Ultrabasic rocks(including serpentinite, peridotite, dunite and pyroxenit)(#), gabbro(×) and rare greenschist.
Geological boundary
Fault
Modified after H.J.C. Kirk(1961) and Geological Survey of Malaysia(1978)
116° 45′ E
5° 30′ N
5° 45′ N
5° 15′ N
117° 30′ E
N1540
N1520
N1500
N1480
E4660
E4720
Q2
Q1
P4Gr
N2Tj
S. Milian
S. Lokan

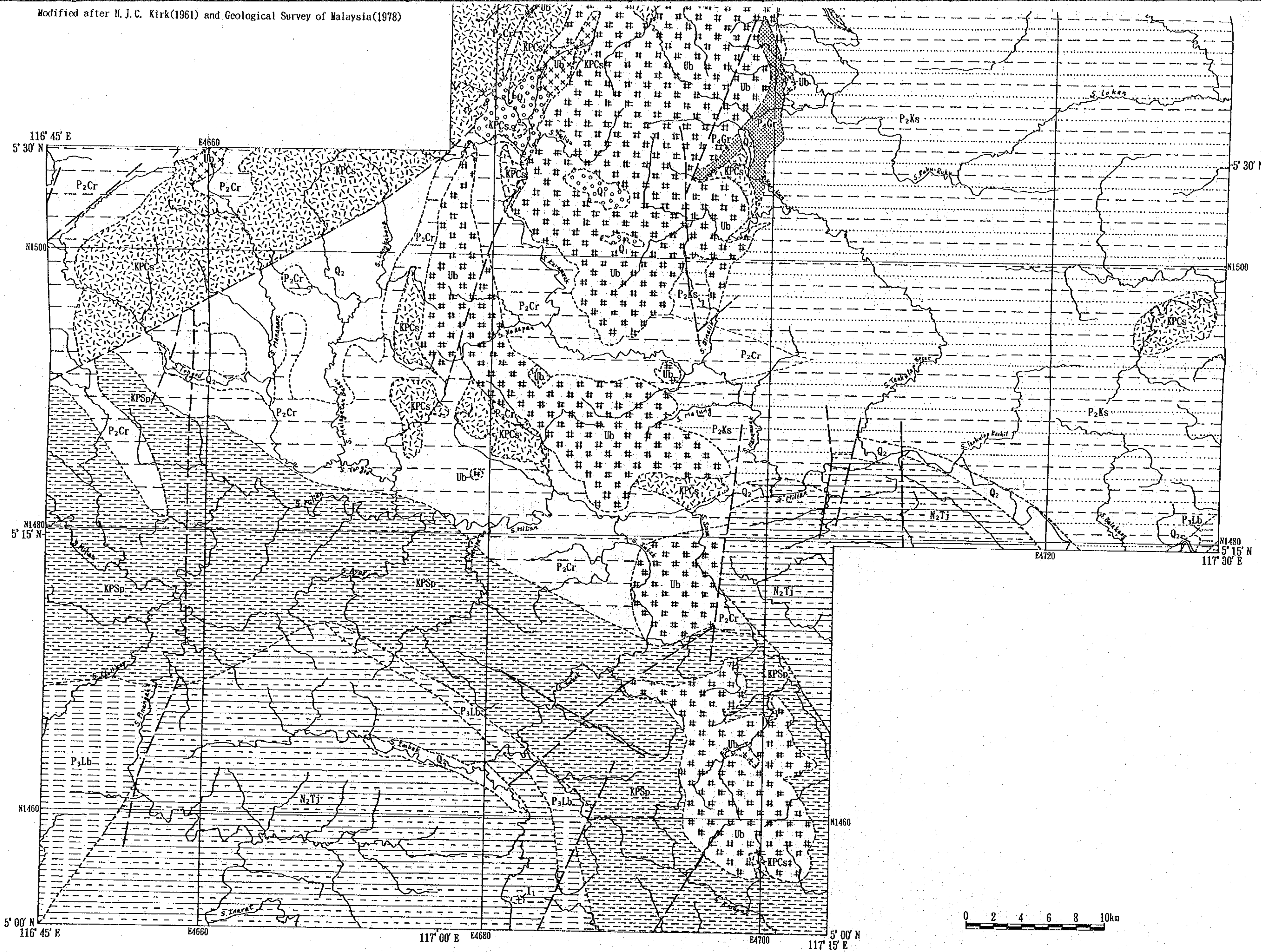



Fig. II-1-7 Geologic map of Labuk area

mudstone, sandstone, siltstone and conglomerate.

A small part at the northeastern margin of the area is occupied by Bongoya formation ($N_4By$) of middle Miocene to Pliocene in age.

Terrace deposits ($Q_1$) of Pleistocene is found in the limited areas along rivers. Alluvium gravels ($Q_2$) are found in the lower stream of Sungai Labuk and along main rivers.

A small andesite porphyry stock is found in the southern marginal part of the area where Tanjong formation occurs.

Geologic structure of this area is characterized by complicated structure in the area of ultra-basic to basic rocks and Chert-Spilite formation. Fault systems of a NE-SE direction are dominated in ths area. Other fault systems are N-S and NNW-SSE systems. The geologic structure of the sedimentary rocks are also complicated in the vicinity of ultra-basic to basic rocks and Chert-Spilite formation. The Tanjong formation situated in the south extend further south and forms basin structure.

Mineralization in this area is represented by Cyprus type copper deposits hosted by Chert-Spilite formation. This type of mineralization is known in Telupid area in many places. The most significant mineralized zone is Bidu Bidu Hill ore deposits situated along Sungai Sualog. This ore deposit is Cyprus type copper deposit and the exploration work is almost completed. Other mineral showings in this area are chromite deposit on the ultra-basic rocks.

### 1-3-2 Sampling

The sampling work was carried out along streams using road network in the central to notheastern part of this area where plantation is distributed. Due to limited road system in the northern and southern parts of this area, camps were established at Telupid, lower sream of Sungai Milian and upper most sream of Sungai Milian and sampling was conducted using these camps. For remote area, sampling was carried out by flighing camp along the streams. Because it was difficult to walk along rivers, boat with engin was used for the survey of the Sungai Sugut, a part of Sungai Labuk, upper and middle stream of Sungai Milian.

At the sampling site of each stream sediment sample, geology nearby, color, grain size, order of stream etc, were described and sample list (Appendix 9) was prepared. The sample location of the stream sediment samples are shown in Fig.II-1-8 and Plate II-1-2.

Pan concentrate samples were collected in the main stream. The sampling site

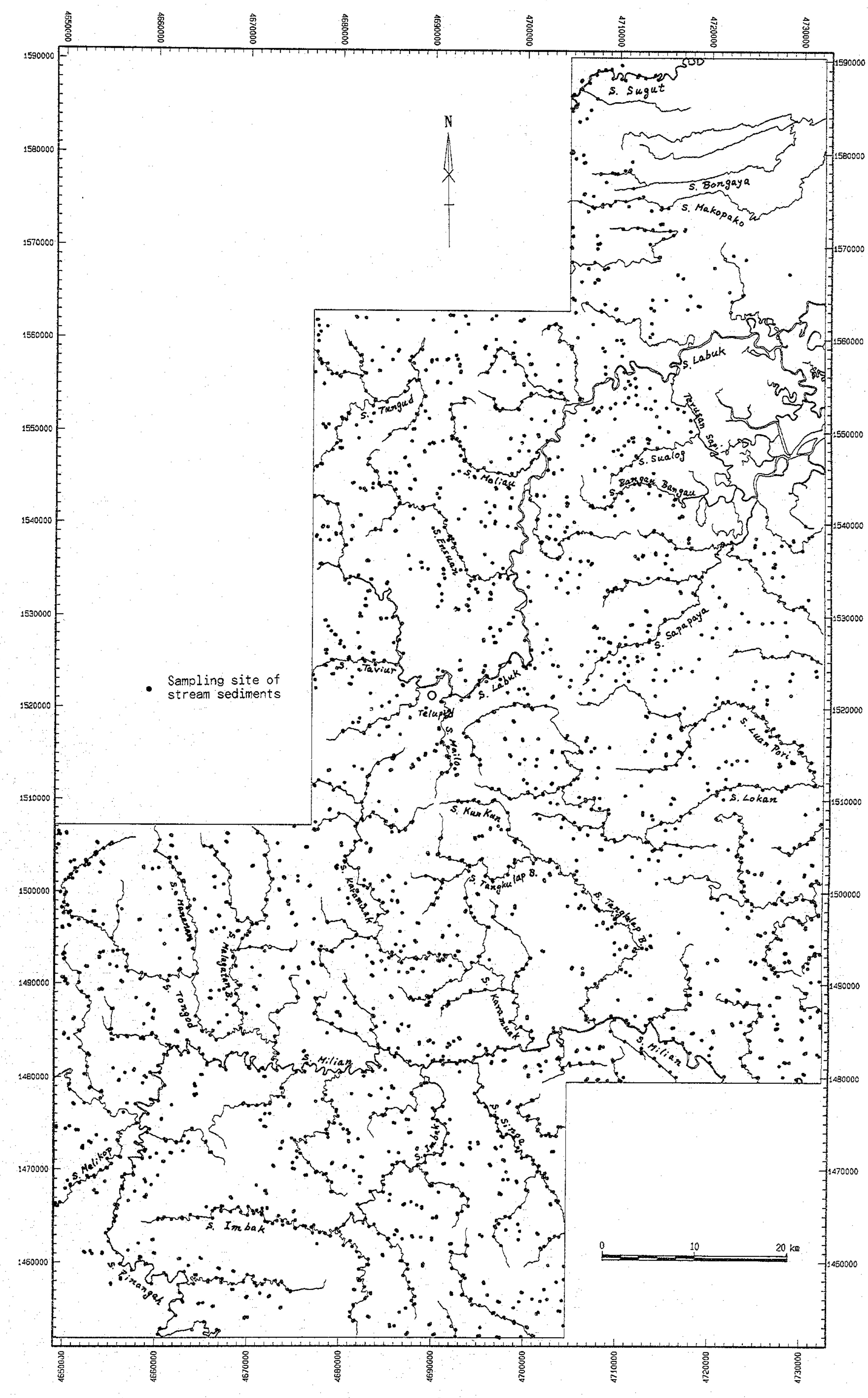



Fig. II-1-8 Location map of stream sediment samples in Labuk area

was described as the same manner of the stream sediment samples and the sample list (Appendix 12) was prepared for each sampling site. The location of the sample points are shown in Fig. II- 1-9.

Rock samples representing the geology of this area were collected. The location of these rock samples are shown in Fig. II-1-9.

Soil samples were collected in the area of ultra-basic rocks where lateritic soil is developed. At the each sampling site, color, grain size, topography etc. were described. The location of these soil samples are shown in Fig. II-1-9.

During the sampling work, a geologic survey was conducted and samples for laboratorial studies were collected. The laboratorial studies includes thin sections, polished sections and ore assaying. The sample locations of these laboratorial studies are shown in Fig. II-1-9.

1-3-3 Stream sediment geochemical survey

List of the stream sediment samples in this survey are shown in Appendix 9 and the analytical results are in Appendix 10.

(1) Pathfinder element

Twenty one elements were analyzed for each sample and the analytical results were statistically treated by computer. Statistics obtained by this data treatment are given in Table II-1-7. As shown in this table, analytical values of Au, Mo and W indicates less than their detection limit for most the samples. The maximum values of Au (6,530 ppb), Cr (117,538 ppm), Hg (24,735 ppb) and Ni (6,778 ppm) indicate comparatively higher values.

Correlation coefficients among the elements were calculated in order to examine the relation between each element. Correlation matrix is shown in Table II-1-8. Among the elements, the following elements indicate good correlation (correlation coefficient; more than 0.600) between them.

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

Among these pair of elements, the elements indicated by (-) have negative correlation (less than -0.600) between them. The elements including Co, Cr, Cu, Mg, Ni and Zn reflecting ultra-basic rocks have good correlation among them. Uranium (U) has characteristically negative correlation with these elements.

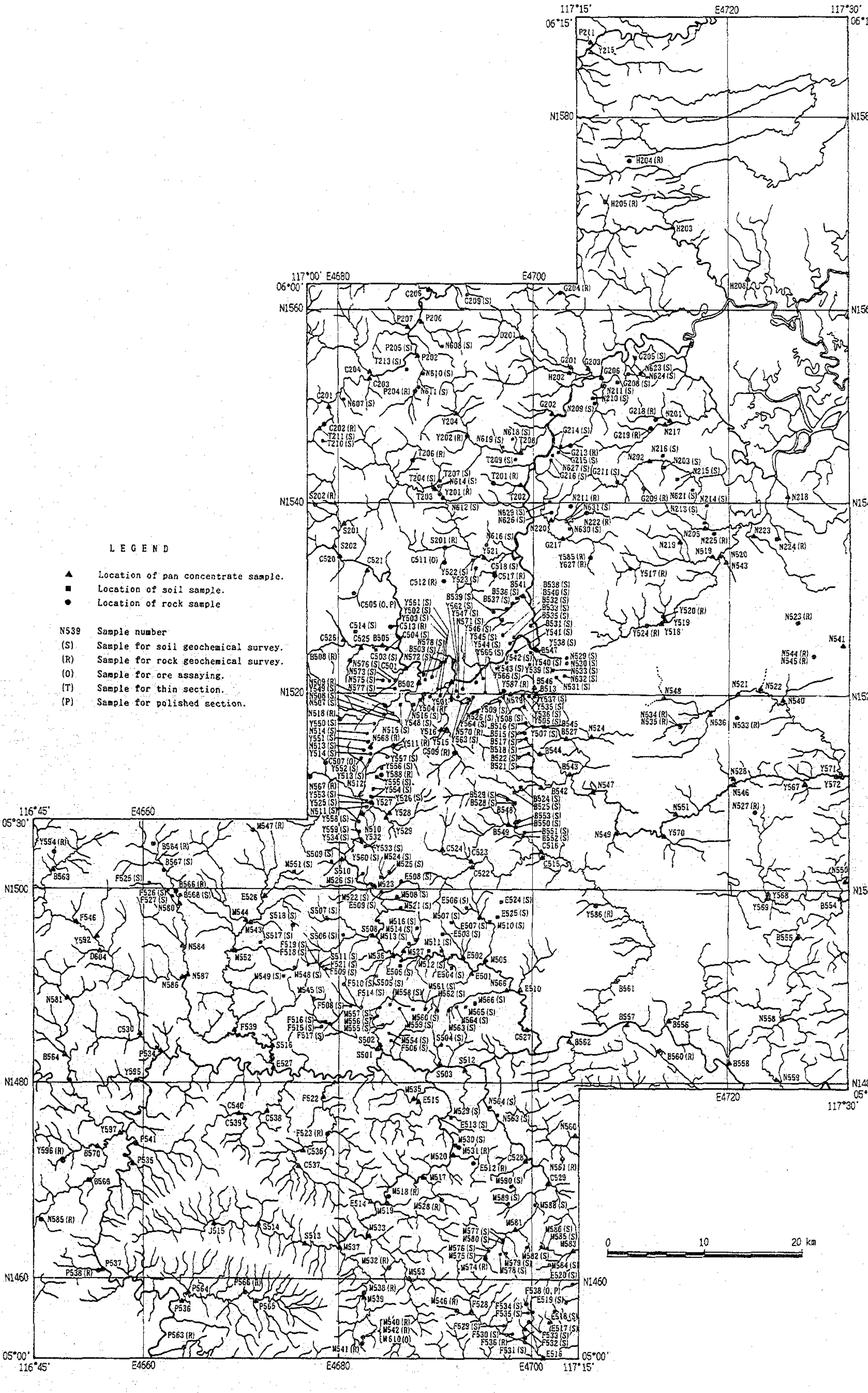



Fig. II-1-9 Location map of samples for geochemical and laboratorial studies in Labuk area

Table II-1-7 Statistics of stream sediment geochemical survey in Labuk area

| Element | Statistics | | | | | | EDA method*3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Below detection limit (%) | Maximum value | Minimum value | Mean*1 value (b) | Standard deviation | b + 2S.D. *2 | Median | Upper Wisker | Upper Fence |
| As (ppm) | 55.0 | 929 | < 1 | 1.7 | 0.632 | 30.9 | 0.5 | 10.0 | 366.7 |
| Au (ppb) | 75.5 | 6,530 | < 1 | 0.9 | 0.562 | 12.0 | 0.5 | 2.0 | 0.5 |
| Ba (ppm) | 6.7 | 1,137 | < 2 | 43.2 | 0.439 | 326.0 | 53.0 | 91.0 | 378.1 |
| Co (ppm) | 7.7 | 1,088 | < 1 | 11.6 | 0.789 | 440.6 | 8.0 | 88.0 | — |
| Cr (ppm) | — | 117,538 | 51 | 739.8 | 0.783 | 27,270.7 | 343.0 | 5,995.0 | 97,138.7 |
| Cu (ppm) | 0.2 | 608 | < 1 | 11.6 | 0.357 | 60.0 | 9.0 | 24.0 | 121.7 |
| Hg (ppb) | 30.7 | 24,735 | < 10 | 17.4 | 0.496 | 170.2 | 15.0 | 47.0 | 602.9 |
| K (%) | 4.1 | 1.96 | < 0.01 | 0.150 | 0.536 | 1.775 | 0.190 | 0.390 | — |
| Mg (%) | 2.0 | 21.00 | < 0.01 | 0.434 | 0.857 | 22.422 | 0.320 | 3.620 | — |
| Mn (ppm) | 15.2 | 13,316 | < 5 | 128.3 | 1.008 | 13,289.7 | 142.5 | 1,499.0 | — |
| Mo (ppm) | 82.9 | 10 | < 1 | 0.6 | 0.183 | 1.4 | 0.5 | 0.5 | 0.5 |
| Na (%) | 1.7 | 2.89 | < 0.01 | 0.098 | 0.523 | 1.091 | 0.090 | 0.300 | 2.838 |
| Ni (ppm) | — | 6,778 | 5 | 79.2 | 0.800 | 3,152.9 | 39.0 | 872.0 | — |
| Pb (ppm) | 49.0 | 558 | < 2 | 2.6 | 0.442 | 19.6 | 2.0 | 8.0 | 88.2 |
| S (%) | — | 1.357 | 0.005 | 0.022 | 0.282 | 0.079 | 0.021 | 0.035 | 0.102 |
| Sb (ppm) | 10.3 | 772.6 | < 0.2 | 4.29 | 0.861 | 226.23 | 4.10 | 22.20 | 355.92 |
| Sr (ppm) | 3.6 | 121 | < 1 | 14.4 | 0.430 | 104.2 | 16.0 | 30.0 | 109.0 |
| Ti (%) | — | 14.04 | 0.01 | 0.227 | 0.448 | 1.788 | 0.170 | 0.450 | 1.142 |
| U (ppm) | 11.9 | 7.2 | < 0.2 | 0.83 | 0.439 | 6.29 | 1.20 | 1.80 | 6.97 |
| W (ppm) | 93.1 | 112 | < 2 | 1.1 | 0.130 | 2.0 | 1.0 | 1.0 | 1.0 |
| Zn (ppm) | 8.1 | 747 | < 1 | 25.9 | 0.748 | 811.5 | 25.0 | 139.0 | — |

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

## Table II-1-8 Coorelation matrix of elements for stream sediments in Labuk area

| | As | Au | Ba | Co | Cr | Cu | Hg | K | Mg | Mn | Mo | Na | Ni | Pb | S | Sb | Sr | Ti | U | W | Zn |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| As | 1.000 | | | | | | | | | | | | | | | | | | | | |
| Au | -.012 | 1.000 | | | | | | | | | | | | | | | | | | | |
| Ba | .099 | .103 | 1.000 | | | | | | | | | | | | | | | | | | |
| Co | -.084 | -.011 | -.478 | 1.000 | | | | | | | | | | | | | | | | | |
| Cr | -.045 | .009 | -.594 | .821 | 1.000 | | | | | | | | | | | | | | | | |
| Cu | -.064 | .094 | -.111 | .675 | .454 | 1.000 | | | | | | | | | | | | | | | |
| Hg | .063 | .143 | -.008 | .333 | .223 | .436 | 1.000 | | | | | | | | | | | | | | |
| K | .061 | .064 | .855 | -.457 | -.631 | -.055 | .037 | 1.000 | | | | | | | | | | | | | |
| Mg | -.103 | -.018 | -.412 | .882 | .741 | .665 | .324 | -.357 | 1.000 | | | | | | | | | | | | |
| Mn | -.155 | -.013 | -.394 | .825 | .677 | .625 | .279 | -.387 | .788 | 1.000 | | | | | | | | | | | |
| Mo | .072 | .027 | .087 | -.060 | -.062 | .038 | .121 | .110 | -.087 | -.057 | 1.000 | | | | | | | | | | |
| Na | -.171 | .018 | .178 | .342 | -.001 | .468 | .213 | .328 | .419 | .393 | -.007 | 1.000 | | | | | | | | | |
| Ni | -.030 | .004 | -.524 | .904 | .915 | .605 | .311 | -.539 | .871 | .759 | -.078 | .147 | 1.000 | | | | | | | | |
| Pb | .150 | .054 | .426 | -.464 | -.442 | -.292 | -.206 | .401 | -.462 | -.424 | .143 | -.150 | -.454 | 1.000 | | | | | | | |
| S | -.032 | -.117 | -.039 | .359 | .117 | .466 | .180 | .073 | .409 | .234 | .056 | .521 | .260 | -.092 | 1.000 | | | | | | |
| Sb | -.016 | .003 | -.454 | .752 | .753 | .516 | .308 | -.455 | .671 | .675 | .032 | .175 | .739 | -.395 | .235 | 1.000 | | | | | |
| Sr | -.135 | .037 | .602 | -.269 | -.540 | .081 | .025 | .740 | -.183 | -.154 | .040 | .682 | -.429 | .192 | .277 | -.294 | 1.000 | | | | |
| Ti | -.304 | .011 | -.057 | .331 | .096 | .430 | .181 | .063 | .322 | .444 | -.029 | .649 | .160 | -.251 | .327 | .318 | .513 | 1.000 | | | |
| U | .145 | .082 | .681 | -.740 | -.697 | -.498 | -.148 | .696 | -.718 | -.672 | .084 | -.171 | -.729 | .509 | -.265 | -.613 | .404 | -.252 | 1.000 | | |
| W | .017 | .075 | .077 | -.077 | -.066 | -.047 | .076 | .091 | -.055 | -.065 | .122 | .028 | -.061 | .101 | -.013 | -.029 | .078 | -.019 | .100 | 1.000 | |
| Zn | -.079 | .020 | -.374 | .807 | .720 | .627 | .156 | -.335 | .808 | .704 | -.041 | .382 | .778 | -.347 | .372 | .638 | -.167 | .321 | -.652 | -.042 | 1.000 |

(2) Single element analysis

Based on the results of statistic data treatment, distribution map of each element was prepared using four ranks mentioned in the palagraph of 1-1-3. Threshold value of each element was delineated using EDA method which is the same method applied to Kinabalu area. Results of the EDA method are shown in Table II-1-8. The distribution maps of each element are shown in Appendix 11. The distribution of high value sample (more than background value plus standard deviation) and anomalous sample (more than threshold value) for each element is summarized as follow;

As : High value samples are found at the central and southern parts of the area. Significant high value samples are found in the surroundings of Telupid and the tributary of Sungai Imbak. Among thes samples, anomalous samples are found in the tributary of Sungai Imbak. These anomalous samples are surrounded by low value (less than 1ppm) samples.

Au : High value samples are found in the Sungai Sugut area, Bidu Bidu Hill deposit area, west of Telupid, eastern part of the area, Sungai Tangkulap Besar area, tributary of Sungai Karamuak and tributary of Sungai Imbak. The most significant anomalous zone was found in the tributary of Sungai Imbak where six samples with more than 1,000 ppb (maximum value 6,530 ppb) are confirmed. Another anomalous zone is situated at the middle stream of Sungai Imbak where three samples with more tha 1,000 ppb (maximum value 2,900 ppb) were confirmed. In the middle stream of Sungai Karamuak, the samples with more than 100 ppb (maximum value 881 ppb) are concentrated. Other anomalous zones are small in scale and the sample contains less than 200 ppb Au.

Ba : High value samples are distributed in Sungai Sugut at the north, northwest of Telupid, middle stream of Sungai Karamuak at the south and upper stream of Sungai Milian. Among these areas, anomalous samples (more than 378 ppm) are found in these three areas excluding Sungai Sugut area. These three areas are situated in the area of pre-Eocene sedimentary rocks.

Co : High value and anomalous samples are distributed in the area of ultra-basic and basic rocks. The sample with the maximum value (1,088 ppm) are situated in the southwest of Telupid.

Cr : High value and anomalous samples are well correspond to the distribution of ultra-basic and basic rocks. The sample with the maximum value (117, 538 ppm) is situated at upper stream of Sungai Mailo, south of Telupid. The samples collected in this stream also indicate high values. Other anomalous zones are distributed in upper stream of sungai Karamuak and middle stream of Sungai Labuk near Bidu Bidu Hill ore deposits.

Cu : High value samples are found in the areas of Sungai Sugut at northern marginal part, Bidu Bidu Hill ore deposits and Sungai Karamuak at the south. Generally, the high value samples are distributed in the area of Chert-spilite formation. Amomalous samples are found in Sungai Sugut (maximum value; 212 ppm), Bidu Bidu Hill ore deposit area (maximum value; 516 ppm), middle stream of Sungai Karamuak (maximum value; 580 ppm) and the area between Sungai Karamuak and Sungai Milian (maximum value; 608 ppm).

Hg : High value and anomalous samples are distributed in Sungai Sugut, surroundings of Telupid, Sungai Karamuak, Sungai Imbak, eastern part of the area. Among these areas, the significant anomalous zone is confirmed in the area of Sungai Imbak where five samples with more than 5,000 ppb are distributed. The maximum value in this anomalous zone is 24,735 ppb and this anomalous zone corresponds to the anomalous zone of Au.

K : High value samples are found in the area of sedimentary rocks. Conspicuous high value zones are found in the Sungai Sugut and Sungai Imbak.

Mg : High value samples are well correspond to the distribution of ultra-basic rocks. High value samples are also confirmed in the area of Chert-Spilite formation in the west. This area may have some distribution of ultra-basic rocks.

Mn : High value and anomalous samples are restricted in the areas of ultra-basic and basic rocks and Chert-Spilite formation. The sample with the maximum value of 13,316 ppm is confirmed in the tributary of Sungai Labuk.

Mo : Most of the sample (82.9 %) indicates the value less than the detection limit. The maximum value (10 ppm) is also low and comparatively high value samplers are scattered.

Na : High value samples are distributed in the area of Chert-Spilite formation ar the northern part and in the area of ultra-basic and basic rocks in the southern part.

Ni : High and anomalous samples are concentrated in the area of ultra-basic rocks and show similar distribution tendency of Cr.

Pb : High value samples are relatively concentrated in the southwestern and eastern parts of the area. The sample with the maximum value (558 ppm) is found at Sungai Labuk but this sample is isolated. At the tributary of Sungai Imbak, anomalous zone (maximum value; 227 ppm) are found in the anomalous zone of Au and Hg.

S : High value samples are concentrated in the western and southern marginal parts of the area. The western part is the area of Chert-Spilite formation, and the southern marginal part is the area of Tanjong formation. The most significant anomalous zone is situated in the tributary of Sungai Imbak where anomalous zones of Au, Hg and Pb are distributed.

Sb : High value samples are found in the Sungai Labuk at the north and Telupid at the central part. Ultra-basic and besic rocks are distributed in these areas. The sample with the maximum value (772.6 ppm) is confirmed in Sungai Telupid. South of this sampling site is the most significant anomalous zone.

Sr : High value samples are found in the area of Chert-Spilite formation at the west and Tanjong formation at the south. Anomalous samples are scattered and no significant anomalous zones were confirmed.

Ti : High value samples are well correspond to the distribution of Chert-Spilite formation and show similar distribution tendencies of Na. The values are low for the samples collected in the sedimentary rocks.

U : High value samples are scattered in the southeastern part of the area where sedimentary rocks are distributed. Anomalous samples are also scattered and no significant anomalous zones are confirmed.

W : High value samples are scattered in the entire area. The sample with high values (95 ppm and 112 ppm) are found in the tributary of Sungai Imbak where anomalous zone of Au was confirmed.

Zn : Distribution tendency of high value samples are similar to that of Co. The high value samples are well correspond to the distribution of ultra-basic and basic rocks. The sample with the maximum value (747 ppm) are situated at the south of Telupid.

Judging from the distribution tendencies of the elements, the elements are classified into two groups. One is closely related with geology and the other is related with mineralization in this area. Seven elements including As, Au, Cu, Hg, Pb, S and Zn are thought to have relationship with mineralization. Distribution of anomalous samples for these seven elements are shown in Fig. II-1-10.

(3) Multi element analysis

In order to clarify the relationship among the pathfinder elements, cluster analysis was made in this survey. Dendrogram calculated is shown in Fig. II-1-11. As shown in this figure, the analysis by the Ward method delineated the clusters more clearly. This results show that the following groups of element form cluster.

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

These related elements each other show similar distribution tendencies.

In addition to the cluster analyses, factor analyses of varimax rotation method were applied in this survey. Results of the factor analyses are shown in Table II-1-9. Six factors are deliniated in this survey. The elements which have close relationship with these factors are as follows:

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

Among these factors, factor 1, 3 and 4 have negative relationship with these elements. The elements in ( ) indicate comparatively weak relationship with the factor. Judging from the relationship between the factor and the related elements, the factor 1 has relation with ultra-basic rocks and weak relation with copper mineralization. The factor 2 may relate to sedimentary rocks and Chert-Spilite

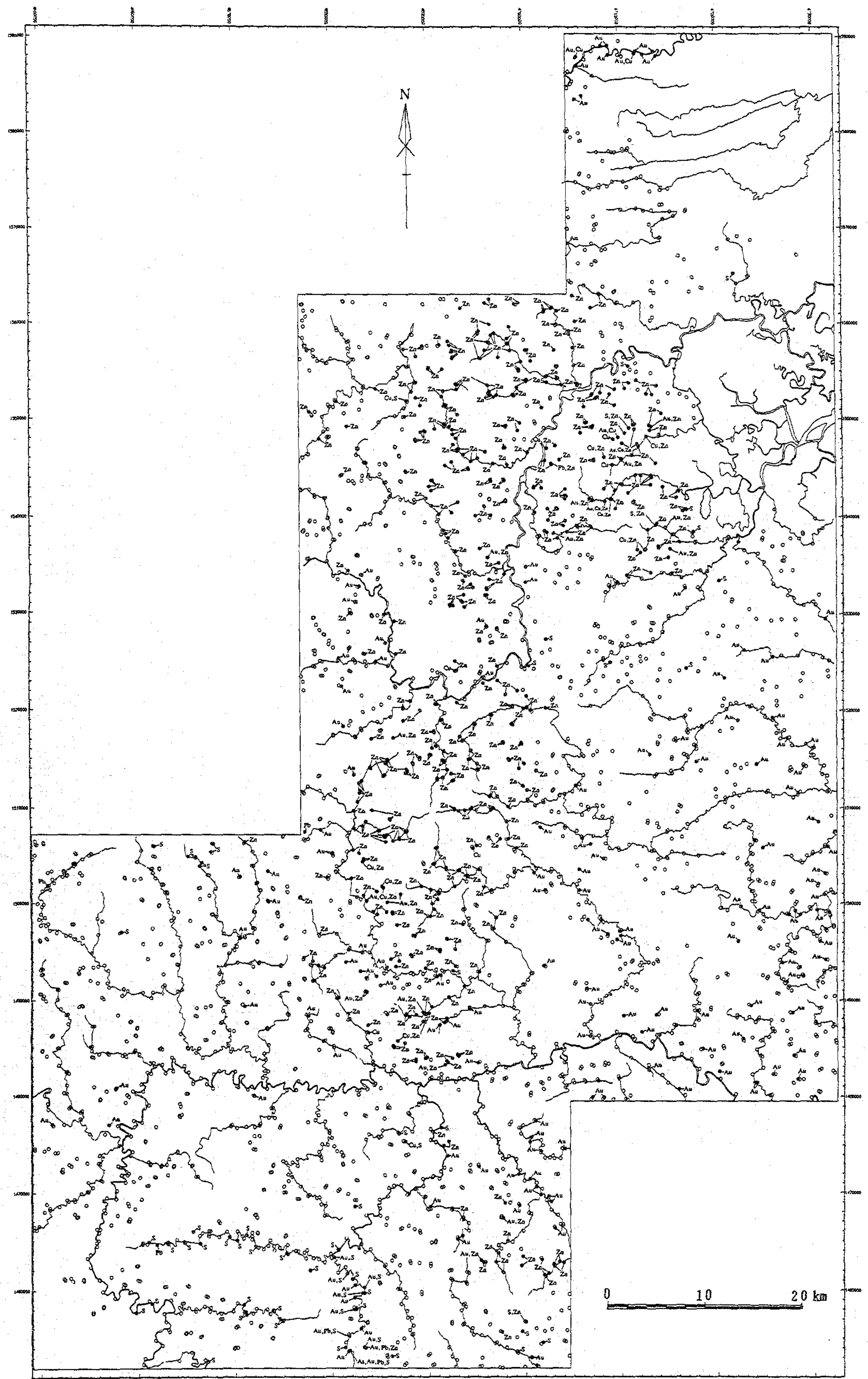
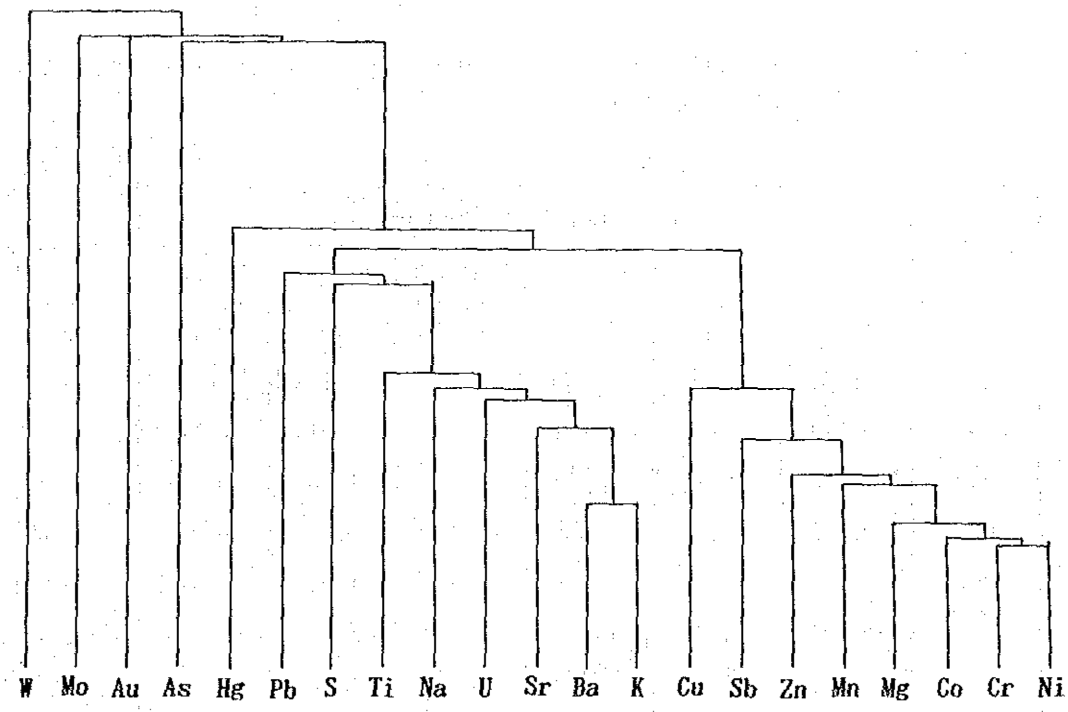
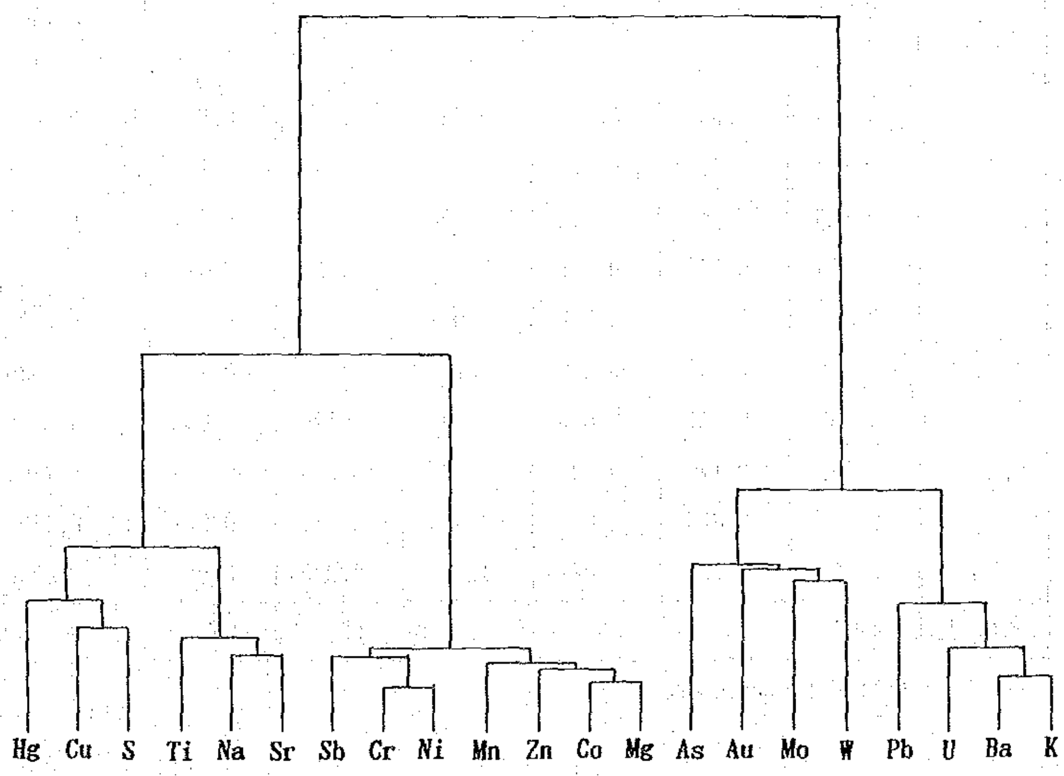



Fig. II-1-10 Distibution map of anomalous stream sediment samples for major elements in the Labuk area




Nearest neighbor method




Ward method

Fig. II-1-11 Dendrogram of elements for stream sediments in Labuk area

Table II-1-9 Results of factor analyses for stream sediments in Labuk area

| Element | Factor loading (Varimax rotation) | | | | | | Communality |
|---|---|---|---|---|---|---|---|
| | Factor 1 | Factor 2 | Factor 3 | Factor 4 | Factor 5 | Factor 6 | |
| As | 0.027 | -0.440 | -0.082 | 0.075 | 0.076 | -0.153 | 0.2359 |
| Au | -0.041 | 0.021 | -0.103 | -0.253 | 0.108 | -0.142 | 0.1087 |
| Ba | 0.314 | -0.035 | -0.851 | -0.108 | 0.019 | -0.113 | 0.8493 |
| Co | -0.903 | 0.108 | 0.201 | 0.099 | 0.168 | 0.089 | 0.9128 |
| Cr | -0.836 | -0.099 | 0.400 | -0.144 | 0.026 | 0.075 | 0.8959 |
| Cu | -0.677 | 0.200 | -0.116 | 0.188 | 0.349 | -0.077 | 0.6749 |
| Hg | -0.291 | 0.017 | -0.063 | -0.043 | 0.578 | -0.210 | 0.4692 |
| K | 0.324 | 0.092 | -0.863 | 0.038 | 0.067 | -0.155 | 0.8874 |
| Mg | -0.875 | 0.117 | 0.100 | 0.181 | 0.176 | 0.171 | 0.8836 |
| Mn | -0.796 | 0.309 | 0.165 | -0.040 | 0.121 | 0.087 | 0.7801 |
| Mo | 0.025 | -0.061 | -0.036 | 0.036 | 0.062 | -0.376 | 0.1521 |
| Na | -0.319 | 0.599 | -0.400 | 0.348 | 0.152 | -0.029 | 0.7658 |
| Ni | -0.907 | -0.083 | 0.265 | 0.000 | 0.143 | 0.121 | 0.9339 |
| Pb | 0.330 | -0.212 | -0.339 | 0.003 | -0.327 | -0.337 | 0.4893 |
| S | -0.326 | 0.182 | -0.145 | 0.601 | 0.128 | -0.095 | 0.5468 |
| Sb | -0.737 | 0.108 | 0.312 | -0.032 | 0.156 | -0.152 | 0.7006 |
| Sr | 0.236 | 0.562 | -0.645 | 0.218 | 0.063 | -0.119 | 0.8525 |
| Ti | -0.259 | 0.761 | -0.080 | 0.131 | 0.145 | -0.049 | 0.6938 |
| U | 0.641 | -0.145 | -0.521 | -0.189 | -0.085 | -0.174 | 0.7763 |
| W | 0.038 | 0.010 | -0.047 | -0.055 | 0.014 | -0.271 | 0.0801 |
| Zn | -0.864 | 0.131 | 0.077 | 0.161 | -0.080 | 0.043 | 0.8029 |
| F.C.*1 | 49.1 % | 13.1 % | 21.6 % | 5.9 % | 5.8 % | 4.5 % | — |

*1: Factor contribution

formation. Factor 3 may relate to sedimentary rocks and the factor 4 possibly indicates gold mineralization. Factor 5 have some relation with alteration. Factor 6 shows no clear relationship. Consequently, factor 1, 4 and 5 have some relationship with mineralization. Using these factors, distribution map of the factor scores was prepared (Fig. II-1-12). On this map three different colors are given to each facter. The relationship between the color and the facter are as following;

Factor 1 : red, Factor 4 : blue, Factor 5 : yellow

Distribution of these factor scores are summarized as follows:

Factor 1 : High factor score zones are distributed in the Bidu Bidu Hill deposit area, west of the Bidu Bidu Hill ore deposits, Telupid area and west of Sungai Imbak. These areas are occupied by ultra-basic to basic rocks. Because this facter is strongly related to the geology, the relationship between the high factor score zone and copper mineralization are not clear.

Factor 4 : Distribution of high factor score (negative figure) zones correspond to the distribution of Au. The high factor score zones are found in the areas of Sungai Sugut, upper stream of Sungai Labuk, eastern part and the area from Sungai Milian to Sungai Imbak.

Factor 5 Distribution of high factor score zone correspond to the distribution of Kulapis formation. But the distribution tendencies are different to the distribution of Hg.

The results show that the factor 4 delineates gold mineralization.

### 1-3-4 Pan concentrate survey

#### (1) Sampling

During the survey 169 pan concentrate samples were collected from main streams in this area. The sample was collected by five times panning (approximately 25 liters of gravels). Maximum weight among the samples is 1,180 grams, but many samples collected in the area of sedimentary rocks are less than one gram. Locations of these samples are shown in Fig. II-1-9 and the list of sample are shown in Appendix 12.

#### (2) QME analysis

Results of the QME analyses are shown in Appendix 13. As the results of the QME analyses, magnetite, chromite, hematite, ilmenite, goethite, pyrite and zircon were recognized as the heavy minerals. Minor amounts of leucoxene, rutile, monazite and tourmaline were also observed. Some samples contain comparatively

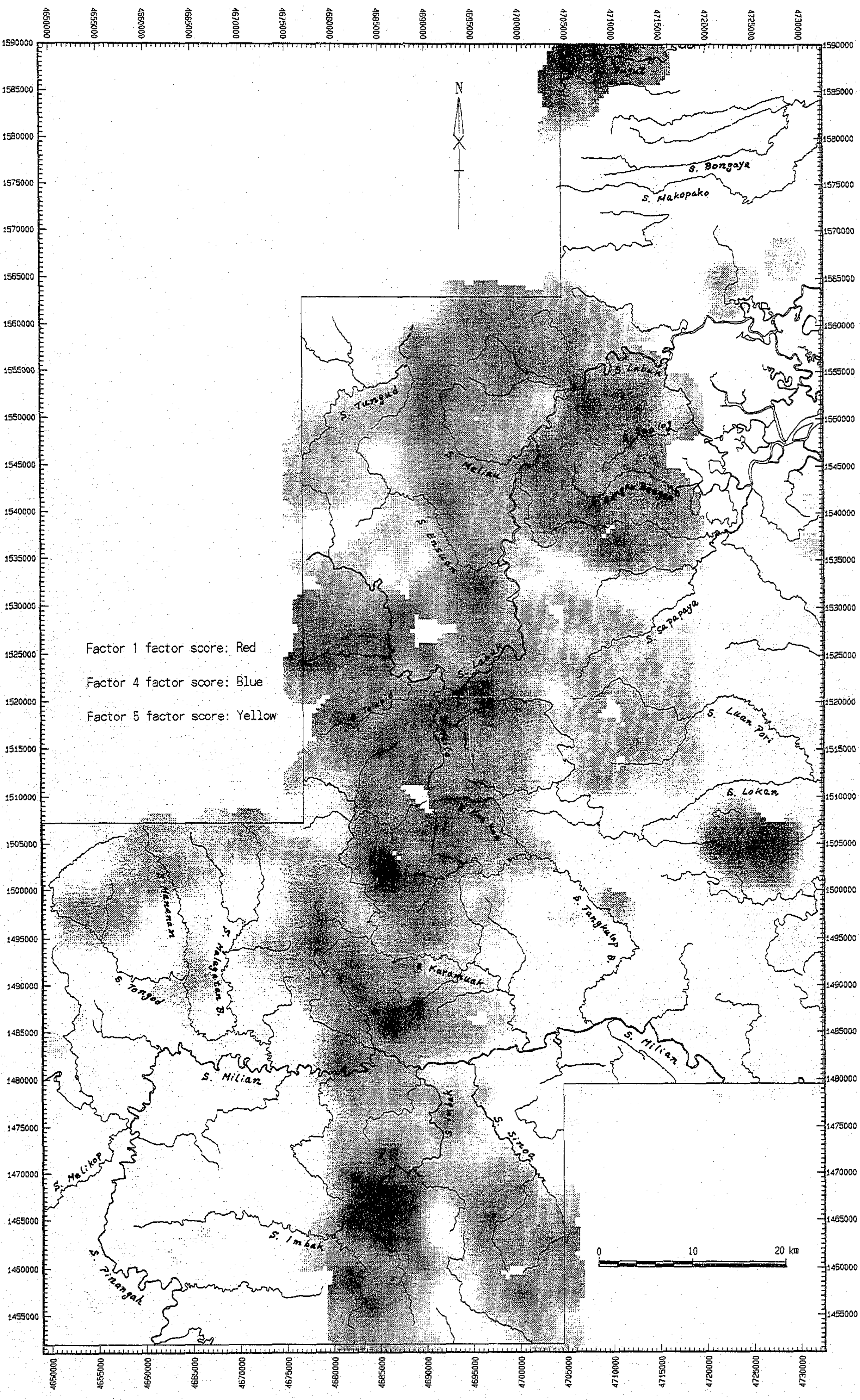



Fig. II-1-12 Distribution map of factor scores for stream sediment samples in Labuk area

large amounts of pyroxenes and hornblende. The minerals detected in this survey are almost same as the minerals in Kinabalu area. The samples with small amount collected in the area of sedimentary rocks contain many quartz and plagioclase. The relationship between heavy minerals and geology is summarized as follows:

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

Chromite : Chromite was also detected in many samples. Significant amounts of chromite was confirmed for the samples collected in the central and western parts of the area. Ultra-basic to basic rocks occur at the upper stream of these parts.

Ilmenite : Ilmenite was observed in the most of the samples. No clear tendencies can be observed.

Goethite : Goethite tends to occur in the southern and western parts of this area where sedimentary rocks are distributed.

Pyrite : A small amount of pyrite was confirmed in many samples. More amounts of pyrite are observed in the western part of the arera where sedimentary rocks are distributed.

Zircon : Zircon was confirmed in many samples. Zircon tends to occur in the samples collected in the western part of this area where sedimentary rocks are distributed.

1-3-5 Rock geochemical survey

Seventy (70) representative rock samples were collected in this survey and chemically analyzed for 21 elements same as the stream sediment samples. Locations of the sample are shown in Fig. II-1-9. The sample list is shown in Appendix 14 and the analytical results are shown in Appendix 15. As the results of the chemical analyses, more than 60 % samples give less than the detection limit for the elements of Au and Pb.

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

As : About 41 % samples give the value less than the detection limit. The maximum value is 29 ppm. The samples indicate more than 20 ppm are sedimentary rocks. Contents of As in ultra-basic and basic rocks are mostly less than 1 ppm.

Au : 93 % samples give the value less than the detection limit. The maximum value (4 ppb) was obtained from the sample of shale.

Ba : Chert give the maximum value of 548 ppm. The samples indicating more than 100 ppm are mostly sedimentary rocks.

Co : Specularite give the maximum value (337 ppm). The most samples of peridotite and serpentinite indicate high values of more than 100 ppm. Excepting these two kind rocks, no differences can be observed.

Cr : Specularite give the maximum value of 1,868 ppm. Ultra-basic rocks tend to give higher values of more than 700 ppm. Other than these rocks no significant differences are recognized.

Cu : Chert gives the maximum value (126 ppm). No differences are found among the rock types. Intrusive rock collected at the tributary of Sungai Imbak indicate slightly high value (57 ppm).

Hg : The maximum value (257 ppb) was obtained in sandstone. Sightly higher values are found in sedimentary rocks.

K : Shale indicate the maximum value of 2.47 %. The sample indicating more than 1.00 % are sedimentary rocks. Ultra-basic rocks indicate less than the detection limit (0.01 %).

Mg : Peridotite gives the maximum value (24.71 %). Ultra-basic rocks give more than 20 % of Mg, but gabbro and basalt show in a range of 3 % to 6 % Mg contents.

Mn : Chert give the maximum value of 16,148 ppm. High value samples (4,371 ppm and 2,570 ppm) are sandstone. The samples with less than the detection limit (5 ppm) are gabbro and some sedimentary rocks.

Na : Basalt gives the maximum value of 4.19 %. Gabbro and basalt show comparatively higher values of more than 2 %. Ultra-basic rocks give lower values.

Ni : Peridotite gives the maximum value (2,262 ppm). Ultra-basic rocks indicate more than 1,500 ppm. Basalt and gabbro indicate comparatively higher value of more than 100 ppm. Other samples are less than 100 ppm.

Pb : The maximum value (21 ppm) was obtained from chert. 60 % of the sample show less than the detection limit. Sedimentary rocks give comparatively higher values.

S : The maxmum value of 2.331 % was obtained from sandstone. Other rocks show less than 1.000 %. Muddy sedimentary rocks indicate sightly higher values.

Sb : Specularite gives the maximum value (37.4 ppm). Basic rocks show slightly higher values.

Sr : Microgabbro gives the maximum value of 731 ppm. No significant differences of the contents are found among the rock types.

Ti : Gabbro gives the maximum value (0.87 %). Basalt and gabbro indicate slightly higher values.

U : Intrusive rock give the maximum value of 4.8 ppm. Sedimentary rocks indicate comparatively higher values.

W : The maximum value (512 ppm) was obtained from chert. Sedimentary rocks tend to give higher values.

Zn : Intrusive rock gives the maximum value of 233 ppm. Ultra-basic rocks tends to give higher values of more than 100 ppm.

1-3-6 Soil geochemical survey

A total of 225 soil samples were collected in this area and six elements (Al, Co, Cr, Fe, Ni and Pt) were chemically analyzed. Sample location of these samples are shown in Fig. II-1-9. List of the sample and the analytical results are shown in Appendix 16.

The statistics for these samples are as follows:

| Element | Minimum value | Maximum value |
|---|---|---|
| Al | 1.08 % | 16.86 % |
| Co | 5 ppm | 2,173 ppm |
| Cr | 28 ppm | 12,551 ppm |
| Fe | 2.07 % | 48.24 % |
| Ni | 19 ppm | 10,587 ppm |
| Pt | < 5 ppb | 105 ppb |

The analytical results give high maximum value (0.22 %) of Co. This sample (Y561) is collected 2 km west of Telupid where lateritic soil is developped over serpentinite. This sample also show high contents of Fe (46.37 %) and Ni (9,024 ppm). The sample collected at the south bank of Sungai Labuk gives the maximum value of Fe (48.24 %). This sample give high content of Cr (12,432 ppm), but the content of Ni (3,734 ppm) is not so high. The sample with maximum content of Ni (1.06 %) is situated 3 km west of Telupid in the area of serpentinite. This sample indicates high content of Cr (11,382 ppm) and Fe (45.52 %). Among 225 samples in total in this area, 18 % samples give more than 5,000 ppm Ni. The maximum content (105 ppb) of Pt is not high.

1-3-7 Results of laboratorial studies

(1) Observation of thin sections

One thin section sample was collected from intrusive rock in the area of the tributary of Sungai Imbak. Results of the observation are shown in Table II-1-10. As the results of this observation, this intrusive is andesite porphyry and is hydrothermally altered.

(2) Observation of polished sections

Two samples were collected from the mineralized and gossanized zones. The observation results are shown in Table II-1-11. One sample (C505) was collected from Chert-Spilite formation in the western part of the area. As the results, minor chalcopyrite, bornite and chalcocite were recognized in this sample. One sample (F538) was collected from a gossanized zone in the southeastern margin of