Chapter 4 Geophysical Survey (CSAMT Method)

4-1 Outline of Survey

The same CSAMT method as in the Bambangan area was applied in the Mankadau area in order to clarify the underground resistivity structure and to select the most promising potential area for the occurrence of porphyry copper type ore deposit.

To carry out this survey, the area was also separated into a reconnaissance survey area, "BI" of 96 km^2 and a semi-detailed survey area, "bI" of 4 km^2. The survey station in the reconnaissance survey area were located along the ridges and creeks, while the stations in the semi-detailed survey area, were taken along the same grid as in the geochemical survey route to increase the density of the stations.

The details of the survey amount are shown as follows;

Types of Survey	Station Interval	Number of Stations
Reconnaissance Survey	400 - 500 m	167
Semi-detailed Survey	100 - 150 m	36
	Total	203

4-2 Result of Survey

In this area, a low resistivity zone of less than 50 ohm-m is dominantly distributed, and a high resistivity zone, more than 100 ohm-m is seen both in the centre and in the northeastern end of survey area, splitting the above mentioned low resistivity zone.

The resistivity structure consists of two to three layers structure with its resistivity distribution suggesting the extension of WNW-ESE and N-S trend structures as shown in Fig. III-14-1 - 3.

A low resistivity zone showing two layer structure with less than 500 ohm-m in general are detected in three areas: centeral- northeast, southeast and southwest part in the area.

A low resistivity zone in the centre-northeast zone extends almost 50% of whole area, from the shallow zone to the depths vertically. The one detected in the southeast is distributed almost same as the central one, while the other one detected in the southwest can be separated to the depth of 200 m into three independent distributions, but being connected to form one anomaly at the depths showing a pantaloon shape. The same anomaly pattern is also seen as low resistivity anomaly of less than 30 ohm-m.

A resistivity distribution ranging from 50 - 100 ohm-m indicates the subsided structure in the northeastern part of the area as shown in Fig. III-15. While a high resistivity zone of more than 100 ohm-m detected in the central zone of the area well coincides with the shape of ultrabasic rocks which are local in a small scale, scattered in NW-SE direction.

Judging from the fact that two more resistivity patterns suggest the NE-SW structure in this area, the discontinuities of resistivity seem to be caused by many complex fault structures in the area.

Therefore, ultrabasic rocks cropped out in the centre of the area in NW-SE direction, are bounded by two faults and controlled by a N-S structure, where peridotite is seen separated into several blocks. This is a reason why a small scale block of resistivity changes is seen at the depths of this area.

However, in the northwestern part of the area, little resistivity changes are seen from the surface to the depth, suggesting the existence of the massive resistive rocks.

Comparatively low resistivities of less than 100 ohm-m show a flat change of resistivity zone in each frequency range, which must be reflecting hornfels of unknown age, consisting mainly of sandstone.

Consequently, judging from the resistivity pattern of the area, there seems to be less possibility of finding a promising sulphide mineralized zone in this area.

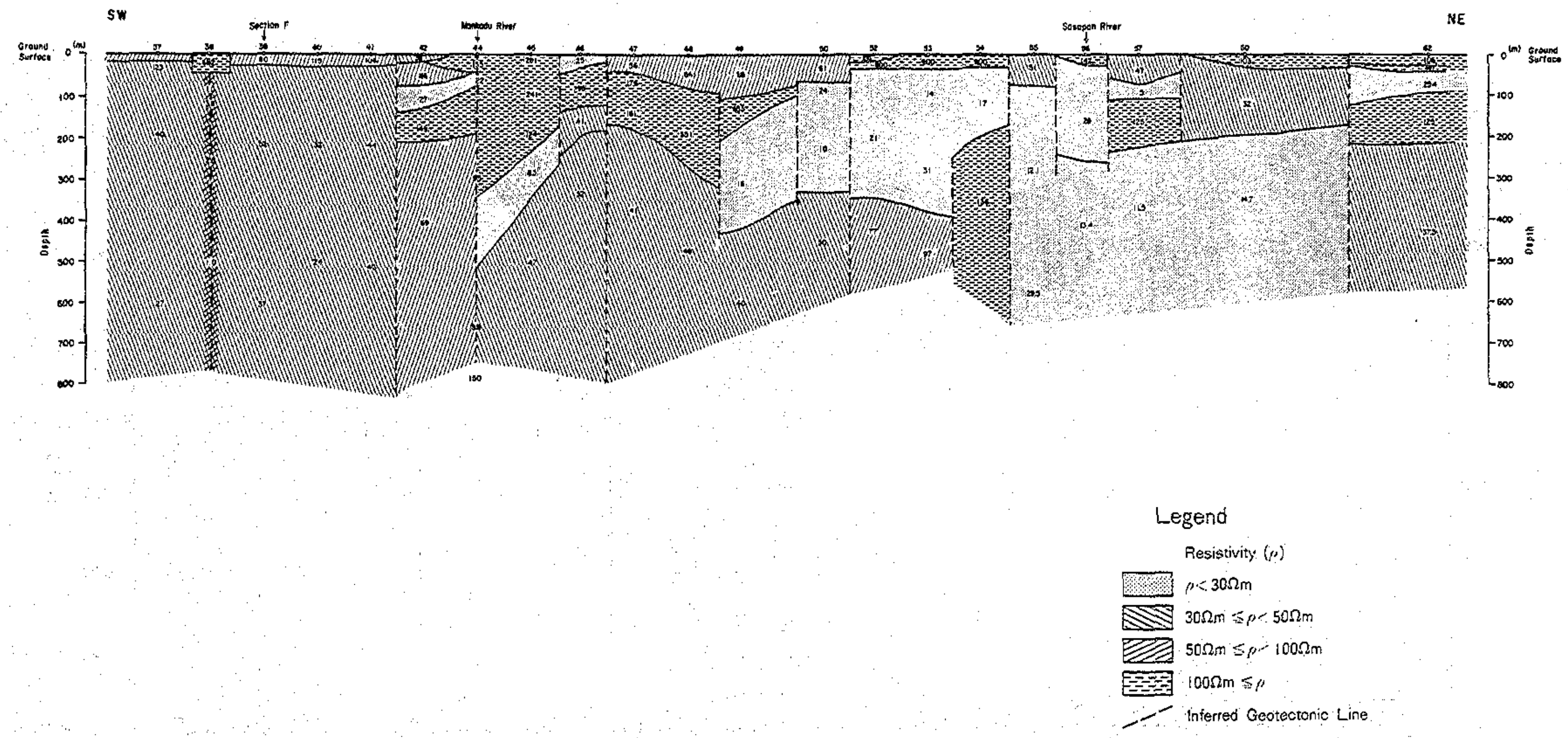

Fig. III-14-1 Resistivity Structural Map in Mankadau (B) Area (Section E)

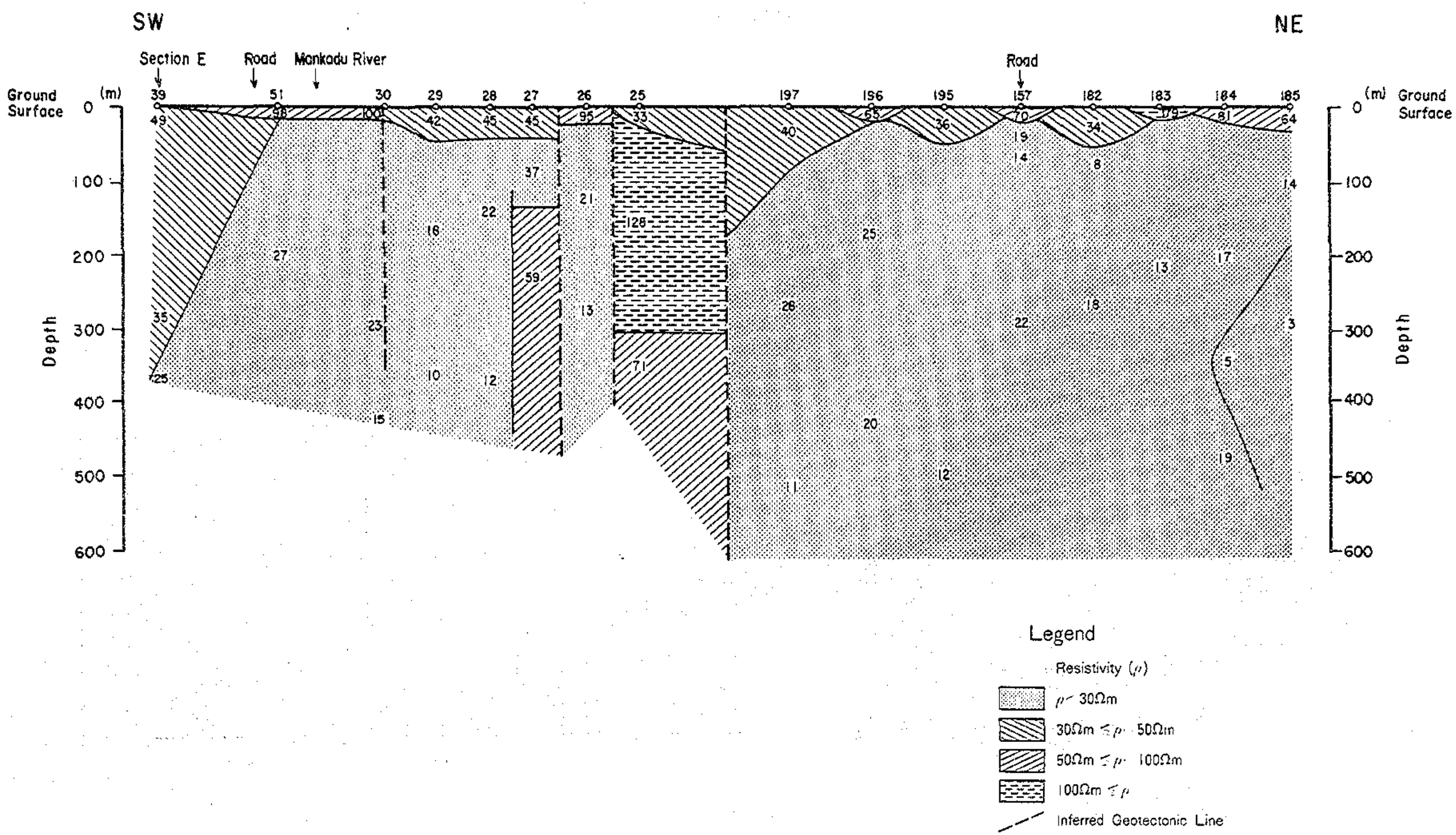

Fig. III-14-2 Resistivity Structural Map in Mankadau (B) Area (Section F)

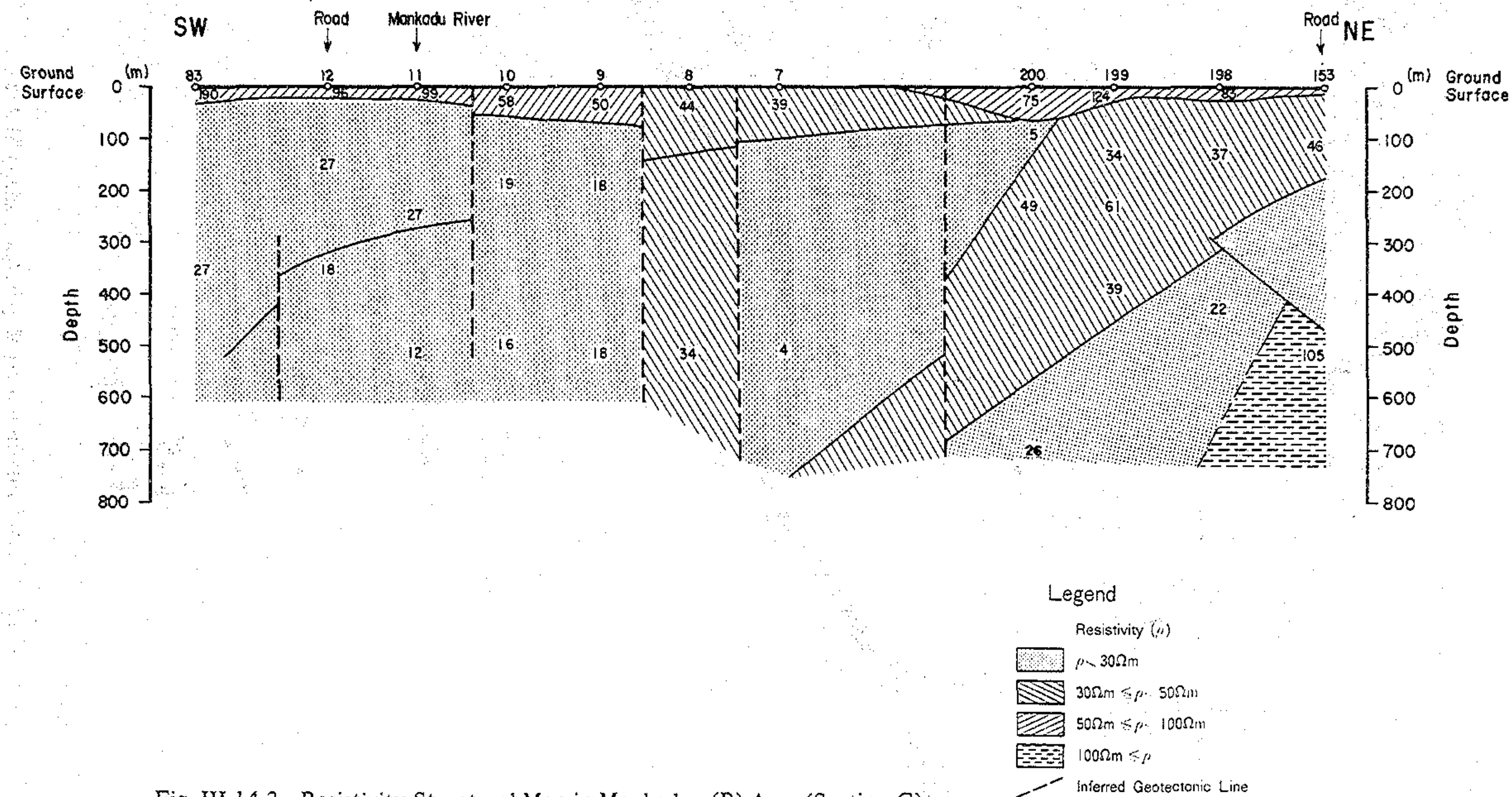

Fig. III-14-3 Resistivity Structural Map in Mankadau (B) Area (Section G)

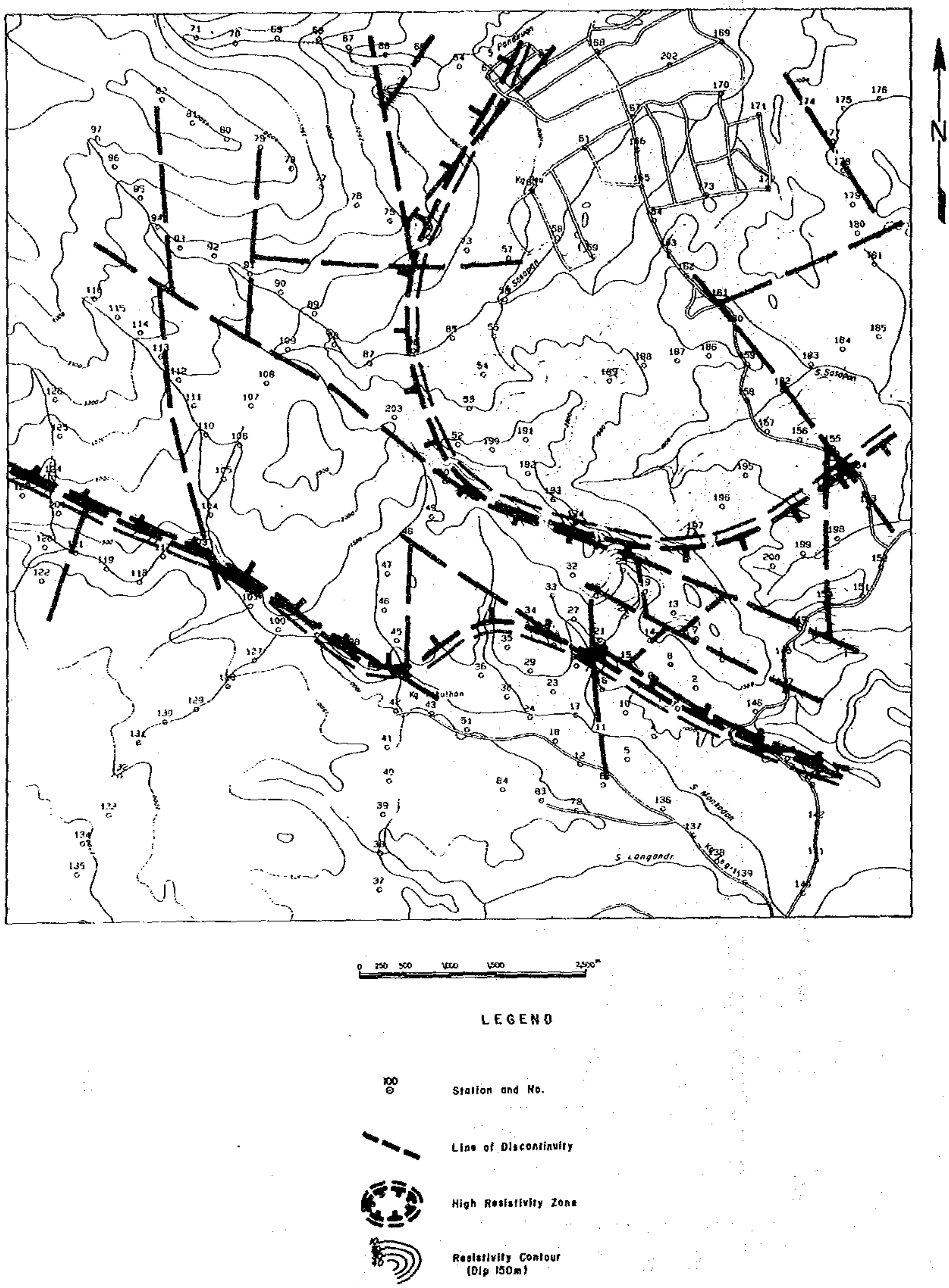

Fig. III-15 CSAMT Interpretation Map in Mankadau (B) Area

PART IV PALIU (c) AREA

Chapter 1 Geology

1-1 Outline of Geology

The sedimentary rocks, correlated to the Trusmadi Formation are widely distributed in the area, and numerous dikes and stocks of granodiorite porphyry have intruded into the above rocks, which are assumed to be correlated to later Paleocene.

Fig. IV-1 shows the geological map and typical columnar section of the area respectively, and the outline of the geology is described as the followings.

1-2 Geology

1-2-1 Sedimentary Rocks

The sedimentary rocks mainly consist of sandstone intercalated with thin layers of mudstone and shale. They are roughly divided into three members, as the first member consisting of only sandstone, the second consisting of sandstone interbedded with thin layers of mudstone and the third consisting of sandstone intercalated with thin layers of shale in an ascending order. In general, the lower members are found in the northern part of the area, the middle in the central part and the upper in the southeastern part successively.

The sandstone is medium to fine-grained and light gray to gray in color. It is poorly bedded and often massive and hard.

The sandstone often forms rhythmically alternating beds with thin layers (several to tens centimetres in thickness) of mudstone, with considerable changes in rock facies.

The mudstone is black and compact rock interbedded with sandstone as thin layers. It is well bedded and fairly continues laterally, and sometimes interbedded with thin layers of sandstone or siltstone.

The shale is reddish brown, silty, compact and fissile.

These sedimentary rocks have been metamorphosed to hornfels in the surrounding part of the intrusive bodies of granodiorite porphyry.

The total thickness reaches up to 500 metres.

1-2-2 Igneous Rocks

The granodiorite porphyry is the only intrusive rock in the area, and the largest stock is found in the northeastern part of the area. Many stocks and dikes of various sizes are distributed from the northern part to the central part.

The rock is characterized by the phenocrysts of hornblende and biotite, with a porphyritic texture.

The groundmass is holocrystalline, mainly consisting of quartz and plagioclase, with small quantities of biotite and hornblende. Although the rock is lithologically almost uniform , it has locally an equigranular texture, showing an appearance of granodiorite.

The xenolithes of sandstone and mudstone are often observed at the contact with sedimentary rocks.

1-3 Geological Structure

The fault and fold structures formed in and after Neogene period are well developed in the area. The faults of N-S system are predominant, but those intersected in oblique angle are often found.

The intrusive rocks trending north to south are commonly found, which seem to be associated with the faults of the same direction. These faults show a small displacement and do not reflect a large-scaled geological structure, only controlling local structures. However, the faults of N-S and NE-SW systems show the same direction as the tectonic lines in Kinabalu mountains.

Although the fold structure seems to be complicated, the direction of fold axes tend to change radially from E-W to N-S through NE-SW successively from the east to the west part.

The formation dips 20° to 40° in the western part and 50° to 60° in the southeastern part.

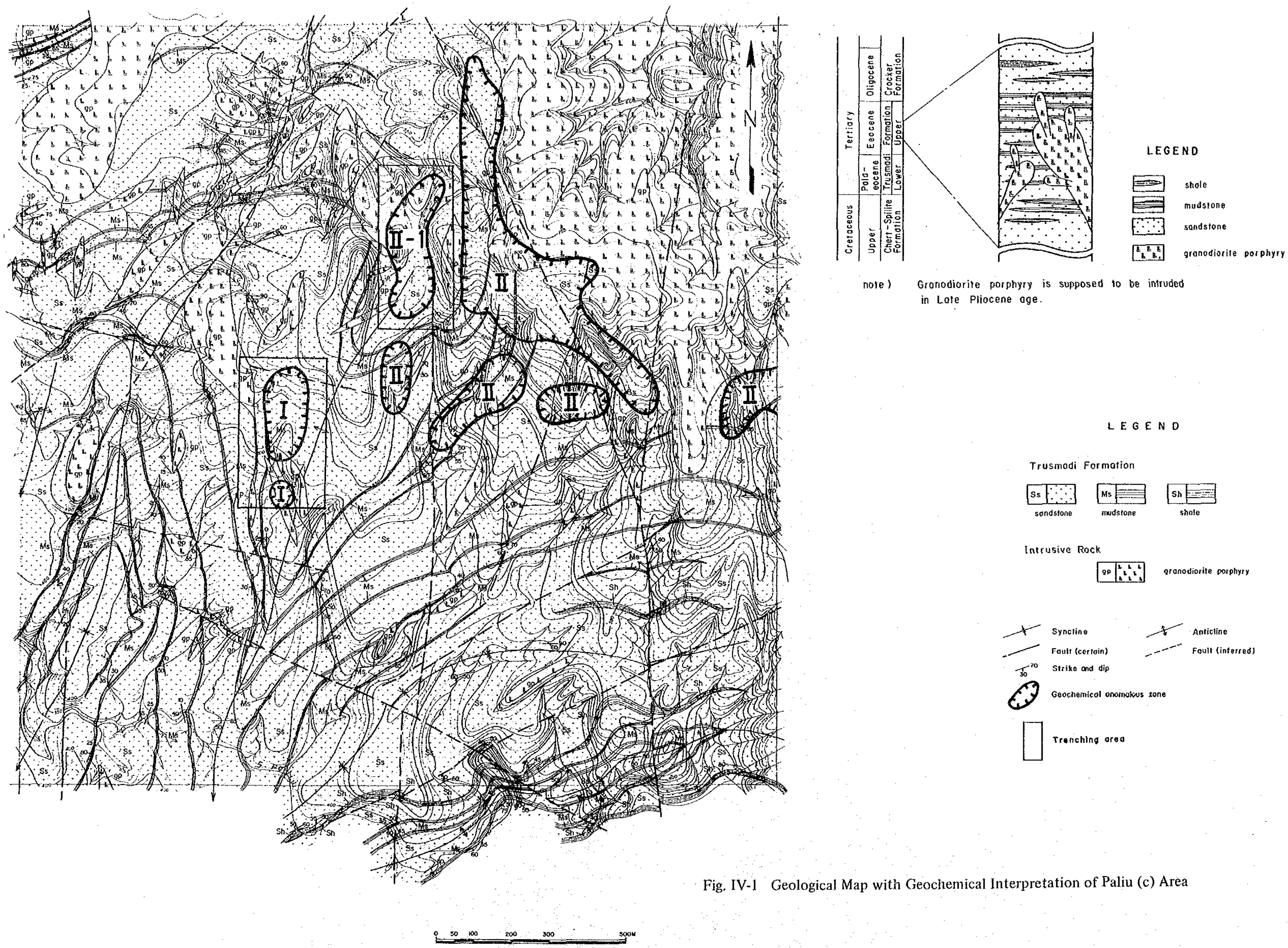

Fig. IV-1 Geological Map with Geochemical Interpretation of Paliu (c) Area

Chapter 2 Mineralization

A vein-type and dissemination-type mineralization associated with the intrusion of granodiorite porphyry is observed in the areas. Silicification and chloritization are associated with the mineralization.

(Fig. IV-2)

The mineralization is observed in the zones from the eastern to the central part and from the northwestern part to the western part.

(1) Eastern Part and Central Part

The mineralization is distributed on the southern and southwestern sides of granodiorite porphyry stock, and surroundings of the stock. It is characterized by film-like and disseminated pyrite mainly along the cracks in sedimentary rocks. It is accompanied with irregular-shaped quartz veins in some places. The ore minerals consist of pyrite, pyrrhotite and very small quantities of chalcopyrite.

(2) Northwestern Part and Western Part

The mineralization is found around the dikes of various sizes, and characterized by dissemination and vein. The ore minerals are composed of pyrite, pyrrhotite and small quantities of chalcopyrite, sphalerite, galena and molybdenite, which occur both in intrusive rocks and sedimentary rocks.

The geochemical survey for soil and stream sediments conducted in Phase I, extracted the geochemical anomalous zones as shown in Fig. IV-1, all of which are found near the contact between intrusive rocks and sedimentary rocks.

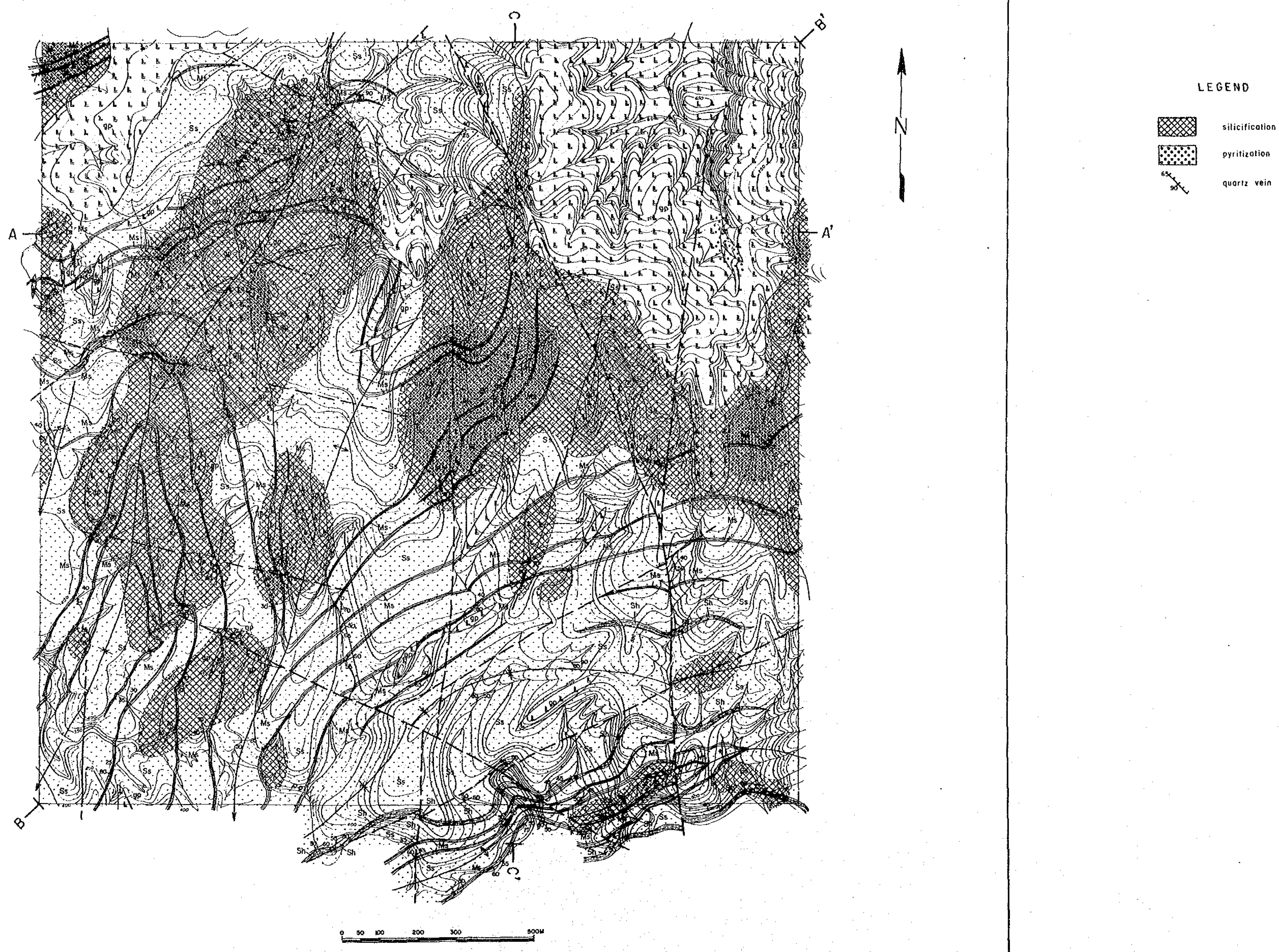

Fig. IV-2 Distribution Map of Alteration Zone in Paliu (c) Area

Chapter 3 Geochemical Survey

3-1 Geochemical Survey (Stream Sediments)

3-1-1 Outline of Survey

Silty stream sediment under 80 mesh deposited at the bottom of stream was collected for the geochemical samples in Phase I.

The samples were collected in the middle of the stream as principle, and consideration was given not to be mix with by mud and organic matter. The samples were taken at an interval of 50 metres. Samples of 665 pcs were collected by these methods, which were dried in natural atmosphere and provided for chemical analysis.

The samples prepared at the site were all sent to the Geological Survey of Malaysia, Sabah, where they were analyzed by atomic absorption method in the same way as the soil samples. The samples were analyzed for four elements such as Cu, Pb, Zn and Mo.

The detection limit was 1 ppm for each element.

3-1-2 Result of Survey

For treatment of the data, single variate analysis and multivariate analysis were performed as in the case of soil.

As the effect of classification of rock facies was not so clear in single variate analysis, the analytical values of all the samples were treated in the lump together. Histogram and cumlative frequency curves are as shown in Fig. IV-3 and Fig. IV-4. Table IV-1 shows the statistical values and correlation coefficient.

In multivariate analysis, only score sum method was used for examination. As 99 per cent of Mo assay values were below the detection limit among the four elements analyzed, Mo was not able to be processed.

(1) Single Variate Analysis

The distribution of the threshold value ($\chi + 2t$) of each element is as follows,

Cu : High Cu values are dristributed mainly in the upper reaches of the creeks in the central to northeastern part, where diorite porphyry stocks or dikes are distributed. The Cu values are inclined to decrease south and westward.

Pb : Unlike the distribution of Cu, high Zn values are located in the silicified zone which extends from the central to the northern part.

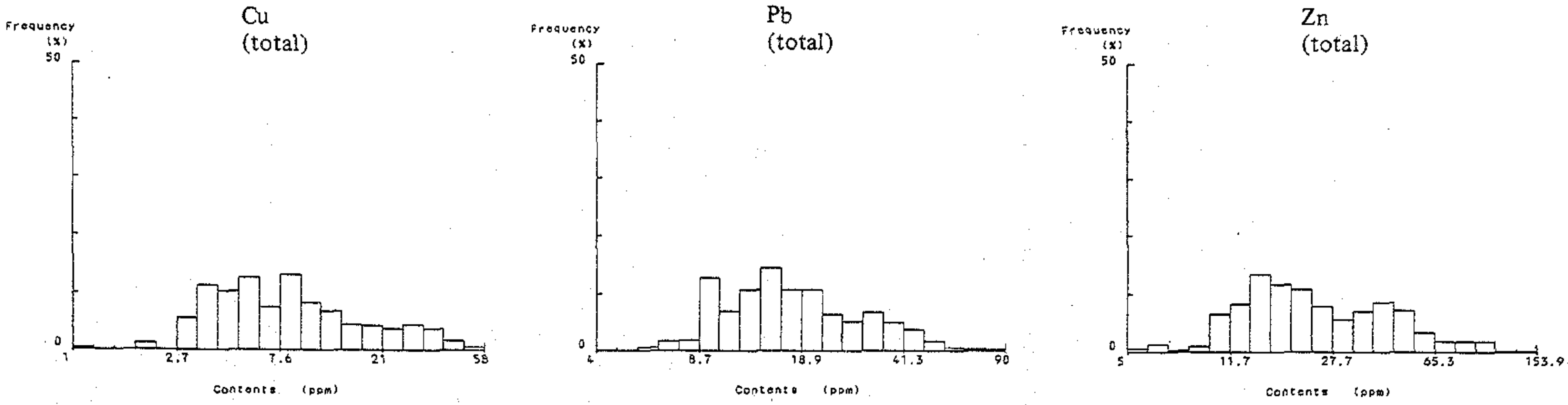

Fig. IV-3 Histgram for Stream Sediment Samples in Paliu (c) Area

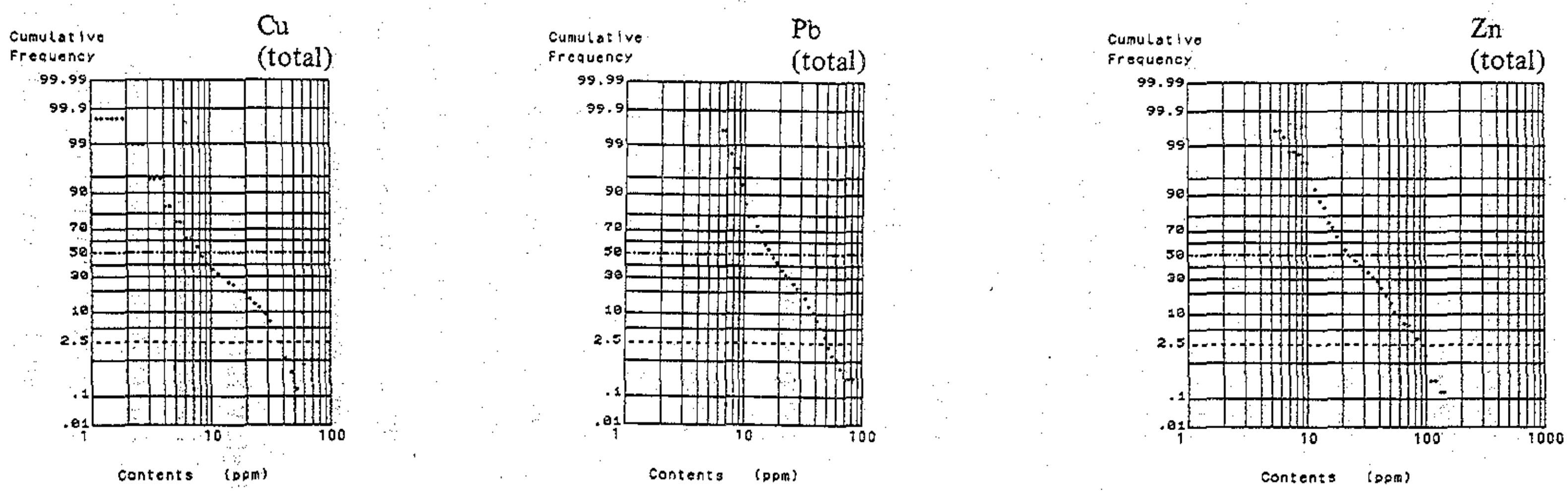

Fig. IV-4 Cumulative Frequency Curve for Stream Sediment Samples in Paliu (c) Area

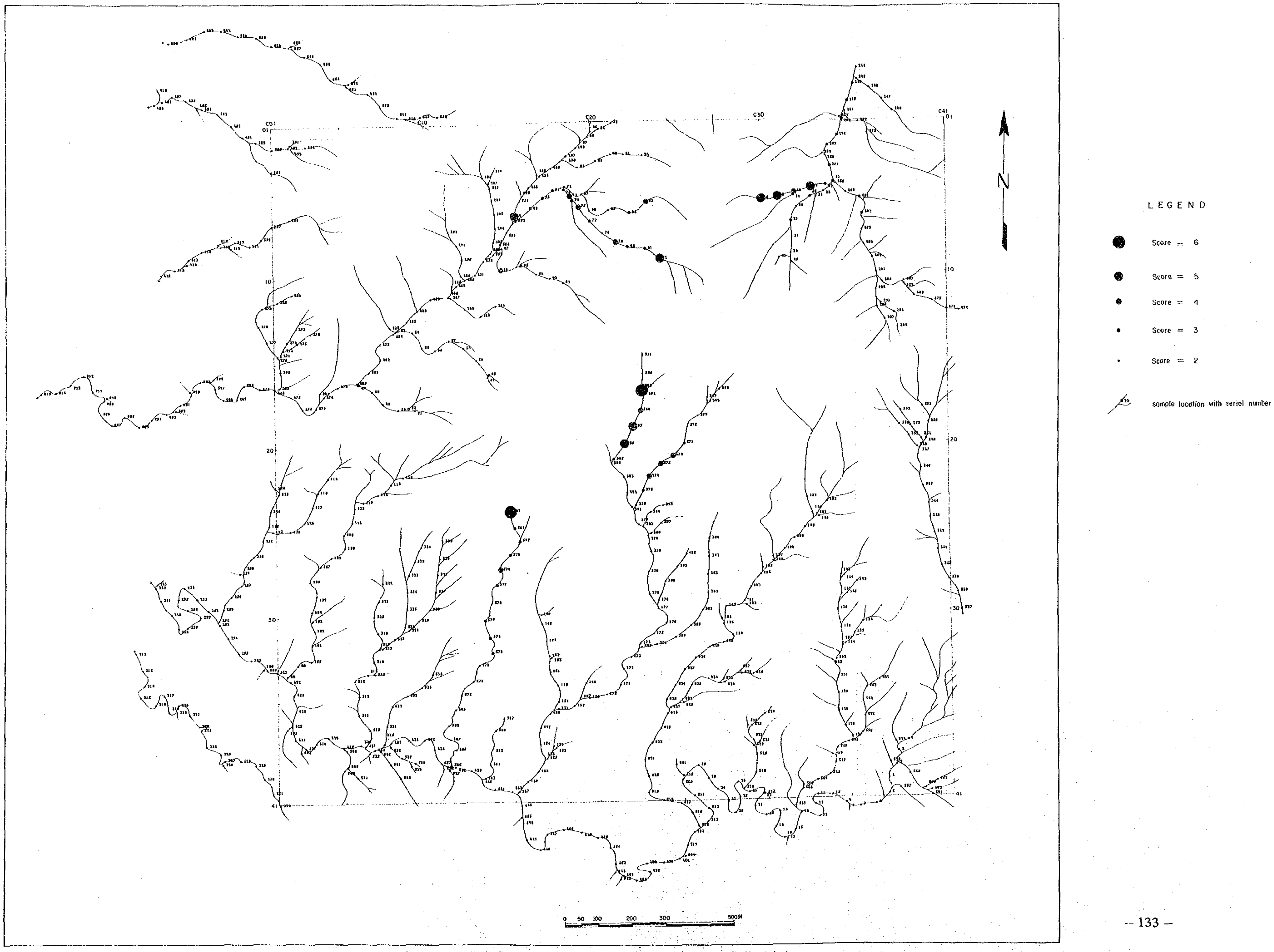

Fig. IV-5 Score-Sum Map of Stream Sediment Samples in Paliu (c) Area

Table IV-1 Statistic Values for Stream Sediment Samples in Paliu (c) Area

			Intrusive rock	Sedimentary rock	Total
Cu (ppm)	Number of samples	(n)	117	548	665
	Maximum value	(Vmax)	58	44	58
	Minimum value	(Vmin)	3	1	1
	Geometric mean	($\bar{X}$)	18.1	7.3	8.6
	Standard deviation	(t)	0.281	0.272	0.312
	$10^{\log\bar{x}+t}$		34.6	13.7	17.6
	$10^{\log\bar{x}+2t}$		(66.0)	25.6	36.2
	$10^{\log\bar{x}+3t}$		(126.1)	(47.8)	(74.2)
Pb (ppm)	Number of samples	(n)	117	548	665
	Maximum value	(Vmax)	71	90	90
	Minimum value	(Vmin)	4	6	4
	Geometric mean	($\bar{X}$)	22.2	16.7	17.6
	Standard deviation	(t)	0.223	0.218	0.224
	$10^{\log\bar{x}+t}$		37.1	27.6	29.5
	$10^{\log\bar{x}+2t}$		62.0	45.6	49.4
	$10^{\log x+3t}$		(103.6)	75.3	82.7
Zn (ppm)	Number of samples	(n)	117	548	665
	Maximum value	(Vmax)	103	154	154
	Minimum value	(Vmin)	10	5	5
	Geometric mean	($\bar{X}$)	34.5	22.2	24.0
	Standard deviation	(t)	0.234	0.266	0.270
	$10^{\log\bar{x}+t}$		59.1	41.0	44.7
	$10^{\log\bar{x}+2t}$		101.0	75.6	83.2
	$10^{\log\bar{x}+3t}$		(173.7)	139.4	(154.9)
Mo (ppm)	Number of samples	(n)	117	548	665
			All data show the values below detection limit.		

note) ( ) ; value not present

Correlation Matrix

	Cu	Pb	Zn
Cu	1	–	–
Pb	0.551	1	–
Zn	0.574	0.834	1

Zn : The Zn distribution well coincides with that of Pb.

(2) Score Sum Analysis

Fig. IV-5 shows the result of analysis by score sum.

Based on the distribution of each element, the followings are recognized from score sum diagram.

The samples which have score 6 are No. 389 collected at the uppermost reaches of a northerly trending creek in the central part and No. 582 at the uppermost reaches of a north-northeasterly trending creek in the southwestern part.

These are considered to be the zones of the highest potential in the survey area.

Next, the values larger than score 4 (containing at least one element which has the value larger than $\bar{\chi} + 2t$) will be discussed. The distribution is as follow.

In the intrusive rock in the northeastern part (sample Nos. 42 to 46).

In the branch of a northeasterly trending creek in the northwestern part (sample Nos. 66, 68, 74, 75, 79, 82 and 93).

In the uppermost reaches of a northerly trending creek in the central part (sample Nos. 386 to 389 and 372 to 374).

In the uppermost reaches of a north-northeasterly trending creek in the southwestern part (sample Nos. 578 and 582).

These distributions are quite similar to these of Pb and Zn which were made clear in the single variate analysis, and they are reflected by anomalies of these two elements.

When compared with the result of geologic mapping, the distribution of the high score values corresponds to the terrain of intrusive granodiorite porphyry in the northeastern part. On the other hand, the distribution of the mineralized zones and alteration zones confirmed by the geologic mapping are found in most of the areas in the above, showing a very good consistency to each other.

3-2 Geochemical Survey (Soil)

3-2-1 Outline of Survey

Soil samples of 1,681 pcs were collected in a grid system of 50 x 50 metres as well as these in the "b" area in Phase I and analysed for Cu, Pb, Zn and Mo in the Geological Survey of Malaysia, Sabah, Malaysia.

A histogram and a cumulative frequency curve for each rock facies were produced based on the analytical data (Figs. IV-6, IV-7).

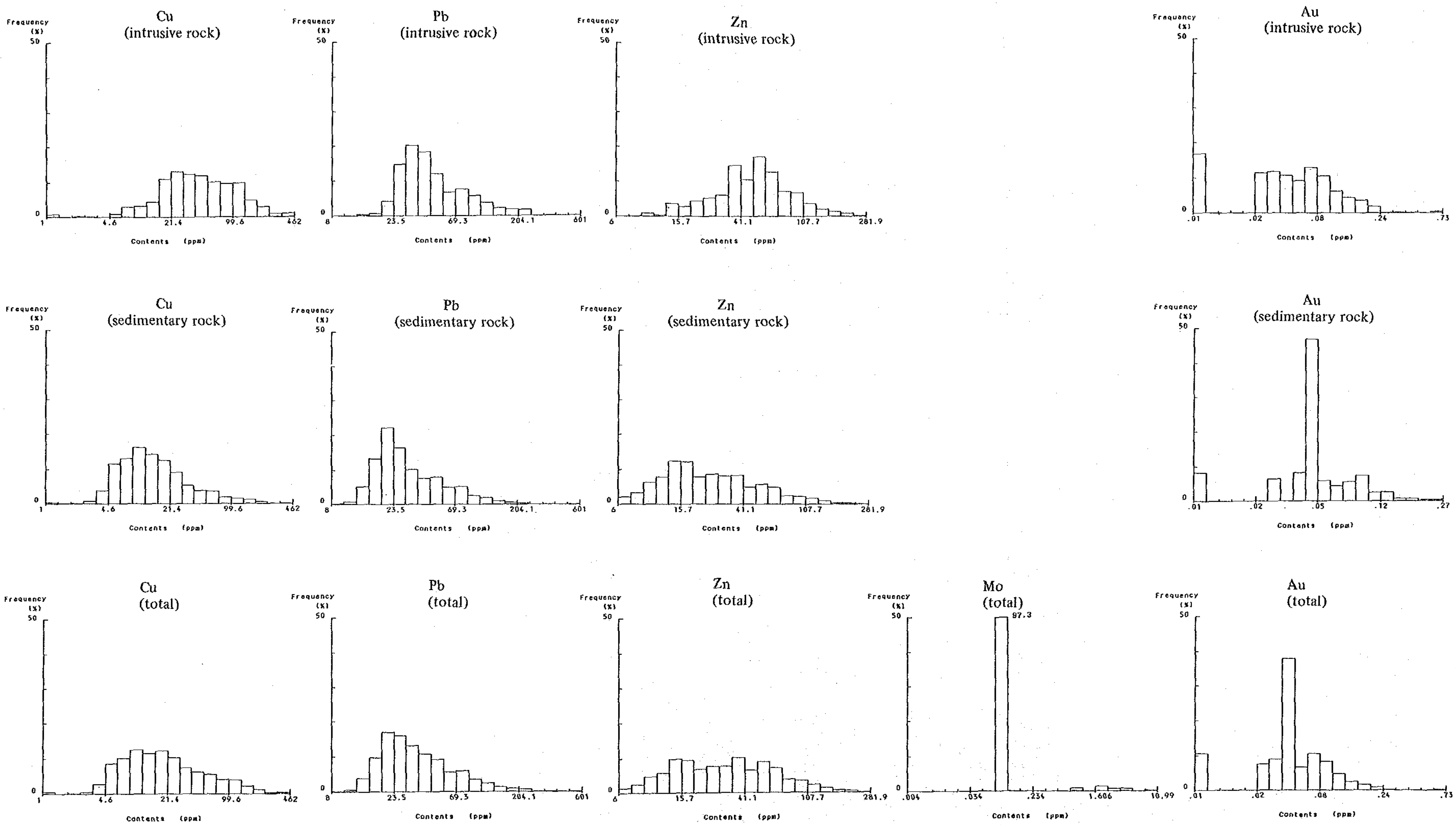

Fig. IV-6 Histgram for Soil Samples in Paliu (c) Area

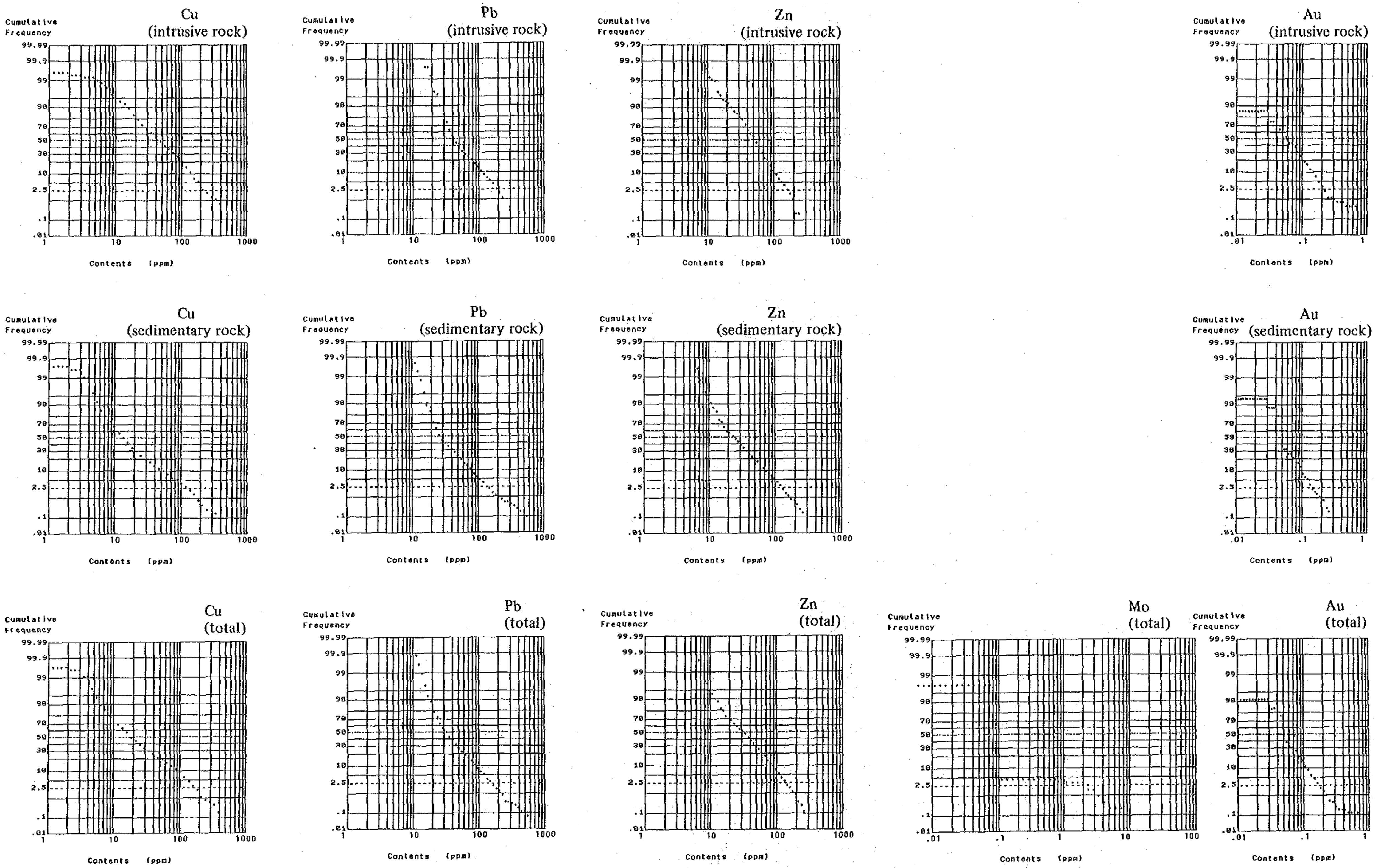

Fig. IV-7 Cumulative Frequency Curve for Soil Samples in Paliu (c) Area

Table IV-2 Statistic Values for Soil Samples in Paliu (c) Area

			Intrusive rock	Sedimentary rock	Total
Cu (ppm)	Number of samples	(n)	480	1201	1681
	Maximum value	(Vmax)	462	383	462
	Minimum value	(Vmin)	1	1	1
	Geometric mean	($\bar{X}$)	41.3	14.3	19.4
	Standard deviation	(t)	0.409	0.379	0.440
	$10^{\log\bar{x}+t}$		105.9	34.2	53.4
	$10^{\log\bar{x}+2t}$		271.6	81.9	147.2
	$10^{\log\bar{x}+3t}$		(695.5)	196.0	405.3
Pb (ppm)	Number of samples	(n)	480	1201	1681
	Maximum value	(Vmax)	235	601	601
	Minimum value	(Vmin)	14	8	8
	Geometric mean	($\bar{X}$)	46.1	31.0	34.7
	Standard deviation	(t)	0.244	0.266	0.271
	$10^{\log\bar{x}+t}$		80.9	57.2	64.8
	$10^{\log\bar{x}+2t}$		141.8	105.5	120.9
	$10^{\log\bar{x}+3t}$		(248.7)	194.7	225.6
Zn (ppm)	Number of samples	(n)	480	1201	1681
	Maximum value	(Vmax)	250	282	282
	Minimum value	(Vmin)	8	6	6
	Geometric mean	($\bar{X}$)	48.1	24.4	29.7
	Standard deviation	(t)	0.262	0.323	0.335
	$10^{\log\bar{x}+t}$		87.9	51.3	64.2
	$10^{\log\bar{x}+2t}$		160.7	108.0	138.9
	$10^{\log\bar{x}+3t}$		(293.9)	(227.2)	(300.4)
Mo (ppm)	Number of samples	(n)	480	1201	1681
	Maximum value	(Vmax)	11	5	11
	Minimum value	(Vmin)	ND	ND	ND
	Geometric mean	($\bar{X}$)	–	–	–
	Standard deviation	(t)	–	–	–
	$10^{\log\bar{x}+t}$		–	–	–
	$10^{\log\bar{x}+2t}$		–	–	–
	$10^{\log\bar{x}+3t}$		–	–	–
Au (ppm)	Number of samples	(n)	470	680	1150
	Maximum value	(Vmax)	0.72	0.23	0.72
	Minimum value	(Vmin)	ND	ND	ND
	Geometric mean	($\bar{X}$)	0.049	0.048	0.048
	Standard deviation	(t)	0.337	0.314	0.352
	$10^{\log\bar{x}+t}$		0.106	0.099	0.108
	$10^{\log\bar{x}+2t}$		0.231	0.204	0.243
	$10^{\log\bar{x}+3t}$		0.503	(0.420)	0.546

note) ( ) ; value not present

Correlation Matrix

	Intrusive rock			Sedimentary rock			Total		
	Cu	Pb	Zn	Cu	Pb	Zn	Cu	Pb	Zn
Pb	–0.030	–	–	0.494	–	–	0.298	–	–
Zn	0.363	0.603	–	0.589	0.755	–	0.546	0.698	–
Au	0.199	0.004	–0.023	0.174	0.052	0.009	0.174	0.032	–0.002

A value of $\overline{\chi}+2t$, occupying 2.5 per cent of the entire population, was taken as the threshold value. Using this value, anomalous areas were studied with supplementary values of $\overline{\chi}+t$ and $\overline{\chi}+3t$.

The statistic values for each element and each rock facies are shown in Table IV-2.

3-2-2 Result of Survey

(1) Single Variate Analysis

Each distribution of the four elements such as Cu, Pb, Zn and Au among the five elements chemically analyzed was studied. Regarding Au, only 1,148 assay values of the samples collected from the survey lines from No. 1 to No. 28 were analised. The assay results of Mo were used only for reference, because 97.3 per cent of the whole samples were below the detection limit.

The distribution of the threshold value ($\overline{\chi}+2t$) of each element is as follows,

Cu : High Cu vlues are distributed mainly in the terrain of sedimentary rocks near the contact with the diorite porphyry. Especially, they are concentrated around the stock in the northeastern area.

Pb : The anomalies are located in the northern part of the central area and also extend narrowly on the western side of the above-mentioned porphyry.

Zn : The Zn distribution well coincides with that of Pb.

Mo :Maximum value is 11 ppm. Almost all values are below the detection limit, not showing any trend.

Au : Maximum value is 0.72 ppm. The anomalies are scattered in the porphyry in the northeastern part.

(2) Score Sum Analysis

These elements were evaluated by score sum as in the same procedure of analysis for the "b" area, and factor analysis was also used. The results were comprehensively evaluated and indicated on a 1:10,000 scale geological map (Map IV-1).

The elements utilized for the map were those such as Cu, Pb, Zn and Au, Mo was excluded by reason that it was difficult to give adequate score because 97.3 per cent of the whole assay values were below the detection limit.

As the total number of Au analysis was 1,148 as mentioned before, the scores were given utilizing the assay results of No. 1 to No. 28 of each survey line. As a result, the number of elements used for the score sum map was different between the northern part of the survey area (from No. 1 to No. 28 of each survey line) and the southern part (from No. 29 to No. 41 of each survey line), such as four elements in the northern part and three elemets in the southern part respectively. However, no notable indication is shown in reference to Cu, Pb and Zn in the southern part. Therefore, the result of analysis will be described for the northern part of the survey area (No. 1 to No. 28 of each survey line).

The highest score obtained in the area was nine, which are located in the vicinity of C15-21 and C22-13. The score (6-7) following the above was found in the vicinity of C15-21 and in the western part and the southwestern part of granodiorite porphyry in the northeastern area.

The following facts can be recognized from the distribution in the above.

(i) The score sum map shows a very good consistency with the geologic map, indicating that the high score areas are limited to the stock of granodiodrite prophyry or in the sedimentary rocks around the dikes.

(ii) In the sedimentary rocks in the surrounding area of the granodiorite porphyry mass in the northerastern part of the survey area, the high score zones are distributed in such a way to surround the mass, especially in the southwestern side.

(iii) No mineralization is observed in the vicinity of granodiorite porphyry stoks and dikes distributed in the western part of the survey area.

(iv) The area which seems to be most promising is found in the vicinity of C15-21, showing an extent of about 15,000 square metres on the surface.

(3) Factor Analysis

The samples (1,148 pcs in total) of No. 1 to No. 28 of each survey line were analyzed for four elements, such as Cu, Pb, Zn and Au. Interpretation was made for two cases, such as ① the assay values were treated without classification of rock facies and ② the rocks were classified into granodiorite porphyry and the sedimentary rocks. Factor loading, factor contribution and communality of each factor are shown in Table IV-3.

(4) Discussion

The analysis was made by means of single variate, score sum and factor analysis for the geochemical survey data of the area. Fig. IV-1 shows the result of analysis together with that of geologic mapping.

From the interpretation map, (I) the area centering on C15-21 and (II) the terrain of sedimentary rock adjacent to the stock in the northeastern part of the area, especially the southwestern part of the stock, were extracted as the geochemical anomalous zones.

The distribution of these zones is well consistent with the result of geologic mapping. Silicification and/or weak mineralization are observed there.

The supplementary use of the above analysis was effective to elucidate the mineralization of the area. The details are as follows.

(1) The analysis by score sum was able to treat all the elements analysed collectively for the extraction of geochemical anomalous zone, and it was effective from the point of ranking the potential of the zones.

(2) Factor analysis was important to know the detailed behavior of each element in the geochemical anomalous zones mentioned above. Especially, a zonal distribution was recognized by the factors which characterize Pb-Zn and Cu-Zn.

(3) The classification of rock facies was important for obtaining the result of analysis as proved by simple element analysis. That is, it is necessary to analyze separately for each rock facies because of its different background value.

Comparing the result of drainage survey with that of soil geochemical survey, the following case can be mentioned.

(1) The area of the highest potential found in the area is located in the uppermost reaches of a north-northeasterly trending creek in the southeastern part, which is consistent with the anomaly C15-21 detected by soil goechemical survey.

(2) The anomaly recognized in the eastern part of the area is consistent with the soil geochemical survey, which agrees
with the distribution of mineralized and silicifide zones spread over the surrounding area of the stock of granodiorite prophyry in the northeastern part of the area.

(3) The result of the soil geochemical survey and that of the stream sediment show a discrepancy of about 100 metres in general. This seems to show the distance of move of the stream sediments trnsported by the stream.

(4) The correlation between Pb and Zn is high in the area, which was confirmed by the geochemical surveys of soil and stream sediments.

Table IV-3 Result of Factor Analysis in Paliu (c) Area

Total

factor loadings

	factor–1	factor–2	factor–3
Cu	0.246	0.671	0.243
Pb	0.832	0.167	0.017
Zn	0.696	0.517	–0.032
Au	–0.006	0.081	0.424

factor contribution

factor	contribution	%	acc.%
1	1.236	55.5	55.5
2	0.752	33.7	89.2
3	0.240	10.8	100.0

Communarity

Cu	Pb	Zn	Au
0.570	0.720	0.752	0.187

Intrusive Rock

factor loadings

	factor–1	factor–2	factor–3
Cu	0.065	0.608	0.216
Pb	0.804	–0.047	–0.010
Zn	0.700	0.432	–0.047
Au	–0.020	0.116	0.452

factor-contrifutions

factor	contribution	%	acc. %
1	1.142	58.1	58.1
2	0.571	29.1	87.2
3	0.253	12.9	100.1

Communarity

Cu	Pb	Zn	Au
0.420	0.649	0.678	0.218

(continued)

Sedimentary Rock

factor loadings

	factor–1	factor–2	factor–3
Cu	0.482	0.521	0.308
Pb	0.862	0.132	0.062
Zn	0.804	0.366	–0.015
Au	0.011	0.156	0.423

factor contribution

factor	contribution	(%)	acc.950
1	1.621	69.7	69.7
2	0.426	18.3	88.0
3	0.278	12.0	100.0

Communarity

Cu	Pb	Zn	An
0.598	0.764	0.780	0.182

Chapter 4 Trenching

4-1 Outline of Survey

As shown in Fig.IV-1, trenching was carried out at ten points in the I area which covers some anomalies located in the central part of the area and in the II-1 area with a maximum anomaly which as chosen from the many anomalies detected around the granodiorite porphyry in the northeastern area.

The trenches were excavated in the perpendicular direction to the trend of mineralization, which are distributed in the surrounding part of granodiorite porphyry bodies.

The location of trenches is shown in Fig. IV-1, IV-8 and their specifications are as follows.

Trench No.	Location	Direction	Scale			
			Length (m)	Width (m)	Depth (m)	Volume (m)
1	C15-20	E-W	4.8	1.0	2.3	11.0
2	C15-21	N75°W	5.5	1.0	1.2	6.6
3	C15-22	N80°W	5.4	1.4	2.7	20.4
4	C15-23	N40°E	4.5	0.8	3.2	11.5
5	25 m SSW of C15-25	N60°E	4.7	0.7	1.6	5.3
6	10 m SSE of C15-26	N60°E	6.5	1.8	1.5	17.6
7	C22-12	N35°W	6.6	1.4	2.2	20.3
8	C22-13	N60°W	6.2	1.3	1.5	12.1
9	C22-14	N60°W	4.9	0.5	3.4	18.9
10	C22-15	N40°W	5.0	1.0	1.6	8.0

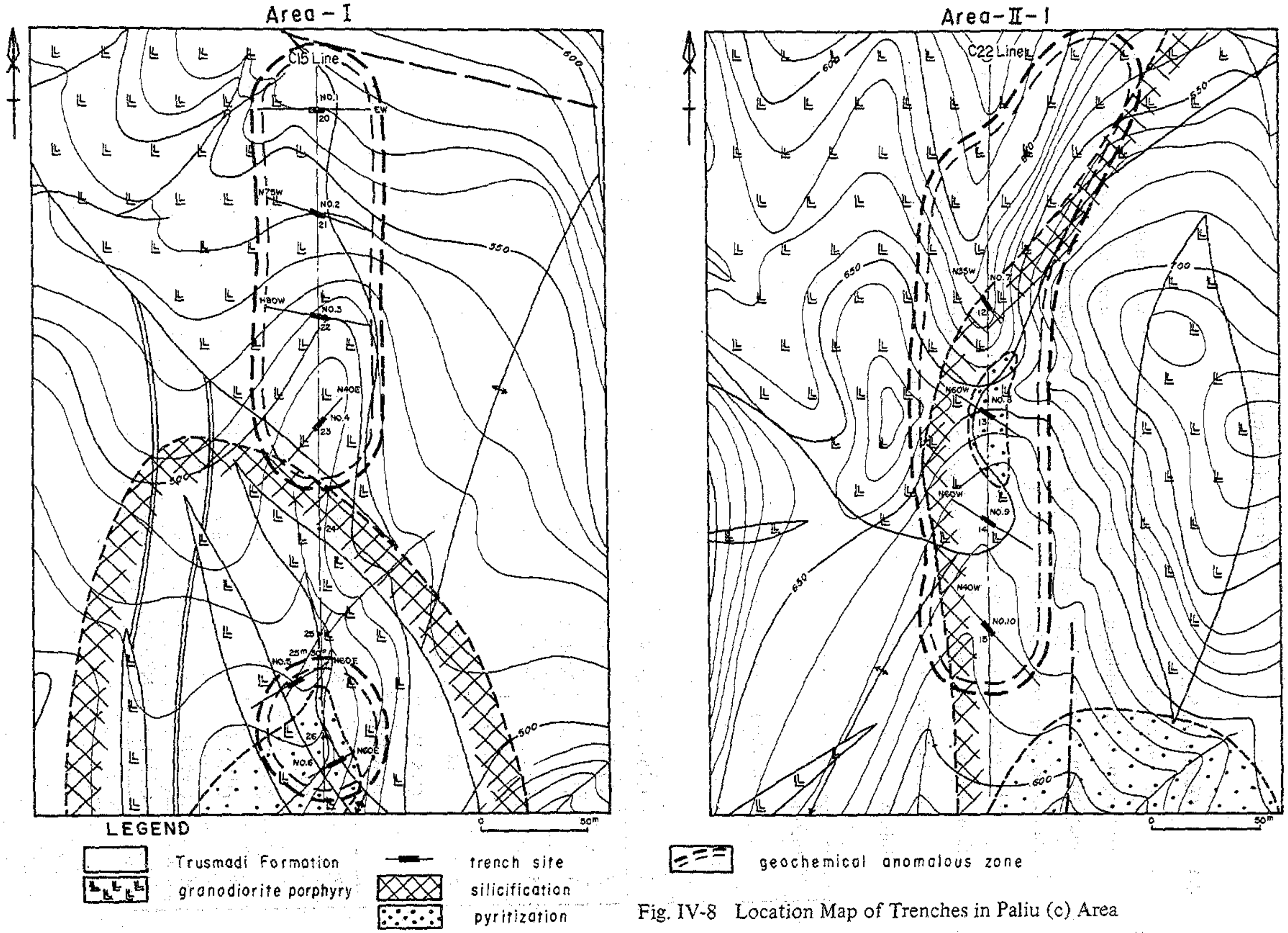

Fig. IV-8 Location Map of Trenches in Paliu (c) Area

4-2 Result of Survey

1. Trench No. 1

The basement rock consists of granodiorite porphyry, whose upper part has been disintegrated to sand by weathering. Weak joint is observed. Leaching and argillization have irregularly developed. Granules to cobbles of granodiorite are scattered in the soil. Mineralization is not accompanied.

2. Tranch No. 2

The basement rock consists of granodiorite porphyry. Massive, hard and gray sandstone is found in places. The granodiorite porphyry, which bears an onion structure characteristically, has been disintegrated to sand by weathering. Weak joint is well observed. The sandstone has been metamorphosed to hornfels, being accompanied by storong silicification. The sandstone is occasionally found in granodiorite porphyry as a xenolith block. Although the boundary between two rocks is sharp, it is irregular in shape.

3. Trench No. 3

Granodiorite porphyry corresponding to the C horizon was confirmed below thick soil. Although granodiorite porphyry has been weathered to the soft sandy rock, an original texture still remains. The rock generally appears blockly, and weakly argillized zones are partly distributed. Irregular shape of aplite dikes with a width of about one centimetre each intrude in the rock. The aplite consists of quartz and plagioclase. Mineralization was not confirmed.

4. Trench No. 4

Weathered granodiorite porphyry which corresponds to C horizon was confirmed as well as in the trench No. 3. An onion structure peculiar to the rock is often observed in weathered sandy rock, and hard boulders of the rock remain in the central core of the blocks. Mineralization is not confirmed.

5. Trench No. 5

The basement rock consists of massive and hard sandstone with gray to brownish gray in color, showing fine-grained and silty facies, and is broken into blocks by joints. Weak silicification is observed along the joints. Although weak silicification is recognized throughout the rock, no mineralization is confirmed.

6. Trench No. 6

The basement rocks consist of gray to pale gray sandstone and granodiorite porphyry which has intruded into sandstone.

The sandstone is a fine to medium-grained hard rock with a joint structue. It has been altered to hornfels at the contact with granodiorite porphyry, having been highly silicified and leached out and gradually changed to pale gray sandstone. The granodiorite porphyry has irregularly intruded into sandstone in a shape of small dikes. The boundary is sharp and sometimes pale gray zones are found along the boundary. The rock is highly weathered and changed to sandy soft facies.

Regarding the mineralization, dissemination and fine streaks of pyrite and very small quantities of chalcopyrite are recognized around the boundary between sandstone and granodiorite porphyry.
The mineralized zone is almost consistent with the silicified zone. A similar mineralization is also observed in sandstone and granodiorite porphyry exposed in a small creek adjacent to the trench.

7. Trench No. 7

The excavation of the trench has not encountered the basement rock, having confirmed only weathered granodiorite corresponding to B and C horizons. Brownish gray mudstone is distributed in the horizons. The granodiorite porphyry has been softened by weathering however great boulders which sizes are up to three metres in diameter with abundant joints are found. The mudstone is silty and massive, showing a sharp boundary in an irregular shape with granodiorite porphyry. No mineralization was distinguished.

8. Trench No. 8

The basement rock consists of sandstone intercalated with thin layers of bluish brown mudstone and intrusive bodies of granodiorite porphyry. Sandstone is gray, massive and hard rock with irregular joints. The prominent silicification is observed around the contact with granodiorite porphyry, which is stained by limonite along the joint.

The mudstone is rather soft as compared with the sandstone and forms thin layers with the thickness of about 10 centimetres, showing a weak schistosity. The granodiorite porphyry has a sharp contact with sandstone and mudstone.

The mineralization is characterized by disseminated pyrite and very small quantities of tetrahedrite in silicified zone of sandstone layers.

9. Trench No. 9

Only weathered granodiorite porphyry corresponding to C horizon distributed in the trench without the occurrence of basement rock. An onion structure is common in weathered sandy rock, and the core consisting of hard rock appears to be a pebble. Limonite stain is observed along the weak joint. No mineralization was distinguished.

10. Trench No. 10

The basement rock consits of gray massive sandstone intercalated with thin layers of brownish gray mudstone. The sandstone is massive with irregular joints. The mudstone is soft and forms layers of three to five centimetres thick, striking north-northwest.

Weak silicification is observed throughout the sandstone. No mineralization is observed.

The assay result of the collected samples from each trench is shown in Table N-4.

Table IV-4 Result of Chemical Analysis of Trench Samples in Paliu (c) Area

Ser. No.	Sample No.	Trench No.	Assay Result Au (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	Remarks
1	1-1	No. 1	0.07	373	163	23	1	
2	1-2	No. 1	0.07	280	250	26	1	
3	1-3	No. 1	0.06	268	353	33	1	
4	1-4	No. 1	0.06	206	248	42	1	
5	1-5	No. 1	0.04	388	387	143	1	
6	1-6	No. 1	0.06	765	2,330	305	1	
7	1-7	No. 1	0.04	1,050	1,900	459	1	
8	1-8	No. 1	0.03	220	127	177	1	
9	2-1	No. 2	0.11	990	2,830	450	3	
10	2-2	No. 2	0.06	422	6,052	398	3	
11	2-3	No. 2	0.03	533	810	420	1	
12	2-4	No. 2	0.04	265	101	326	1	
13	2-5	No. 2	0.04	199	46	370	1	
14	2-6	No. 2	0.04	91	33	360	1	
15	2-7	No. 2	0.03	143	45	488	1	
16	2-8	No. 2	0.06	338	155	365	1	
17	3-1	No. 3	0.04	186	107	275	2	
18	3-2	No. 3	0.04	80	80	223	1	
19	3-3	No. 3	0.06	90	38	456	1	
20	3-4	No. 3	0.05	49	52	263	1	
21	3-5	No. 3	0.04	67	51	266	2	
22	3-6	No. 3	0.03	109	205	281	1	
23	3-7	No. 3	0.03	55	166	346	1	
24	3-8	No. 3	0.03	91	40	218	1	
25	3-9	No. 3	0.03	157	325	252	1	
26	3-10	No. 3	0.04	130	108	698	1	
27	4-1	No. 4	0.04	55	23	255	1	
28	4-2	No. 4	0.03	73	25	135	1	
29	4-3	No. 4	0.04	59	37	180	1	
30	4-4	No. 4	0.03	66	26	272	1	
31	4-5	No. 4	0.01	92	45	165	1	
32	4-6	No. 4	0.04	53	23	100	1	
33	4-7	No. 4	0.04	186	43	176	4	
34	4-8	No. 4	0.04	287	103	301	4	
35	5-1	No. 5	0.04	51	67	75	1	
36	5-2	No. 5	0.07	89	59	80	1	
37	5-3	No. 5	0.01	89	53	90	2	
38	5-4	No. 5	0.04	70	65	86	1	
39	5-5	No. 5	0.03	43	55	82	1	
40	5-6	No. 5	0.01	89	43	72	1	

Ser. No.	Sample No.	Trench No.	Assay Result					Remarks
			Au (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	
41	5-7	No. 5	0.09	60	96	33	1	
42	5-8	No. 5	0.03	88	62	75	1	
43	6-1	No. 6	0.14	78	30	49	1	
44	6-2	No. 6	0.16	60	31	31	1	
45	6-3	No. 6	0.11	62	54	33	2	
46	6-4	No. 6	0.14	53	27	25	1	
47	6-5	No. 6	0.11	45	24	19	1	
48	6-6	No. 6	0.11	88	31	46	2	
49	6-7	No. 6	0.10	90	28	42	1	
50	6-8	No. 6	0.17	211	60	103	11	
51	6-9	No. 6	0.14	66	27	42	15	
52	6-10	No. 6	0.19	103	38	83	2	
53	6-11	No. 6	0.13	75	26	27	8	
54	6-12	No. 6	0.13	63	32	55	1	
55	6-13	No. 6	0.11	62	39	87	1	
56	7-1	No. 7	0.04	83	226	310	1	
57	7-2	No. 7	0.04	81	185	233	1	
58	7-3	No. 7	0.03	126	126	428	1	
59	7-4	No. 7	0.05	86	675	345	2	
60	7-5	No. 7	0.07	60	376	226	1	

Ser. No.	Sample No.	Trench No.	Assay Result					Remarks
			Au (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	
61	7-6	No. 7	0.03	55	755	246	2	
62	7-7	No. 7	0.04	63	380	241	3	
63	7-8	No. 7	0.03	73	385	326	3	
64	7-9	No. 7	0.03	52	263	285	2	
65	7-10	No. 7	0.07	53	556	238	3	
66	8-1	No. 8	0.01	72	430	530	2	
67	8-2	No. 8	0.03	56	950	388	1	
68	8-3	No. 8	0.08	28	180	330	1	
69	8-4	No. 8	0.05	19	470	168	1	
70	8-5	No. 8	0.06	28	220	281	2	
71	8-6	No. 8	0.04	123	705	545	1	
72	8-7	No. 8	0.03	68	950	465	1	
73	8-8	No. 8	0.04	25	610	265	1	
74	8-9	No. 8	0.05	26	856	270	1	
75	9-1	No. 9	0.08	35	346	148	1	
76	9-2	No. 9	0.08	35	510	162	1	
77	9-3	No. 9	0.13	52	243	223	1	
78	9-4	No. 9	0.13	53	48	165	1	
79	9-5	No. 9	0.71	58	57	193	1	
80	9-6	No. 9	0.09	43	56	186	1	

Ser. No.	Sample No.	Trench No.	Assay Result					Remarks
			Au (ppm)	Cu (ppm)	Pb (ppm)	Zn (ppm)	Mo (ppm)	
81	9-7	No. 9	0.11	42	30	142	2	
82	9-8	No. 9	0.10	31	50	143	1	
83	10-1	No.10	0.03	36	290	80	1	
84	10-2	No.10	0.10	90	81	120	1	
85	10-3	No.10	0.01	70	41	52	1	
86	10-4	No.10	0.07	386	375	123	1	
87	10-5	No.10	0.01	69	91	220	1	
88	10-6	No.10	0.04	56	33	58	1	
89	10-7	No.10	0.03	49	34	103	1	
90	10-8	No.10	0.04	43	37	85	1	
91	10-9	No.10	0.04	53	96	86	1	

PART V

CONCLUSIONS AND RECOMMENDATIONS

Chapter 1 Bambangan (A, a) Area

1-1 Conclusions

To confirm the occurrence of porphyry copper type ore deposit, geological survey, geophysical (CSAMT method, IP.SIP method) survey and drilling were carried out.

The following conclusions are summarized from the results of these surveys.

1. Regarding two known small outcrops along the Bambangan creek, no continuation downward was resulted by drilling, consequently the mineralization is seen small and local.

2. As a result of CSAMT survey, three low resistivity zones (A-1, A-2, A-3) were detected. Among these, A-1 anomaly, which is located the closest to the Mamut ore deposit, was followed by IP.SIP geophysical survey.
   The result of this survey led to confirm the IP anomaly (F.E. 3 - 4%) and it was suggested that the anomaly indicates the occurrence of the mineralized zone.

3. The diamond drilling (hole MJM-8) confirmed IP anomaly as a blind porphyry copper type mineralized zone, having pyrite and minor amount of chalcopyrite.

4. The above said mineralized zone, was finally verified by the follow- up drilling (seven holes including the hole of MJM-8). The following characteristics were found.
   1) It occurrs in adamellite porphyry and in the surrounding rocks (hornfels and peridotite),
   2) The scale of mineralized zone is about 400 m in N-S direction, about 200 - 250 m in E-W direction and about 90 m of thickness in the central part,
   3) From the results of seven holes, including the better part in one hole of MJM-8 (which is shown as 110m of which, Cu 0.44%, Au 0.2g/t, Mo 59ppm), the average gradee of 91.4m thickness are Cu 0.14%, Au 0.07%, Mo 31ppm, however, lower grades than these of the Mamut ore deposit (Cu 0.56%, Au 0.6g/t),
   4) There is a thick occurrence of the Pinosuk Gravels (70 - 170 m thick), from the surface to the top of mineralized zone.

5. According to the above mentioned result, the Bambangan creek mineralized zone has a low potential for development.

6. However, it is suggested that some mineralized zone which may be the similar zone as these of the Bambangan, occur in some places underneath of the Pinosuk Gravels.

1-2 Recommendations

From the conclusions summarized above, the following recommendations can be mentioned.

1. So far at the results to be of the present stage are concerned, the mineralized zone (average grade of Cu 0.14%) found in the survey, gives low indications to be of economic values.

2. However, in A-area other than the A-1 area, two low resistivity zones were detected by CSAMT method. Among these, A-3 zone in Kundasang side seems to have a relation with mineralization, but no further survey has been done. Therefore, for this anomaly (A-3), the follow-up IP.SIP geophysical survey (drilling based upon the results of IP.SIP survey) is considered necessary.

Chapter 2 Mankadau (B, b) Area

2-1 Conclusions

The area has been drawn the attention as having the floats of high grade massive sulphide copper ore (Cu 25 - 60%), chromite ore deposit and its floats distribution.

Geological, geochemical (soil) and geophysical (CSAMT method) surveys were carried out in this area.

The following conclusions are summarized from the results of these surveys.

1. The source of origin and occurrenes of the floats of high grade massive sulphide copper, taking into account the nature previously known of the ore (bearing in spilitic basalt as Cyprus type), have not yet been found.
   Some amount of floats of chromite ore was found in the upper stream of the Lingangaa creek, in the same creek where floats of high grade massive sulphide copper distribute.

2. The outcrop of the Paranchangan chromite ore deposit could not be observed because the old trenches appear to have been collapsed, and observing only the lump of massive chromite ore mixed up with the waste and the low-grade disseminated zone surrounding the massive ore deposit, can be observed. Judging from these fact and old data, lateral extent of the chromite ore body is approximately 15 m x 6 m with a grade of Cr_2O_3 about 30%.
   The distribution of dunite, which is essential to the occurrence of chromite ore deposit, is rarely found in the area.

3. In spite of the execution of geochemical and geophysical surveys, neither indication nor anomaly suggesting the occurrence of mineralized zone of copper and chrome were confirmed.

4. As the results of surveys mentioned above, the area has a low potential for finding a economical ore deposit for development.

2-2 Recommendations

From the conclusions stated above, no further survey is seen necessary, because no prospective occurrences and indications have been obtained there.

Chapter 3 Paliu (c) Area

3-1 Conclusions

Geochemical anomalies (stream sediments) of Cu, Pb, Zn are to be detected by the collaborative exploration work between Malaysia and West Germany. Occurrence of a lineament which is similar to these of the Mamut ore deposit area by the interpretation of Landsat imagery.

In order to verify these sources and their nature, geological, geochemical surveys (stream sediments, soil) and trenching were carried out during Phase I and II.

The following conclusions are summarized from the results of these survey.

1. The ring-shaped lineament was due to the intrusion of granodiorite porphyry including large size of stock and the surrounding small stocks and dikes.

2. In the surrounding area of the intrusives of granodiorite porphyry, it was confirmed a weakly altered zone of porphyry copper type, bearing pyrite, pyrrhotite with rare chalcopyrite as the shape of dissemination/stringer. However, the grade of dissemination and alteration is rather weak.

3. No geochemical anomalies by stream sediments were detected. However, geochemical anomalies by soil were found as only weak anomalies (showing maximum value of Cu 383 ppm, Pb 406 ppm, Zn 282 ppm) in the central area.

4. Total ten trenches were excavated within the above mentioned geochemical anomalies, located in and around the boundary of granodiorite porphyry and the Trusmadi Formation.
   However, no distinct mineralization has been found in the trenches excepting some anomalous values obtained from some trenches, such as Cu 0.1% in No. 1 trench, Pb 0.2 - 0.6% in No. 2 trench and Au 0.1 - 0.19 g/t in No. 6 trench.

5. According to the results of survey mentioned above, the area has a low potential for finding a economical ore deposit.

3-2 Recommendations

As stated above conclusions, because of no significant altered zone, mineralization and geochemical anomalies have been detected for the following up, no further exploration work is considered necessary.