PART Ⅲ GEOCHEMICAL SURVEY

1. GENERAL REMARKS

It is experimentally obvious that geochemical survey for stream sediments is one of the most effective prospecting methods to delineate more promising areas for ore deposits from a broad unsurveyed or reconnaissance surveyed areas. Geochemical soil survey is also very useful one to determine the extent and intensity of mineralized zones distributed in previously semi-detailed and/or detailed surveyed areas.

As shown in Table III–1, the reconnaissance geochemical survey for stream sediments was carried out jointly with the geological survey in an area of 4,300 sq.km in the first phase of the Northwestern Luzon Project, and stream sediment samples of 1,067 pieces were collected along the geological survey routes.

In Phase II, the geochemical semi-detailed survey was conducted in the four areas selected as more promising area by the first phase survey, and 1,971 samples of stream sediment were taken from the four surveyed areas (an area of 1,800 sq.km in total). After completing the semi-detailed geological and geochemical surveys, four small areas were delineated to be conducted detailed investigations on the basis of the results of the semi-detailed surveys.

Detailed geochemical soil investigation was done in the said four areas, an area of 180 sq.km, and 657 samples were collected along the geological survey routes.

In the Phase III, the final phase, of this project, detailed geochemical survey with higher sampling density was conducted in the two areas (25 sq.km in total) delineated as the most promising area for ore deposits from the Phase II detailed surveyed areas, and 511 soil samples were obtained.

The stream sediment samples collected in Phase II and the soil samples taken from one of the two surveyed areas in Phase III were analyzed by BMG in Manila, and the rest samples were also analyzed in Japan.

In consequence of these surveys, 10 geochemical anomalous zones were obtained in Phase I and 14 zones in the four semi-detailed survey areas in Phase II. The anomalous zones in the Phase II include most of the zones obtained in Phase I. A great number of anomalous zones were also detected by the geochemical detailed surveys in Phase II and III.

The distribution of the above-stated anomalous zones are obviously consistent with that of mineralized zones, and the results of these surveys are very useful to delineate promising areas. Especially, the geochemical soil survey with high sampling density is the most suitable method to clarify the extent of distribution of mineralized zones and to presume the intensity of mineralization.

Table III–1 Details of Geochemical Survey in Project Area

Phase	Accuracy of Survey	Analyzed Sample	
		Stream Sediments	Soil
Phase I	Reconnaissance Survey	Name of Area : Whole area An Area : 4,300 km^2 Number of Sample : 1,117 pcs Sampling Density : 0.25 pcs/km^2 Indicator Element : Cu · Zn	
Phase II	Semi-detailed Survey	Name of Area : Abra, Solsona, Bontoc Kabugao An Area : 1,800 km^2 Number of Sample : 1,971 pcs Sampling Density : 1.10 pcs/km^2 Indicator Element : Cu · Zn	
	Detailed Survey		Name of Area : Bucloc, Ableg, Lacub Malibcong An Area : 180 km^2 Number of Sample : 657 pcs Sampling Density : 3.65 pcs/km^2 Indicator Element : Cu · Zn
Phase III	Detailed Survey		Name of Area : Manikbel, Layacan An Area : 25 km^2 Number of Sample : 511 pcs Sampling Density : 20.44 pcs/km^2 Indicator Element : Cu

2. GEOCHEMICAL STREAM SEDIMENTS SURVEY

2–1 Survey Method and Treatment of Analytical Data

2–1–1 Survey Method

In order to collect much and better information on mineralization from the whole survey area, the reconnaissance geochemical stream sediments survey in Phase I was planned to cover the area as widely and equally as possible. However, the principal rivers were chosen as the geological and geochemical survey traverses and all samples were taken from several tributaries of the principal rivers as one sample per one tributary without considering of the scale of their basins. As the result, the sampling intervals are conflicting and there are some striking differences among the represented extents of each sample. The average of sampling density is 0.25 pieces per sq.km.

In Phase II, the semi-detailed geochemical stream sediments survey was undertaken in four areas, namely; Abra, Solsona, Bontoc and Kabugao. The geochemical anomalous zones obtained by the reconnaissance survey in Phase I are located in these four areas.

In this phase survey, the main tributaries and their branches were selected as the survey traverse to avoid overlapping with the Phase I sampling location and to cover a wider area. Sampling sites were arranged to divide affected extent of each samples as equally as possible. The sampling density of this survey was increased to 1.10 sample/sq.km as compared with 0.25 sample/sq.km of Phase I.

Each stream sediments sample was collected by direct sieving under running water. Care was taken to avoid contamination of the sample with organic materials and bank sediments to minimize sampling errors. The samples collected from each site were placed in vinyl bags for delivery to the base camp. After drying, all collected samples in Phase I were analyzed quantitatively for Cu and Zn in Japan by the atomic absorption method, and also all samples in Phase II were analyzed by BMG in Manila by the same method as in Japan.

The analytical procedure is mentioned as follows.

1 gram of sample was taken and digested with 5ml of concentrated HNO_3 and 3ml of $HClO_4$ on a sandbath until white vapor appeared. After cooling, dissolution was accomplished by addition of 5ml of HNO_3 (1:2). The solution was made up to exactly 20ml by adding distilled water. The sample solution is filtered and the filtrate was analyzed by the atomic-absorption spectrophotometry using wave lengths of 3247 Å for Cu and 2139 Å for Zn.

2–1–2 Treatment of Analytical Data

The analytical data of 1,067 samples of the Phase I and 1,971 samples of the Phase II surveys were treated to delineate the geochemical anomalous zones by adopting the simplified statistical treatment method of Lepeltire (1969). The mean background value (b), the threshold value (t) and subsidiary threshold values (t', t'') were obtained from the cumulative frequency distribution graph and they are shown in Table III–2.

Table III–2 Regional Mean Background and Threshold Values of Phase I and II Surveys (Stream Sediments)

		b	t'	t	t''	2 t	2 t''	Number of Samples
Phase I	Cu	32 ppm	72 ppm	125 ppm	ppm	250 ppm	ppm –	pcs 1,067
	Zn	58	–	120	187	–	374	
Phase II	Cu	48	115	170		340		1,971
	Zn	60	150	250		500		

b : Mean background value
t : Threshold value
t', t'' : Subsidiary threshold values

Generally the various representation methods had been used to draw the geochemical anomalies on the map. Here the anomaly was drawn with an area of sampled river basin patterned with the combination of the kind of indicator elements, and the intensity of anomaly based on the idea that the metal contents of stream sediments at the sampling site are influenced by sediments flowed from the whole of its basin. In this case, it can be deduced that the geochemical anomaly obtained from certain sample lies within the basin including its sampling site. Therefore the patterned anomalous zone has an advantage of showing directly the area that should be surveyed in next phase. On the contrary, over-estimating the anomalous zone is avoided because evaluation it by one sample is considered parallel to the evaluation of basin without considering its scale. During the estimation of the anomalies, the relation between its intensity and the scale of the basin should be carefully considered.

2–2 Result of Survey

As the result of the treatments of the analytical data, many geochemical anomalous zones were detected in each surveyed area. Details of each anomalous zone are as follows:

2–2–1 Geochemical Anomalous Zones of Phase I

The anomalous value was defined as the value higher than the subsidiary threshold value t' (72 ppm Cu) and the threshold value t (120 ppm Zn) in this phase. Consequently, ten geochemical anomalous zones are obtained around the peripheral portions of plutonic rocks as shown in PL. 3.

(1) Solsona River anomalous zone

This anomalous zone is situated in the upper streams of the Solsona River. The zone is not so intense but closely distributed. The maximum values are 239 ppm Cu and 99 ppm Zn. The zone overlies the area where gabbro is distributed. A chalcopyrite-pyrite-quartz vein (15 cm in width, Cu: 19.90%) forming a portion of the Solsona mineralized zone, was observed in this anomalous zone.

(2) Palsuguan River anomalous zone

This anomalous zone is widely distributed in the middle to upper part of the Palsuguan River. The zone is composed of Cu and Zn anomalies which are not so intense, but closely distributed. The maximum values are 194 ppm Cu and 311 ppm Zn. In this zone, the Palsuguan mineralized zone consisting of pyrite-dissemination are recognized in various places along the main stream of the Palsuguan River. A small amount of disseminated chalcopyrite is observed in the quartz diorite.

(3) Malanas River anomalous zone

This anomalous zone is situated in the middle to lower part of the Malanas River, and composed of Cu and Zn anomalies. The maximum values are 99 ppm Cu and 219 ppm Zn. In the main part of the zone, andesitic rocks of the Licuan Group are extensively distributed, and granodiorite occurred in the eastern margin of this area. Although remarkable mineralization is not observed in the main part of the zone, a small amount of pyrite dissemination forming a part of the aforementioned Lacub mineralized zone was recognized in the east end of the zone.

(4) Bucloc River anomalous zone

This anomalous zone extends over the basins of the Bucloc and Ikmin rivers. The zone is composed mainly of many Cu anomalies which are not so intense and not so closely distributed. The maximum values in the zone are 157 ppm Cu and 129 ppm Zn. The zone is mainly located in granodiorite mass. In the central part of the zone, both Bucloc and Manikbel mineralized zones are localized consisting mainly of disseminated pyrite and chalcopyrite. In the western part, on the other hand, the Ikmin mineralized zone consisting mainly of disseminated pyrite and pyrite-quartz veins are confirmed.

(5) The upper stream of the Bucloc River anomalous zone

This anomalous zone is situated in the upper stream of the Bucloc River. It is marked by intense Zn anomalies with the maximum value of 565 ppm Zn. In the zone, andesite lava and its pyroclasitic rocks of the Licuan Group Formation II are widely scattered. A remarkable mineralization is not observed in the zone, with the exception of a small amount of disseminated pyrite in andesite lava.

(6) The Layacan River anomalous zone

This anomalous zone is located in the middle to upper part of the Layacan River. The zone is composed of Cu and Zn anomalies accompanied by very high values, but distributed sporadically. The maximum values are 1,066 ppm Cu and 944 ppm Zn. In the zone, basalt lava of the Licuan Group Formation I is acknowledged, and in the western half of this zone, the Layacan mineralized zone which consists of chalcopyrite-bornite vein (20 cm in width, Cu 32.76%) and pyrite dissemination along cracks in basalt lava, and pyrite dissemination around quartz diorite porphyry dike was distinguished. Eastern part of the zone, a remarkable mineralization is not observed.

(7) The Balilian River anomalous zone

This anomalous zone is situated in the lower reaches of the Balilian River, a branch of the Chico River. The zone is composed of Cu and Zn anomalies which are not so intense, but closely distributed. The maximum values are 153 ppm Cu and 332 ppm Zn. In the zone, basalt lava of the Licuan Group Formation I and pyroclastic rocks of the Tineg Formation are localized. A remarkable mineralization as well as partial silicification and pyritization in the Tineg Formation were observed.

(8) The Lenneng River anomalous zone

This anomalous zone is situated at 5 km south of Kabugao. The zone is composed of Cu and Zn anomalies with the maximum values of 164 ppm Cu and 246 ppm Zn. This zone is composed of granodiorite and pyroclastic rocks of the Licuan Group Formation II. Pyrite dissemination accompanied by a small amount of chalcopyrite is partly observed in quartz diorite porphyry dikes intruding the granodiorite in the northern part of this zone.

(9) The upper stream of the Tineg River anomalous zone

This anomalous zone is situated in an area of approximately 11 sq.km in the upper most part of the Tineg River. The zone is composed of a few but relatively intense anomalies of Cu and Zn. The maximum values are 368 ppm Cu and 246 ppm Zn. The zone is in the quartz diorite mass where several silicified zones are discernible and partly accompanied by dissemination and micro-veinlets of pyrite.

(10) The upstream of the Binongan River anomalous zone

The anomalous zone is situated in the eastern portion of Malibcong, upstream of the Binongan River. The zone is composed of relatively intense anomalies of Cu and Zn. The maximum values are 292 ppm Cu and 510 ppm Zn. In this zone, andesite lava of the Licuan Group Formation II intruded by quartz diorite are distributed. Around the intrusive contact between the andesite lava and quartz diorite, the Dorao mineralized zone which consists of pyrite disseminations accompanied by a small amount of chalcopyrite is localized. The stream sediment sample indicating the maximum value of Cu were taken from a small creek near an outcrop of the pyrite-dissemination.

Besides the anomalous zones mentioned above, there are many anomalies in various places such as the basin of the Apayao River, the Bulney River, the middle part of the Tineg River, the middle part of the Binongan River, the mouth of the Baren River and so on. However, neither anomaly is closely distributed.

2–2–2 Geochemical Anomalous Zones of Phase II

The semi-detailed geochemical investigations for stream sediments were conducted in the Abra, Solsona, Bontoc and Kabugao areas where the remarkable geochemical anomalous zones were detected by the first phase survey. Consequently, 14 anomalous zones in total were obtained in the four surveyed areas as shown in PL. 4.

Following descriptions are details of each anomalous zone.

1. Abra Area

(1) Bucloc Anomalous Zone

This anomalous zone is equivalent to the central part of the Bucloc River anomalous zone of the Phase I survey, and it is located on the divide between the Bucloc and Ikmin rivers. It has an area of 7 km E-W and 5 km N-S. The maximum value is 488 ppm Cu with 326 ppm Zn.

The zone is located in an area underlain by plutonic rocks of granodiorite and quartz diorite partly intruded by dacite and quartz diorite porphyry dikes. Most part of this anomalous zone lies in the Bucloc mineralized zone consisting of dissemination of pyrite with a few amount of chalcopyrite.

(2) Manikbel Anomalous Zone

This anomalous zone having an area of 6 km E-W and 5 km N-S is distributed in the northern portion of Ud-Udiao in the upper stream of the Manikbel River. This zone consists mainly of Cu anomalies with the maximum values of 793 ppm Cu and 746 ppm Zn.

The zone overlies andesite lava of the Licuan Group Formation II and quartz diorite, and a granodiorite stock is exposed in the central part of this anomalous zone. Around the stock, many pyrite-disseminated outcrops with a small amount of chalcopyrite occurred. These outcrops are the main component of the Manikbel mineralized zone.

(3) Lacub Anomalous Zone

This zone covering an area of 8 km N-S and 5 km E-W is situated around Barrio Lacub in the middle stream of the Binongan River. Most part of the zone is composed of Cu anomalies with few anomalies of Zn, but southern part of this zone containes abundant Zn anomalies. The maximum value is 519 ppm Cu with 447 ppm Zn.

The distribution of this anamalous zone is almost coincident to that of granodiorite. The northern part of this zone covers the Lacub mineralized zone consisting mainly of dissemination of malachite, chalcopyrite and pyrite, and the distribution of Cu anomalies is consistent with the extent of the mineralized zone. The southern part of the anomalous zone overlies the Rapuaran mineralized zone but Cu anomalies is very few due to no copper minerals in the Rapuaran mineralized zone.

(4) Malibcong Anomalous Zone

This zone is situated on the northeastern foot of Mt. Madocay in the middle stream of the Binongan River. The zone is equivalent to the Binongan River anomalous zone of the Phase I but it was separated from the said zone because this zone is characterized by dominant Cu anomalies.

This anomalous zone is distributed along the contact between andesite lava of the Licuan Group Formation II and granodiorite, and in the northern part of granodiorite the Malibcong mineralized zone composed of dissemination of pyrite chalcopyrite and malachite.

(5) Upstream of Binongan River Anomalous Zone

This anomalous zone has a wide area of 8 km N-S and 4 km E-W and is situated in the eastern portion of the above-mentioned Malibcong anomalous zone.

The zone is marked by dominant Zn anomalies in contrast to the Malibcong anomalous zone, and few Cu anomalies are observable only in the northern part and the south-end of this zone. The maximum values are 1,777 ppm Zn and 240 ppm Cu.

The anomalous zone overlies quartz diorite, granodiorite and andesite lava are distributed, but a remarkable mineralization is not observed.

2. Solsona Area

(1) Upstream of Solsona River Anomalous Zone

This anomalous zone which is equivalent to the Solsona anomalous zone of Phase I, is situated in the upstream of Solsona River with an area of 1.5 km E-W and 2 km N-S.

The zone is composed of some high Cu and Zn anomalies with maximum values of 892 ppm Cu and 1,915 ppm Zn. In this zone, gabbro, andesite lava of the Licuan Group Formation II and limestone of the Alava Formation are distributed, and numereous of pyrite-disseminated outcrops are exposed in the marginal part of the gabbro mass distributed in the northern half of this zone.

(2) Upstream of Madongan River Anomalous Zone

This anomalous zone is a part of the Palsuguan River anomalous zone of Phase I and it is situated in the uppermost part of the Madongan River with an area of 4 km E-W and 3 km N-S.

The zone is composed of high Cu and moderate Zn anomalies. The maximum values are 509 ppm Cu and 244 ppm Zn.

Andesitic pyroclastic rocks of the Licuan Group Formation II are widely distributed in this zone and quartz diorite porphyry stocks and dykes intruded into the rocks in some parts. In the western part of this zone, the Bully Bueno ore deposits which is under construction at present by the Hercules Minerals and Oils, Inc..

(3) Upstream of Palsuguan River Anamalous Zone

This anomalous zone which is a part of the Palsuguan River anomalous zone of Phase I is situated in the northern side of the upstream of the Palsuguan River and has an area of 3 km E-W and 5 km N-S. The zone is composed only of low Cu anomalies.

In the zone, andesite lava and andesitic pyroclastic rocks are widely distributed, and quartz diorite and quartz diorite porphyry intrude them as stock and/or dyke. No remarkable mineralization is observed in the Phase II survey.

(4) Middle Stream of Palsuguan River Anomaous Zone

This anomalous zone is situated in the northern side of the middle stream of the

Palsuguan River with an area of 4 km E-W maximum and 5 km N-S.

The zone is composed of Cu and Zn anomalies closely distributed with the maximum values are 233 ppm in Cu and 530 ppm in Zn.

This zone is composed of andesite lava and its andesitic pyroclastic rocks with some quartz diorite porphyry dykes trending NE-SW. Pyrite dissemination and network forming the Palsuguan mineralized zone are distributed near the dykes.

3. Bontoc Area

(1) Balilian River Anomalous Zone

This anomalous zone is located along the Balilian and Amlusong rivers with a wide area of 8 km E-W and 4 km N-S.

The zone is composed of abundant Zn and a few Cu anomalies. The maximum values are 1,320 ppm in Zn and 407 ppm in Cu.

In this zone, dacitic pyroclastic rocks, dacite lava and limestone of the Tineg Formation are widely distributed, and no remarkable mineralization is observed.

(2) North Layacan River Anomalous Zone

This anomalous zone has an small area of 2 km E-W and 2 km N-S situated in a creek of the northern side of the lower stream of the Layacan River. The zone is composed of dominant Zn anomalies. The maximum value is 724 ppm Zn with 220 ppm Cu.

In this zone, dacitic pyroclastic rocks are distributed with no remarkable mineralization.

(3) Layacan River Anomalous Zone

This anomalous zone is situated in the southern side of the lower stream of the Layacan River with an area of 2 km E-W and 2.5 km N-S and it is composed only of Cu anomalies with the maximum value of 1,066 ppm.

This zone is mainly composed of basalt to basaltic andesite lava of the Licuan Group Formation I and dacitic pyroclastic rocks of the Tineg Formation, and quartz diorite porphyry stocks intrude into basaltic andesite lava. A highly silicified zone (2.0m in width) accompanied by chalcopyrite-bornite-pyrite vein and several veins with remarkable pyrite dissemination are observed in the quartz diorite porphyry stocks distributed in the northern part of this anomalous zone.

4. Kabugao Area

(1) Lenneng River Anomalous Zone

This anomalous zone consisting of moderate Cu and Zn anomalies is widely separated in the eastern side of the Lenneng River with an area of 3 km E-W and 6 km N-S.

Andesite lava of the Licuan Group and limestone of the Alava Formation are distributed in this zone without no plutonic rocks and remarkable dykes. Remarkable mineralization is also not confirmed.

(2) Tawini Anomalous Zone

This anomalous zone occupying a small area of 2 km E-W and 2 km N-S is situated 1 km to the north of Barrio Tawini in the east end of the Kabugao area. This zone is composed of dominant Cu and few Zn anomalies with the maximum value of 403 ppm Cu.

Andesite lava of the Licuan Group Formation II and a stock of diorite porphyry intruding the lava are distributed in this anomalous zone and the stock is accompanied by disseminated zones of pyrite, chalcopyrite and malchite which are main outcrops of the Tawini mineralized zone. This mineralized zone is explored at present by Marcopper Mining Corp.

As stated above, most geochemical anomalous zones, particularly Cu anomalous zones show the close relationship with the distribution feature of the mineralized zones and it is evidently considered that the geochemical stream sediments survey is the most effective method to delineate promising area for mineral resources and to obtain much and better information on mineralization from a wide area.

3. GEOCHEMICAL SOIL SURVEY

3–1 Survey Method and Treatment of Analytical Data

3–1–1 Survey Method

The detailed geochemical soil survey of Phase II was conducted in the Bucloc, Ableg, Lacub and Malibcong areas which were selected as more promising area for mineralization by the Phase I survey.

The soil samples were collected along the geological survey routes previously designated to cover the area as equally as possible. In the anomalous zones detected by the geochemical stream sediments survey, the survey routes and sampling intervals were arranged more closely from each other.

In the geophysical surveyed area, the systematic grid-sampling, 200m E-W and 400m N-S, were carried out along the IP survey line. The average sampling density is 3.65 samples per sq.km.

The detailed geochemical soil investigation of Phase III was carried out in the Manikbel and Layacan areas to determine the extent of the mineralized zones. The soil samples were collected along geological survey routes with the higher sampling density and along the IP survey lines. The average sampling density is 20.44 samples per sq.km.

The soil was sampled from the accumulation zone (B horizon) and placed in vinyl bags to be sent to the base camp. The samples collected from each survey area, 657 samples of Phase II and 511 samples of Phase III, were dried naturally under the sun, and they were divided into two parts, one part for BMG and the other half were analyzed quantitatively for Cu (Phase II and III) and Zn (Phase II) by the some method of the stream sediments.

3–1–2 Treatment of Analytical Data

In order to determine the geochemical anomalous values of soil samples collected in each area, the same statistical method as the analysis of stream sediment was adopted. The statistical values obtained are summaried as Table III–3.

3–2 Result of Survey

From the results of the treatments of the analytical data of Phase II and III, remarkable anomalous zones were detected. Followings are details of each geochemical anomaous zone.

Table III–3 Regional Mean Background and Thrshold Values of Phase II and III Surveys

	Area		b	t″	t′	t	2t	3t
	Bucloc & Ableg	Cu	115	250	400	780	1,560	–
		Zn	60	–	–	100	200	300
Phase II	Lacub	Cu	70	150	210	380	760	–
		Zn	56	–	–	75	150	225
	Malibcong	Cu	50	130	210	450	900	
		Zn	75	–	–	130	260	390
Phase III	Manikbel	Cu	250	300	800	2,500	–	–
	Layacan	Cu	100	–	200	900	–	–

b : Mean Background Value
t′ & t″ : Subsidiary Threshold Value
t : Threshold Value

3–2–1 Geochemical anomalous zones of Phase II

(1) Bucloc Area

As shown in Fig. III–1, Cu anomalies are concentrated in two places, the northern and southern parts of this area. The northern anomalous zone consists of the western and eastern subzones which are located in the northern portion of Ud-Udiao. The western subzone contains four values of over t (780 ppm Cu) with the maximum value of 1,250 ppm and has an area of 0.2 – 0.3 sq.km. The eastern subzone is composed of only a anomaly point. The southern anomalous zone is distributed on the divide between the Bucloc and Ikmin rivers, and it contains six anomaly points of over t (780 ppm Cu). The maximum value of Cu is 2,741 ppm. The extent of this zone is approximately 4.0 sq.km, but from the Marcopper's data, this anomalous zone seems to extend to the southern part of the divide.

Zn anomalies show irregular distribution feature without overlapping with Cu anomalous zones. Therefore, it can be roughly said that the Zn anomalous zone is distributed as one kind of halo of Cu anomalous zone.

In the northern anomalous zone, andesite lava of the Licuan Group Formation II and batholith-shaped quartz diorite are widely distributed and these rocks are intruded by a stock of granodiorite. The Manikbel mineralized zone consisting of pyrite-desseminated outcrops with malachite, azurite and a few chalcopyrite occurs in quartz diorite near the boundary of andesite, especially around the contact between quartz diorite and the stock of granodiorite. The northern anomalous zone covers entirely this mineralized zone.

The southern anomalous zone overlies batholithic granodiorite mass with several dykes of quartz diorite porphyry intruding the mass. In this granodiorite mass, the before-mentioned Bucloc mineralized zone is formed and the distribution feature is well con sistent with that of the mineralized zone. In this anomalous zone, the high FE anomalous zones (more than 5% FE) are detected and they mostly cover the geochemical Cu anomalous zones.

(2) Ableg Area

In this area, Cu anomalous zone is represented by only one anomaly point of 540 ppm Cu, and Zn anomalous zone is detected in the center to western part of the area with the maximum value of 479 ppm Zn. Cu and Zn anomalous zone show roughly zoned distribution.

Geology of the Ableg area consists of batholith-shaped granodiorite and limestone of the Licuan Group Formation II as roof pendant. The limestone is highly skarnitized and formed skarn type mineralized zone. The geochemical anomalous zone is distributed around the limestone.

(3) Lacub Area

As shown in Fig. III–2, Cu anomalous zones consisting of more than t'' (150 ppm) points are mainly distributed in two places. One anomalous zone is situated around Barrio Lacub and its vicinity in the central part of this area. In this anomalous zone with a total area of only 1 sq.km, three higher anomalous zones of more than t (380 ppm) are distributed. The other anomalous zone is situated in about 2.5 sq.km to the SSW of Barrio Lacub, with an area of about 0.3 sq.km. The maximum value of Cu is 2,082 ppm. On the other hand, Zn anomalous zone consisting of more than t (75 ppm Zn) are widely distributed in the west and in the south-west of this area. Considering the relationship between Cu anomaly and Zn anomaly, as anomalies scarcely overlap, it seems that both are distributed independently from each other.

Most of Cu anomalies are located in granodiorite, and some of zones are in andesite lava, particularly near the contact of granodiorite mass. Zn anomalous zone is mainly distributed in andesite lava.

(4) Malibcong Area

According to Fig. III–2, Cu anomalous values of more than t'' (130 ppm) are concentrated mainly in the western part of this area, and anomalous values of more than t (450 ppm) are distributed mainly in three zones with maximum value of 1,106 ppm Cu. Zn anomaly points of more than t (130 ppm) are mainly distributed in the eastern part of this area. The maximum value of Zn is 622 ppm.

The Cu anomalous zone is distributed in granodiorite mass and/or andesite lava of the Licuan Group Formation II. Especially, the higher anomalous zone containing the anomaly points of more than 450 ppm Cu are obtained near the contact between granodiorite and andesite lava. The Zn anomalous zone is mainly distributed in andesite lava.

3–2–2 Geochemical Anomalous Zones of Phase III

The detailed geochemical soil survey was conducted in the Manikbel and Layacan areas to determine the extent and intensity of the mineralized zone. The results of this survey show the distributions of high geochemical Cu anomalous zone which are consistent with that of mineralized zones.

(1) Manikbel Area

It has been clarified by the Phase II survey that the pyrite disseminated outcrops with malachite and a small amount of chalcopyrite were distributed in this area. The detailed geochemical investigation was carried out to confine the extent of this mineralized zone and to clarify the intensity and nature of the zone in detail.

From the result of the detailed investigation, a high Cu anomalous zone covering entirely the mineralized zone are obtained as shown in Fig. III–3. It has an area of 1.5 km E-W and 1.1 km N-S. The higher anomalies, over than t' (800 ppm Cu) are detected on the outcrops containing abundant copper minerals, and it seems to show the manifest correlation between Cu anomalies and Cu mineralizations. The pyrite-disseminated zone with abundant copper minerals occur in quartz diorite near the contact with andesite lava.

The IP electric survey was carried out in the area covering the geochemical anomalous and the mineralized zones. High FE anomalous zones (over 5% of FE values) were detected in both eastern and western parts of the mineralized zone, but the distribution area is low FE anomalous zone (less than 5% FE). This may be considered to be resulted from the poor sulfide mineral in the mineralized zone, and to suggest that the mineralized zone is formed in shallow part.

(2) Layacan Area

As shown in Fig. III–3, geochemical Cu anomalous zones are obtained in the northwestern half of this area, but the intensity of anomaly is weaker than that of the Manikbel area. Only two anomaly points of over t (900 ppm Cu) are detected.

In the anomalous zone, basalt to basic andesite lavas of the Licuan Group Formation I and a stock of quartz diorite porphyry intruding the lavas are exposed and the stock is accompanied by numerous pyrite clay veins. One vein contains chalcopyrite-bornite-pyrite streak (20 cm in width). The highest anomalous point is obtained near this vein.

The distribution of the anomalous zone is mostly consistent with that of the mineralized zone but some anomalous zones are accompanied by no mineralized zones. It seems that the mineralized zone with poor copper minerals shows unclear correlation.

As above stated, most geochemical anomalous zone detected by the detailed geochemical soil surveys are evidently consistent with the distribution feature of mineralized zone, and it can be said that the geochemical soil survey with high sampling density is one of the most effective method to determine the extend of the mineralized zone in detail.

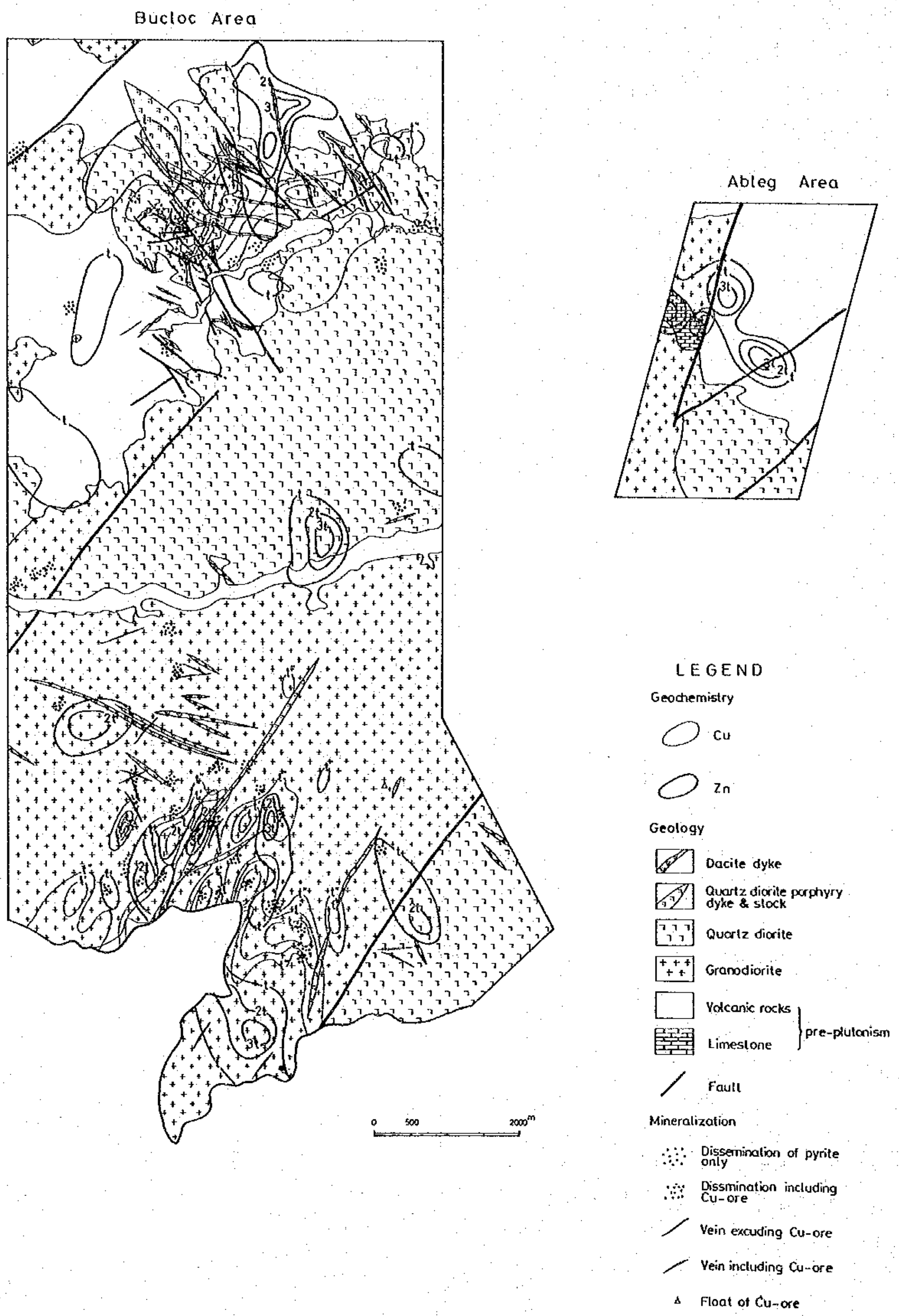


Fig. III–1 Geochemical Anomaly Map in Bucloc and Ableg Areas (Soil)

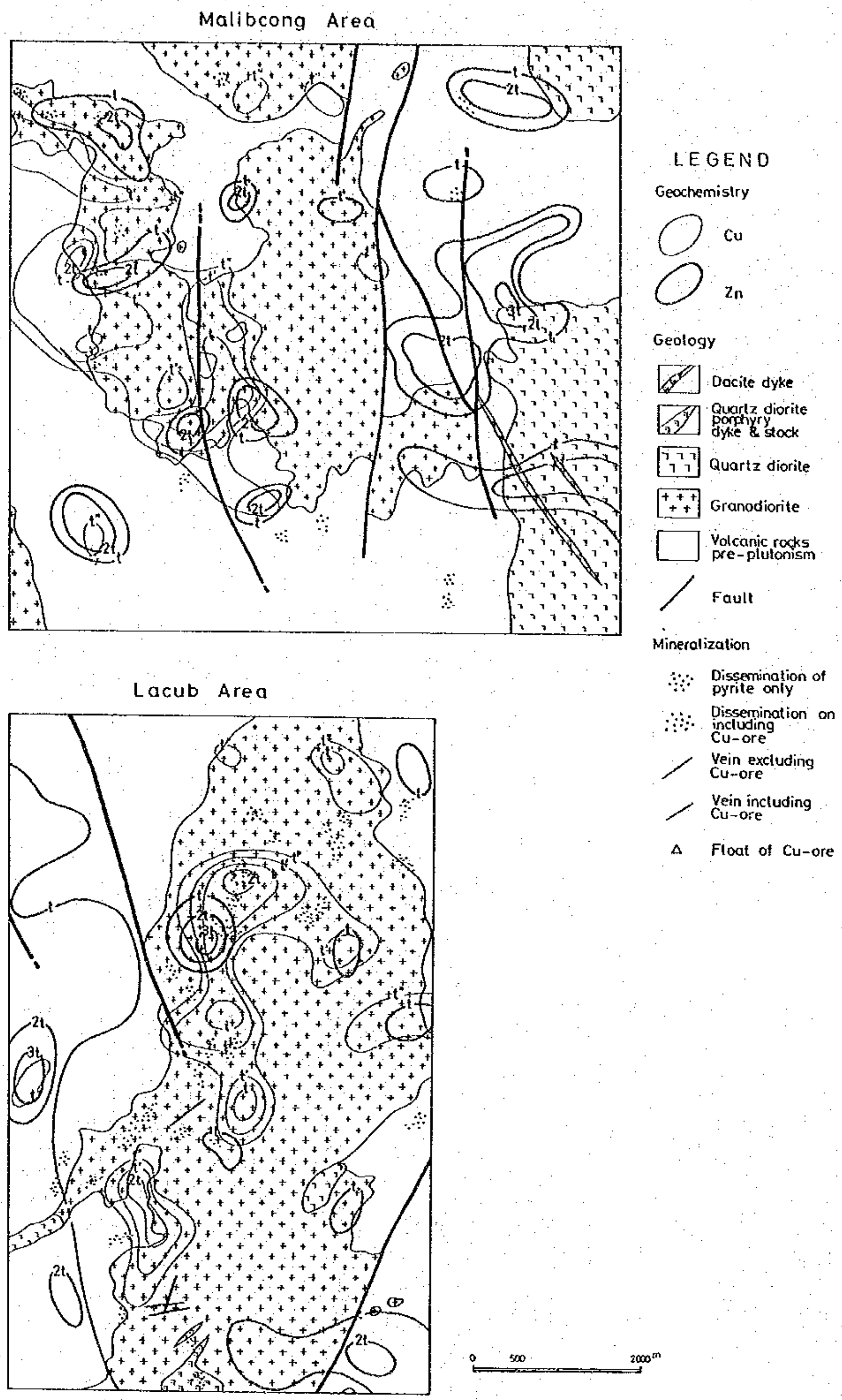
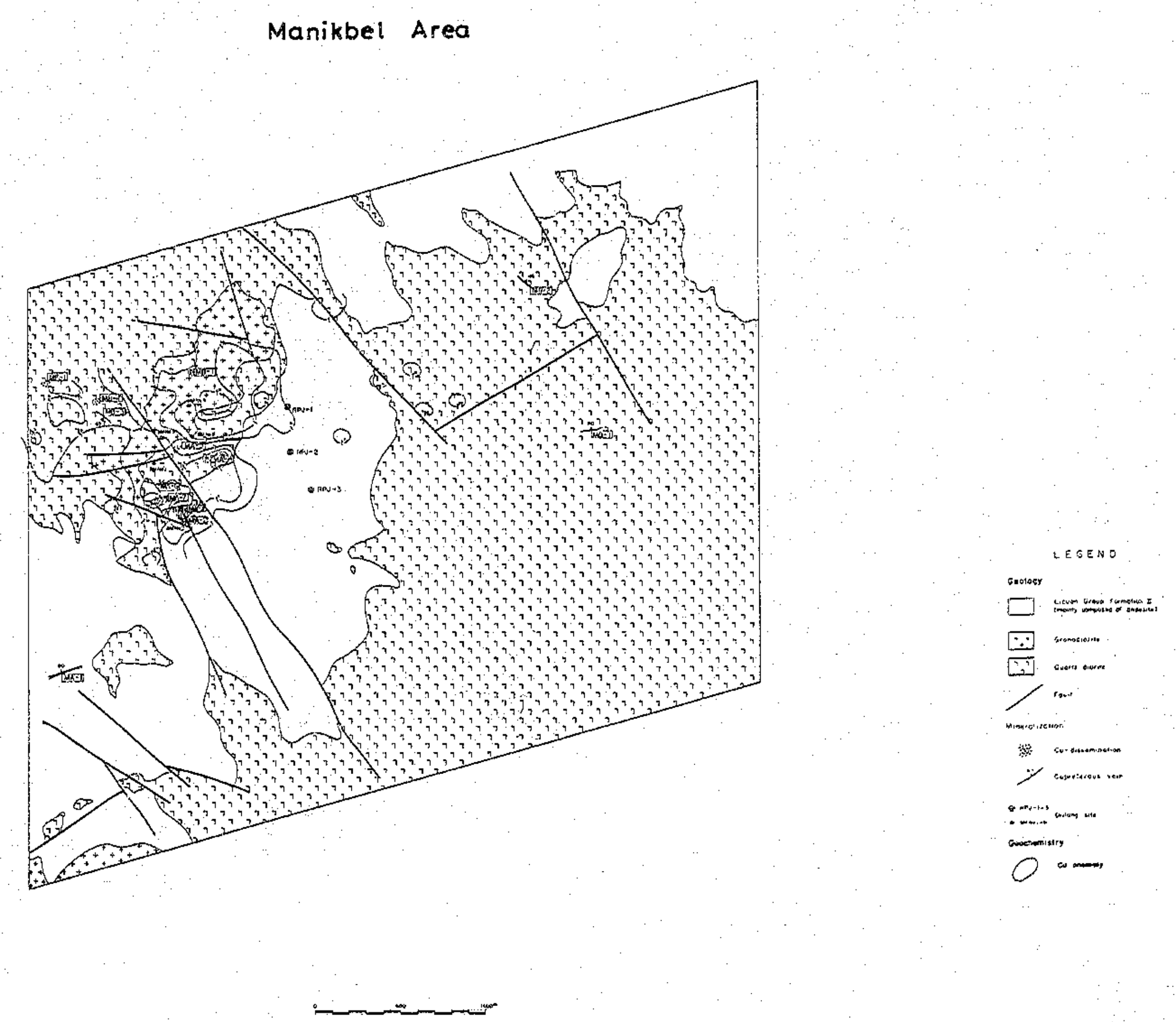


Fig. III–2 Geochemical Anomaly Map in Lacub and Malibcong Areas (Soil)



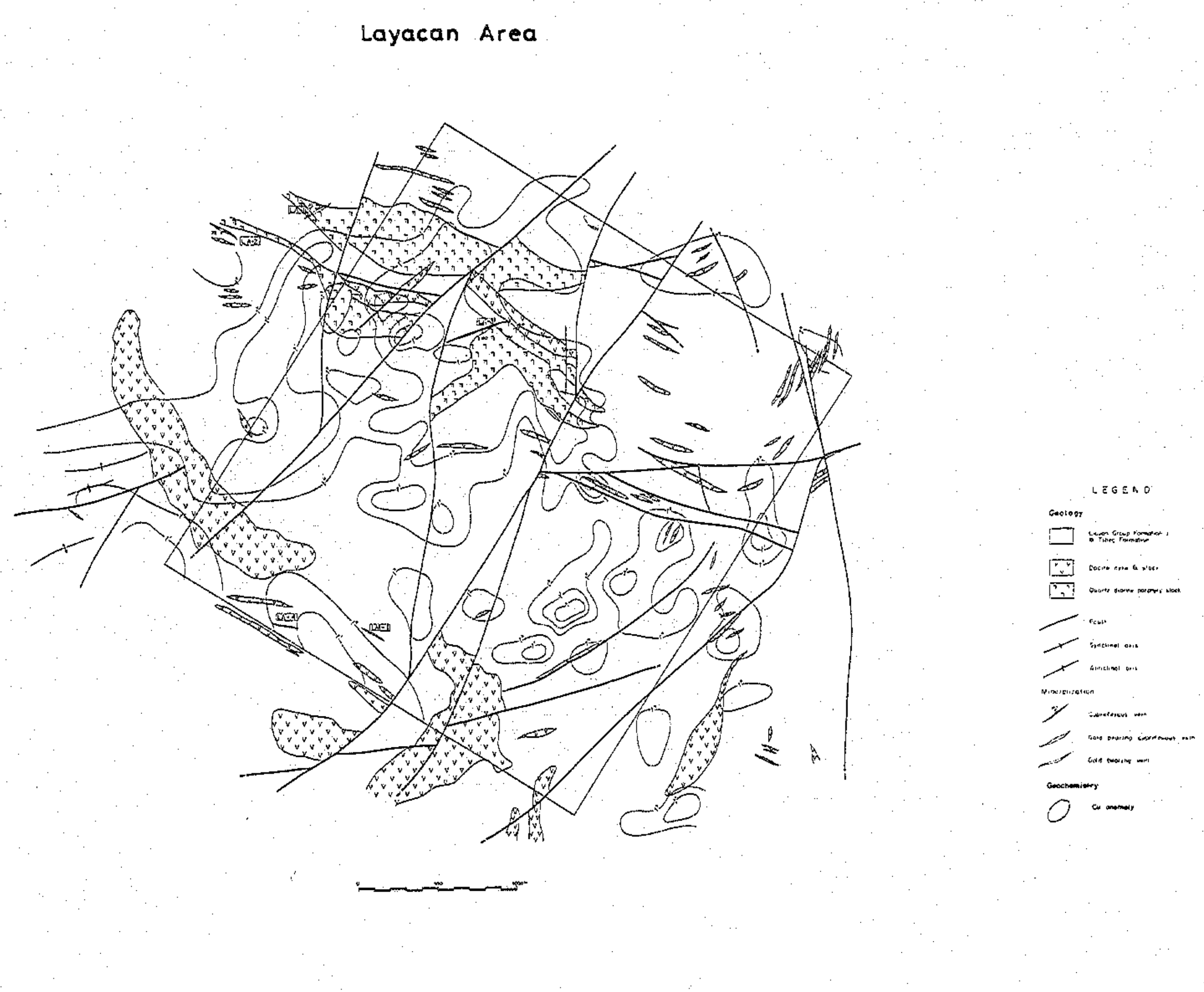


Fig. III–3 Geochemical Anomaly Map in Manikbel and Layacan Areas (Soil)

PART Ⅳ GEOPHYSICAL SURVEY

1. GENERAL REMARKS

In the second phase of the project, the IP (Induced Polarization) and ground magnetic survey were conducted in the Bucloc area, and the IP and Complex Resistivity survey were done in the third phase in the Manikbel area. The results of the aeromagnetic survey performed by NACOMES (National Committee on Mineral Exploration and Survey Operation) prior to this project, and the ground magnetic survey, are also investigated as a whole in the second phase.

The Bucloc area was chosen as having high probability of mineral deposits during the survey. The geological and geochemical reconnaissance in the first phase, and the geological and geochemical semi-detailed survey in the second phase showed that numerous pyrite mineralization were formed in the host rock of granodiorite and quartz diorite, and the Cu-geochemical high anomaly was also detected.

An IP survey was done on 56.2 Km survey lines to delineate the horizontal and vertical distribution of the mineralization in this area. As a result, IP anomaly zones of more than 5 percent FE were detected correlating with the mineralization zones. A ground magnetic survey was done on 2506 survey points for the purpose of detecting the intrusive rocks abundant in magnetic minerals, on the basis of porphyry-copper deposits located in Northern Luzon associated with magnetite.

However, the ground magnetic survey did not show significant results, because the survey area was of homogeneous granodiorite and mineralized zones containing only small amount of magnetic minerals.

The correlation of the results from aeromagnetic survey with ground magnetic survey was limited due to the delay in the analysis of aeromagnetic data, which precluded a sufficient evaluation.

The Manikbel area was chosen as having the highest probability of ore deposits from the results of the second phase, where the numerous disseminations and networks of pyrite with minor chalcopyrite are observed, particularly in the region of the contact between andesite lava and quartz diorite intruding the andesite lava. The geochemical anomaly of more than 800 ppm Cu was also detected within this mineralized zone. The IP (26.5 Km length) and Complex Resistivity (4.8 Km length) survey was carried out in order to determine the depths of these mineralizations to discriminate minerals from geochemical anomalies.

The three IP anomaly zones of more than 5 percent FE, identified closely with the low resistivity, were detected in the western, central and eastern part of the survey area. geochemical Cu anomalies are slightly coincident with these IP anomalies, and coincide roughly with low FE between the Western and Central anomaly zone. These anomalies are assumed to be induced by network mineralizations of pyrite, concentrated along fissures of andesite and/or quartz diorite, and distinctive along the region of contact between andesite and quartz diorite.

Anomalies of type "B" response were detected by the Complex Resistivity survey within the IP anomaly zones. This type "B" response has been shown to be mainly induced by network of pyrite from the physical property measurements. Type "C" response that normally shows the barren host material, was found within the geochemical Cu anomaly zones, and therefore this response indicates that copper mineralization is poor in this region. However, from a new trial of CR data processing developed by M.M.A.J., a different type of response has been detected in high frequency range within this geochemical Cu anomaly zone, and it is reported that this response is probably induced by the mineralization of copper. It is necessary to investigate further this result by the aid of additional rock sample measurements and more acquisition of field data.

Table IV–1 List of Survey Line

Bucloc Area (Phase II)

LINE	LENGTH	INTERVAL	SPACE FACTOR
A	2.2km	100m	n = 1 ~ 5
B	3.5	〃	〃
C	3.5	〃	〃
D	4.0	〃	〃
E	4.0	〃	〃
F	4.0	〃	〃
G	4.0	〃	〃
H	4.0	〃	〃
I	4.0	〃	〃
J	4.0	〃	〃
K	2.3	〃	〃
L	1.6	〃	〃
M	1.6	〃	〃
N	1.8	〃	〃
O	1.9	〃	〃
P	1.9	〃	〃
Q	1.9	〃	〃
R	2.0	〃	〃
S	2.0	〃	〃
T	2.0	〃	〃
Total	56.2km		

Manikbel Area (Phase III)

LINE	LENGTH	INTERVAL	SPACE FACTOR
A	2.5km	100m	n = 1 ~ 5
B	4.0	〃	〃
C	4.0 (1.6)	〃	〃
D	4.0 (1.6)	〃	〃
E	4.0 (1.6)	〃	〃
F	4.0	〃	〃
G	2.5	〃	〃
H	1.5	〃	〃
Total	26.5 (4.8)km		

* ( ) : For Complex Resistivity Survey

Table IV–2 List of Survey Instruments

	PHASE II	PHASE III
IP transmitter	Model CH–T7802 and CH–505, Chiba Electronics Co., Japan	Model CH–T7802 and CH–505, Chiba Electronics Co., Japan
Engine generator	Model 421, Geotronics Inc., USA	Model 421, Geotronics Inc., U.S.A.
IP receiver	Model YDC–443, Yokohama Electronic Co., Japan Model CH–R7801, Chiba Electronics Co., Japan	Model YDC–7505–B by, Yokohama Electronic Co., Japan Model CH–R7801, Chiba Electronics Co., Japan
Portable magnetometer	Model G–816, Geometrics, Inc., USA Model MP–2, Scintrex Ltd., Canada	
Station magnetometer	Model G–806, Geometrics, Inc., USA	
CR receiver		GDP–12/2G, Zonge Enginerring, USA CAP–12, 〃 ISO–12, 〃 FP–1, 〃
CR transmitter		FT–4, Geotronics Inc., USA B–2, 〃

2. IP METHOD

2–1 Outline of Survey

2–1–1 The Second Phase Survey

The IP survey for the second phase was conducted in the Bucloc area. The methods used in this investigation are a variable frequency method (0.3 Hz and 3 Hz), with a dipole-dipole array, electrode spacing of "a"=100 m, and "n"=1 to 5. Twenty survey lines spaced 100 m apart were established with a total length of 56.2 Km. Seventeen of the lines are oriented in the direction N78E, and the other 3 lines are N12W.

The geology in the survey area is generally composed of granodiorite as a batholith, and the dykes of quartz diorite porphyry and dacite intruding granodiorite. Numerous pyrite mineralizations of disseminated and network type occur in these rocks.

2–1–2 The Third Phase Survey

The IP survey for the third phase was done in the Manikbel area, with the same method used as in the second phase. Seven survey lines spaced 250 m apart were established in the direction N74 W, the others being oriented in the normal direction to them. Total length of the survey lines were 26.5 Km.

The geology in the area is characterized by andesite lava and quartz diorite intruding this lava, and both being intruded by many dykes of quartz diorite prophyry and dacite. The quartz diorite is of medium holocrystalline, and generally impregnates a large quantity of fine-grained pyrite, this mineralization is particularly developed in the region of the contact between the quartz diorite and the andesite.

The survey lines for both of phases are listed in Table IV–1, and the instruments for the survey are listed in Table IV–2.

2–2 Results of Survey

2–2–1 The Second Phase Survey

(1) A wide and strong IP anomaly zone was found in the western part of the survey area, and many other FE anomalies of small scale were detected in the southeastern part.

(2) The first anomaly has a width of about 1 Km in the NNW-SSE direction, and become weak and deep to the north. However it becomes more intense toward the south, and changes to the most intensive anomaly continuing from the surface to depths on Line G, H, T and J, and extending to the south outside of the survey area.

(3) Shallow FE anomalies within this zone and the latter anomalies coincide with the geochemical Cu anomalies.

(4) The resistivity value of granodiorite ranges between 500 and 1,000 ohm -m, and from this a low resistivity zone correlated with the argillized mineralized zone would not exist. Relation of the IP anomaly zone to the mineralized zones is that the high FE anomaly zones extending southwest starting from the ridge south of the survey area are mainly coincident with many disseminated outcrops. The most noticeable FE anomaly correlates quite well with the numerous pyrite mineralized zones associated with a strong silicification. It can be considered then that the IP survey is conspicuously an effective methods in determining the horizontal and vertical extent of mineralized zones containing abundant sulfide minerals.

2–2–2 **The Third Phase Survey**

(1) Three anomalous zone were detected in the eastern, central and western parts of the survey area.

(2) The Central anomaly zone which be largest is distributed in the N-S direction, coinciding with the low resistivity zone that extends toward the north.

(3) The Western and Eastern anomaly zones found in the area of quartz diorite, were also detected within the low resistivity zones.

(4) Consequently, the three anomalies exhibits the property of "low resistivity-high FE". Relation of these anomalies with the mineralization is that the Central anomaly zone indicates it is produced by the network mineralization abundant in pyrite, concentrated along joints and fissures. The Central and Eastern anomaly zones may be due to the pyrite network mineralizations. All of these anomalies would be accompanied by small amounts of sulfides.

(5) The geochemical Cu anomalies and the Manikbel mineralization do not conform with these FE anomalies. However, from the two drillings (station 7 and 10 on Line C, station 8 on Line E) done by the Bureau of Mines and Geo-Science, they were able to detect a 0.12 percent to 0.43 percent copper by weight from this mineralization. It can be assumed that relatively small amount of sulfides, as compared with the three distinctive anomaly zone mentioned above, would not induce enough polarization.

3. COMPLEX RESISTIVITY METHOD

Complex Resistivity method is the newest geophysical exploration tool that can remove effects of electromagnetic coupling and to discriminate between sulfide minerals, which has been problem in the IP method. The Complex Resistivity system was first introduced in Japan by M.M.A.J. and at present numerous data have been collecting by M.M.A.J. in the sites of "KUROKO" ore, vein type, disseminated deposits etc. This method was performed to test its flexibility to porphyry copper deposits, and moreover to investigate the electromagnetic coupling removal, spectral response and discrimination of sulfide minerals. The survey was conducted with assistance from Z.E.R.O. (Zonge Engineering and Research Organization).

3–1 Outline of Survey

The survey was carried out only on Line C, D and E, where the distinctive FE anomalies are detected. Each line is 1.6 Km long, with a total of 4.8 Km. The instruments used are listed in Table IV–2.

3–2 Results of Survey

(1) Anomalies of type "B" response were detected between stations 14 and 20 on Line C, D and E, correlating with the FE anomalies, and considered to be due to the pyrite mineralization.

(2) Type "C" response that normally shows the barren host materials, was found within the geochemical Cu anomaly zones, on the west end of the line. Consequently the mineralization of copper is probably quite weak at depths in this region. However, by a new method in CR data processing made by M.M.A.J. an other type response with change of the phase in high frequency range is revealed in the same area, and it is reported that there is a probability of significant mineralization (Chalcopyrite) in this region.

(3) The type "A" response such as detected in the southwestern United States as "textbook" porphyry copper spectra was not encountered in any place of the survey area.

4. MAGNETIC SURVEY

4–1 Outline of Survey

4–1–1 Aeromagnetic Survey at the Northwestern Luzon

NACOMESO (National Committee on Mineral Exploration and Survey Operation) and the Bureau of Mines and Geo-Sciences conducted aeromagnetic survey of Northwestern Luzon in 1975 and 1977.

The summary of the survey method is as follows.

1975: the area from 120° 50′E to the west coast, at 1,800 m A.S.L.

1977: the area to the east of 120° 50′E, at 2,700 m A.S.L.

The interval of main survey lines is about 2.5 Km in N-S direction and of tie lines is about 10.0 Km in E-W direction.

4–1–2 Ground Magnetic Survey

The ground magnetic survey, using portable proton magnetometers was done on the IP lines in Bucloc area, with 2,506 survey points at 50 m spacing.

4–2 Results of Survey

4–2–1 Results of Aeromagnetic Survey

There are four areas of interest judging from the magnetic response patterns.

Area I

The first area covers almost all of the project area, and is occupied by a wide positive anomaly zone with an E-W trend.

It is suggested that geotectonic lineaments with a NNE-SSW direction prevail over the area, and the plutonic rocks are controlled by the lineaments. These lineaments also coincide with the structural faults in the geological map.

Area II

The second area is situated on the northwestern edge of Area I. There is a large scale magnetic anomaly running in a NE-SW direction. The distribution of the basic rocks which cause this anomaly is controlled by the geotectonic lineaments in this direction.

Area III

The third area is located on the western side of Area I. There are less variations of the magnetic values and no distinctive anomalies. Geotectonic lineament may exist along the Abra River area, where sedimentary rocks are dominant.

Area IV

The fourth area is located on the southeastern edge of the survey area, and dominant in the anomalies of southwave type with a E-W direction. This area is separated from the Area I by the structural line of ENE-WSW direction and covered by the narrow magnetic body. The susceptibility in the area is considered to be high compared with that in Area I.

Their order in magnitude of the magnetic susceptibilities obtained is as follows.

II > IV > I > III

4–2–2 Results of the Ground Magnetic Survey

It was impossible to confirm demagnetization that indicates mineralization and alteration, especially pyritization, and there was a distinct difference between granodiorite, andesite and quartz diorite porphyry.

Summary of the results of the second and third phase.

The distinct FE anomalies detected in both of the projects are due to the pyrite mineralizations of network and disseminated type with minor chalcopyrite.

The IP results in the Bucloc area and Manikbel area show similar FE response patterns.

The FE anomalies detected at Manikbel correlate closely with the low resistivity, while in the Bucloc area they are not related to the low resistivity. Geologically, the Bucloc mineralized zone occurs in the central part of the large scale granodiorite which is hard and compact, while the Manikbel mineralized zone is located in the margin of quartz diorite and developed along the joints and fractures, and these fractures affect greatly the low resistivity.

Porphyry copper deposits are in general classified by two types, according to the induced polarization phenomenon; one is "a disseminated sulfide deposits in relatively compact and hard rocks", the other is "network and fine-vein type deposits". It is known that the latter induces more strongly IP anomaly than the former. According to this classification, the Bucloc mineralization corresponds to the former's type and Manikbel to the other.

The significant IP anomalies were not detected in the southeastern part of Bucloc area and in the vicinity of Mamising River in Manikbel area, where some mineralizations outcrop, the geochemical Cu anomalies are also found. Accordingly pyrite content in these areas is poor, consequently the total sulfide content is considered to be less than that in the high FE anomaly zone. It is not definite in the present state whether it indicates a zoning structure of pyrite-chalcopyrite in a porphyry copper deposits, however it is probable that the FE anomaly zone indicate the concentrations of pyrite, and it will be possible to discriminate the pyrite and chalcopyrite zone if the CR survey is further developed.

The CR survey conducted did not define the whole aspect of Manikbel mineralization because of the limited number of survey lines. While a different type of response (phase change in high frequency range) was detected in the geochemical Cu anomaly zones by means of the new technique developed by M.M.A.J., there is a possibility that this response indicates the existence of the copper sulfides.

It will be necessary to investigate further these results by measuring more rock samples and acquiring more field data.

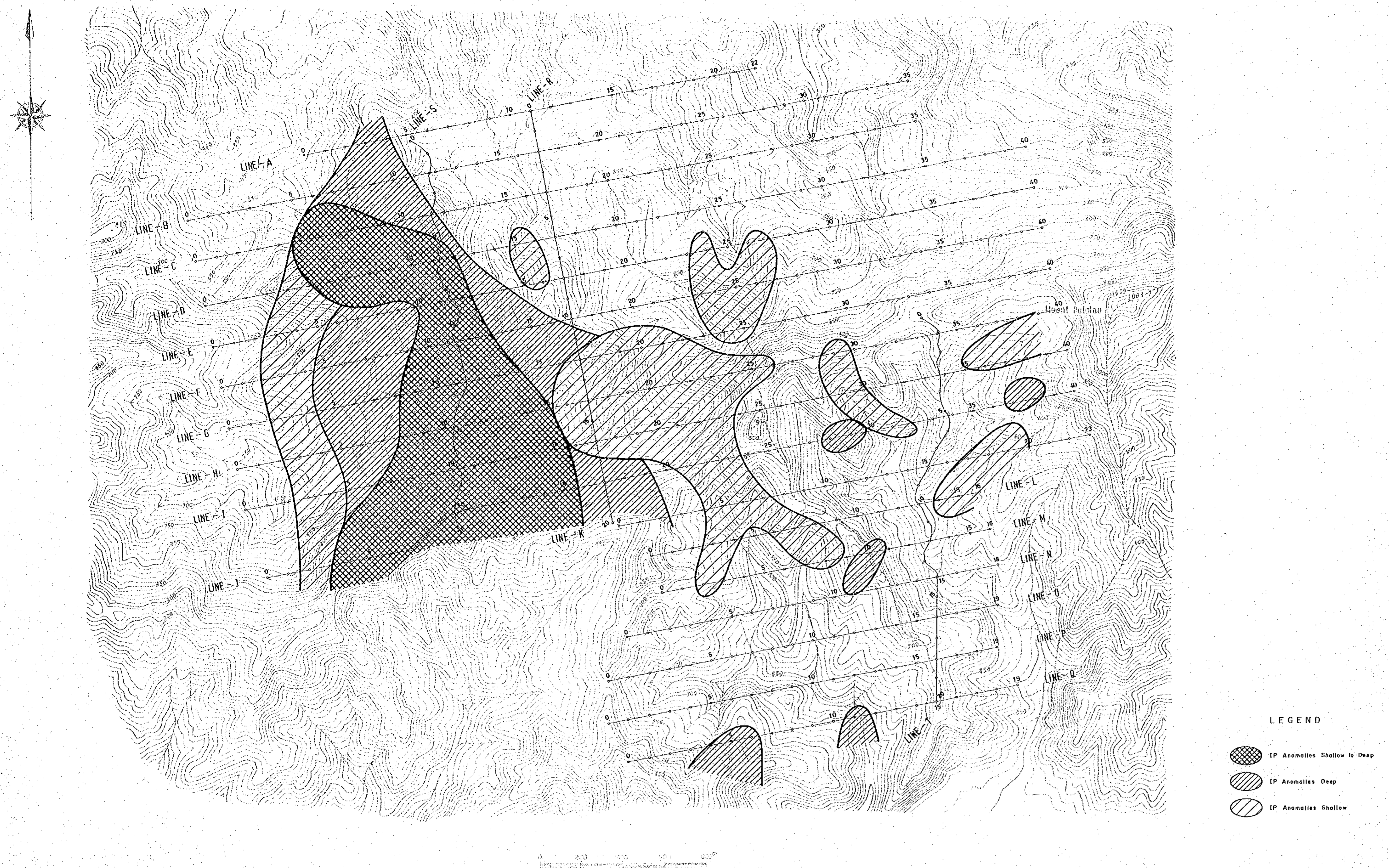


Fig. IV–1 General Interpretation Map in Bucloc Area

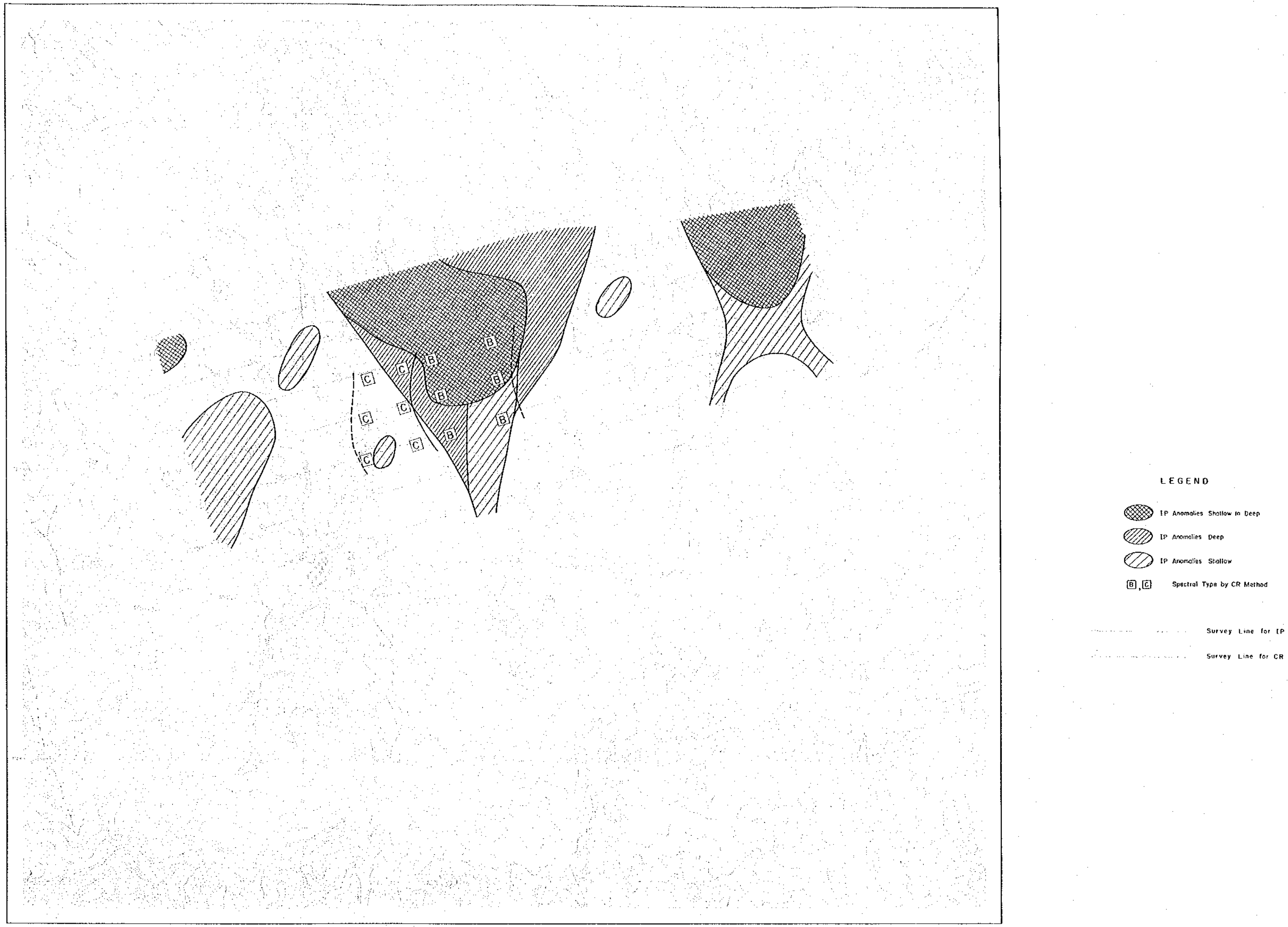


Fig. IV–2 General Interpretation Map in Manikbel Area

PART V DRILLING EXPLORATION

1. GENERAL REMARKS

The drilling exploration was conducted in the Manikbel area which was delineated as the most promising area for ore deposits from the wide project area by the phase I and II surveys. Around drilling sites, pyrite-disseminated outcrops with a small amount of chalcopyrite and abundant malachite are distributed. These outcrops are mainly formed in quartz diorite near the contact with andesite lava of the Licuan Group Formation II.

The distribution area of mineralized outcrops is entirely overlain by high Cu anomalous zone detected by the geochemical soil survey in Phase III. In both eastern and western sides of the mineralized zones, remarkable FE anomalous zones are also detected by the IP etectic survey in Phase III. Particularly, the anomalous zone in the eastern side has a wide area in lateral and vertical.

The purpose of the drilling exploration is to confirm the extent of the minerlized zone in depth and to examine the continuity and nature of the FE anomalous zone distributed in the eastern part of the mineralized zone.

The drilling operations were carried out in three shifts with wireline method using one set of drilling machine, and three holes, 932.20 m in total length, were drilled. Average drilling length per shift is 9.32 m with 98.3 % core recovery.

Besides, BMG had formerly drilled six holes (approximate lengths of each hole is 100 ~ 160 m) in which local Cu mineralizations were manifested in only one hole, BM·NO.6, but other five holes shows no remarkable Cu mineralizations.

Each drilling site is shown in Fig. V-1.

2. RESULTS OF DRILLING EXPLORATION

2–1 RPJ–1 (Drilling length : 310.00 m, Average core recovery : 99.1%)

The drilling site of RPJ–1 is located on the divide between the Manikbel River and the Mamising Creek where it is situated at 500 m east of eastern end of the mineralized zone. At about 300 m west from this site, BM·NO.6 hole conducted previously by BMG is situated. This hole corresponds to NO.15.3 of Line-C of IP survey.

Geology of this drilling site consists of andesite lava of the Licuan Group Formation II and quartz diorite intruding into the lava. The boundary between the andesite lava and quartz diorite is exposed at 70 m northwest of the site, and it gently dips towards the drilling site.

After reaching the bedrock at 8.30 m depth, coarse-grained quartz diorite showing light gray color encountered extending up to 29.20 m depth. From 29.20 to 113.10 m, andesite lava intruded by many dykes of quartz diorite, quartz diorite porphyry were observed. They are altered to hornfels. The core between 113.10 and 196.00 m depths shows complicated occurrence quarts diorite, granodiorite and quartz diorite porphyry. This occurrence seems to suggest that quartz diorite is exhaustively intruded by dykes and/or stocks of granodiorite and quartz diorite porphyry in its maginal parts. Quartz diorite shows often porphyritic texture. Granodiorite is light-greenish gray and medium- to coarse-grained leucocratic rock with equigranular and porphyritic textures in same parts.

Granodiorite is observed from 196.00 to 260.00 m, 282.60 to 299.60 m and 303.70 to 310.00 m depths and is accompanied by dissemination of pyrite and chalcopyrite. From 260.00 to 282.60 m and from 299.60 to 303.70 m in depths, they are quartz diorite and quartz diorite porphyry, respectively. Both rocks are accompanied by no mineralizations.

The mineralization in this hole is observed in andesite quartz diorite and granodiorite. The occurrences of the mineralization are veinlets and/or network of veinlets in andesite and dissemination in quartz diorite and granodiorite.

Usually veins formed in andesite consist of chlorite,calcite and epidote, occassionally quartz, and their width are less than 1 cm, mainly film- or hair-shaped excepting a few wide quartz veins. Principal ore minerals are pyrite and lesser amount of chalcopyrite which is abundant in rather chlorite-calcite-epidote veins than quartz-rich veins.

Metal contents of some remarkable veins observed in andesite are as follows:

Depth (m)	Core length (m)	Au (g/t)	Ag (g/t)	Cu (%)
44.60 ~ 44.80	0.20	0.0	5.4	1.64
55.70 ~ 55.80	0.10	0.0	7.7	2.76
84.60 ~ 84.90	0.30	0.0	2.2	0.72

Each veins show relatively high Cu content but vein width is very thin.

The mineralized zones formed in quartz diorite and granodiorite are mostly of dissemination type and only few zones show network of micro-veinlets. The most interesting mineralized zones are dissemination of pyrite with lesser amount of chalcopyrite in 195.20 to 260.00 m depth, and it formed in granodiorite. Other some mineralized zone with copper minerals are recognized within 292.30 ~ 299.60 m and 303.70 ~ 308.40 m depth. Both zones are also formed in granodiorite.

The average contents of Au, Ag and Cu are as follows:

Depth (m)	Core length (m)	Au (g/t)	Ag (g/t)	Cu (%)
198.00 ~ 210.00	12.00	0.0	0.5	0.14
210.00 ~ 222.00	12.00	0.0	1.0	0.31
222.00 ~ 231.00	9.00	0.0	0.6	0.17
246.00 ~ 260.00	14.00	0.0	1.3	0.22
292.30 ~ 299.60	7.30	0.0	2.1	0.58
303.70 ~ 308.45	4.75	0.0	1.0	0.20

Among these zones, three of them from 198.00 to 231.00 m, are divided parts of the same mineralized zone. It has a wide extent but Cu grade is not encouraging amount.

The polished section, at 202.50 m in depth, shows the occurrence of abundant magnetite with few pyrite and a rare amount of chalcopyrite, but it shows aggregates of lamella molybdenite in granodiorite.

Some samples are analized for S and its maximum content is only 1.31 %. Generally, high IP anomalous zone evidently shows the existence of abundant sulfide minerals such as pyrite and/or chalcopyrite, however, the above-mentioned analytical data seem to indicate that pyrite is relatively poor in each mineralized zones.

2–2 **RPJ–2** (Drilling length : 310.90 m, Average core recovery : 97.5%)

This hole is located at 250 south of RPJ–1 where it is equivarent to the crossing of Line-D and Line-H of the IP survey. The site is enclosed with andesite lava and the contact between andesite lava and quartz diorite is exposed at about 250 m west of this hole. A dyke of quartz diorite porphyry passes over this drilling site in the direction of WNW–ESE and other some small dykes are exposed in the northern portion of this dyke.

In the RPJ–2 hole, overbardens are only 2 m in thickness, and the rock from 2 to 39.00 m in depth is medium-grained quartz diorite porphyry. From 39.00 m depth, dark-greenish gray andesite which is, altered mostly to hornfels continues up to 71.50 m and the below 71.50 m depth light-greenish gray quartz diorite is recognized. Between 100.30 m and 263.90 m in depth, andesite hornfels is encountered with dyke-shaped quartz diorite.

Fine-grained gabbroic rock is seen from 263.90 to 305.20 m depth and below this depth quartz diorite porphyry is observed up to 310.9 m which is the bottom of RPJ–2.

As the above-stated, geology of this hole is characterized by exhaustive intrusion of various dykes. However, it can be roughly said that the boundary between andesite lava and quartz diorite is recognized at 264 m depth and various dykes and/or apophysis intrude around the boundary.

The mineralization observed in this hole shows the obviously different feature from RPJ–1, that is, it is characterized by numerous film- or hair-shaped veinlets of pyrite. These veinlets occur mainly in andesite lava as isolated veinlets and/or network. The widely spreaded dissemination like of RPJ–1 was not obtained in this hole.

Metal contents of remarkable veins in RPJ–2 are as follows:

Depth (m)	Core length (m)	Au (g/t)	Ag (g/t)	Cu (%)
254.10 ~ 254.40	0.30	0.0	10.0	2.42
288.50 ~ 289.40	0.90	0.0	3.6	0.86

2–3 **RPJ–3** (Drilling length : 310.90 m, Average core recovery : 97.5%)

This drilling site is located near the trail connecting Ud-Udiao with Nagasasan and also located on NO.15.4 of Line-E. This site is also enclosed by andesite lava but the contact between this rock and quartz diorite is exposed at 200 m east of the site.

After reaching the bedrock at 6.80 m in depth, the hole drilled andesite lava up to the bottom, and only one small dyke of dark gray quartz diorite porphyry was observed from 247.80 to 264.70 m depth. The andesite lava is mostly aphanitic but it occasionally shows porphyritic texture.

Numerous pyrite-chlorite veinlets and quartz-chlorite veinlets with clay are formed in andesite but chalcopyrite is very few or absent in veins. A few calcite-quartz veins with scattered pyrite are found from 268 m depth to the bottom, and they contain a small amount of chalcopyrite. But their Cu contents are less than 0.1 %. Only one networked zone of pyrite-chalcopyrite-calcite veinlets shows Cu content of 0.40 %. This hole, therefore, it may be considered that the northern boundary of the batholith-shaped quartz diorite mass distributed in the southern part of the Manikbel River shows more steep dip than expected one before drilling.

The geology and mineralization on each hole were described above in detail, and these results can be summarized as follows:

The expected mineralized zone which is considered to be the extension of the mineralized outcrops was recognized in granodiorite between 195.20 and 260.00 in depth of RPJ–1. The zone consists of dissemination of pyrite with a small amount of chalcopyrite, and its Cu content ranged from 0.1 to 0.2 % with the maximum content of 0.43 % Cu. This result seems to suggest that the mineralized zone observed on the surface consists primarily of dissemination of pyrite and chalcopyrite, and high Cu content of outcrops can be considered to be caused by partial secondary enrichment.

In RPJ–2, the boundary between andesite and quartz diorite was confirmed at 263.90 m depth but the mineralized zone was not observed around the boundary because of violent intrusions of various apophysis and dykes which are considered to be post-mineralization. RPJ–3 hole drilled in andesite only.

As the result of the drilling exploration, it can be concluded that the mineralized zone occurs along the outermost zone of the quartz diorite mass as a crust shape with thickness of less than 100 m on the basis of the result of RPJ–1 and lacking of IP anomalies below the mineralized zone.

The intense IP anomalous zone detected in the eastern part of the mineralized zone may be considered to be caused by numerous film- and/or hair-shaped veinlets containing abundant pyrite occurred in andesite lava. The result on each hole is shown in Fig. V–2.

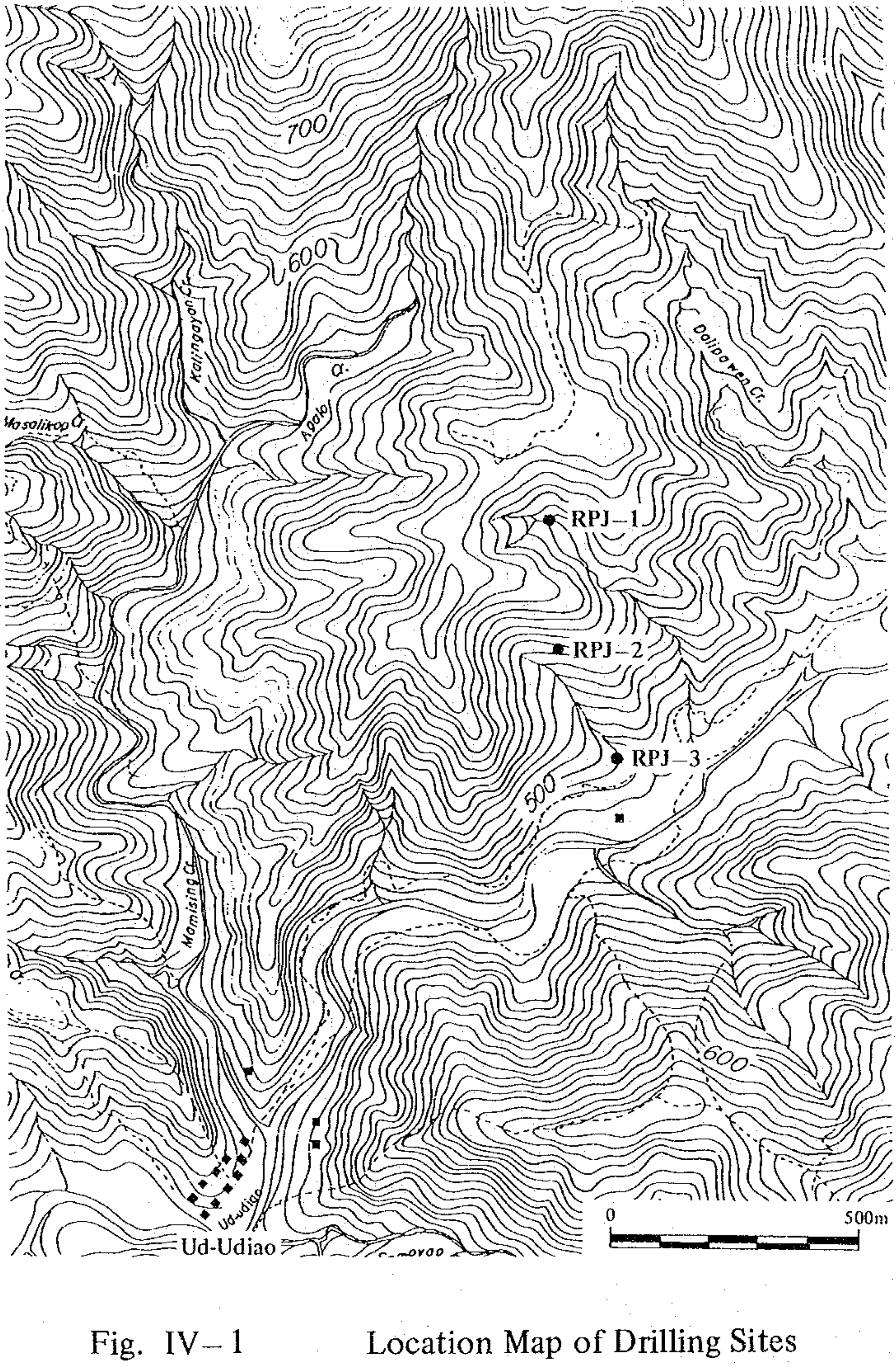


Fig. IV－1 Location Map of Drilling Sites

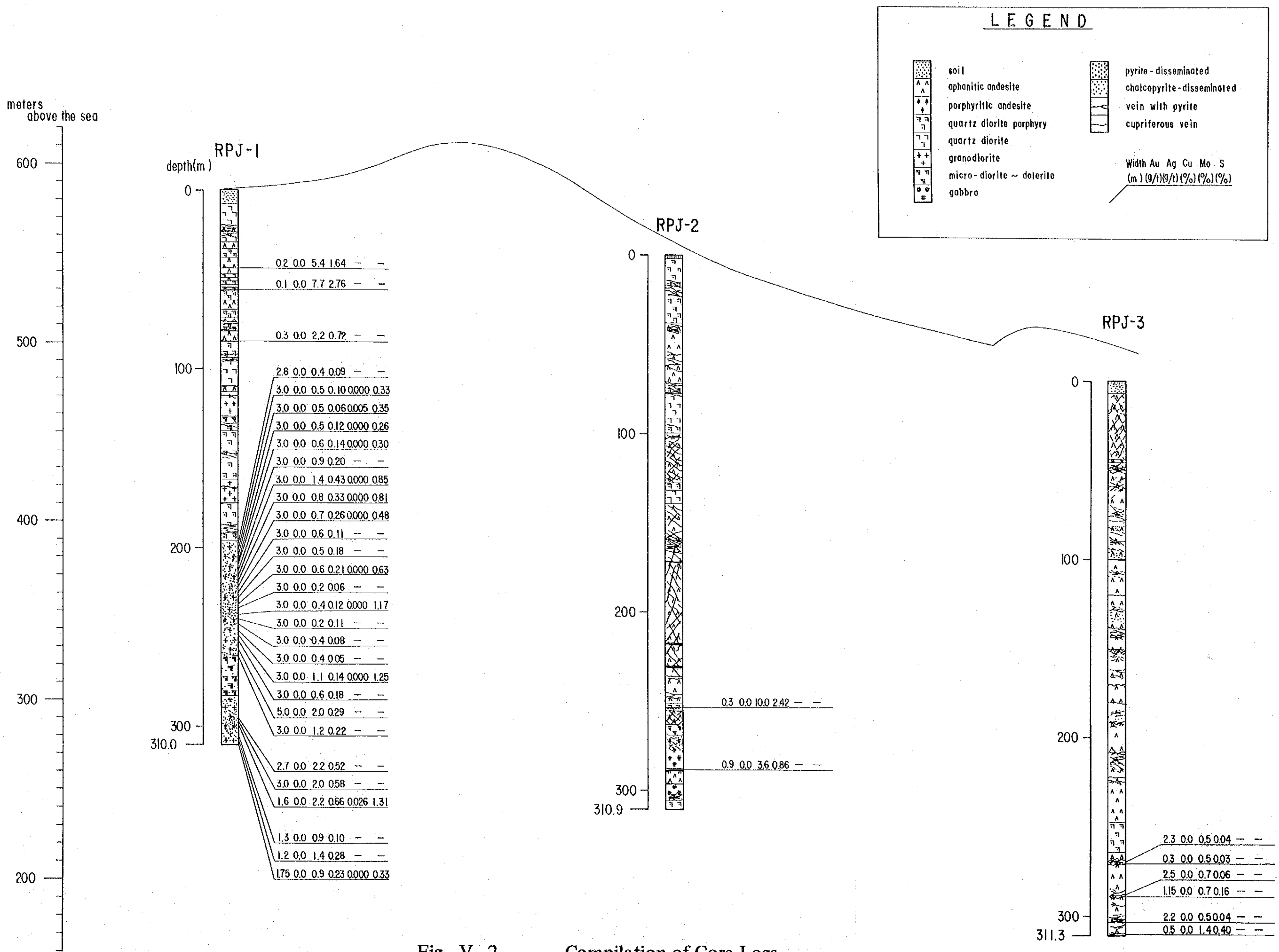


Fig. V–2 Compilation of Core Logs

PART VI CONCLUSION

1. GENERAL DISCUSSION ON SURVEY RESULTS

Since the results of geological, geochemical and geophysical surveys and drilling exploration were described already, the facts mentioned above will be discussed with focusing on the mutual relationship between the mineralization and each survey result as follows:

1. From the result of geological survey, the project area consists mainly of volcanic and its pyroclastic rocks of Paleogene time, basic to acidic plutonic rocks of Late Oligocene to Middle Miocene and hypabyssal and dyke rocks related genetically to the plutonic rocks. The plutonic rocks occur as batholith-shaped mass trending NNE-SSW and/or N-S in the central part of the area. They formed an uplifted zone extending N-S direction and it was confirmed that the project area is geologically equivalent to the axial zone of the Cordillera Central uplift zone.
2. The most significant ore deposits and mineralized zones are dissemination-network type though various types of mineralization are observed in this area. Main primary ore minerals are chalcopyrite, bornite and pyrite, and secondary copper minerals such as malachite and azurite are observed only on mineralized outcrops. Most mineralized zones show characteristic occurrence to be distributed in the marginal part of plutonic rocks and their peripheries.
3. Igneous activity of the area is characterized by vigorous plutonics activity showing various rock facies from gabbro to granodiorite, intermediate to acidic hypabyssal rocks and various dykes, and these intrusive rocks are considered to be products of the same magma. Mineralizations are closely related to igneous activity, as clearly represented by their distribution feature, and it is considered the preceding mineralization was derived from the intrusion of the batholithic plutonic rocks, afterwards the main mineralization was borne on the intrusion of the stock and/or dyke of porphyrite rocks and after that its intrusion of small-scale dykes was accompanied by the succeeding mineralization.
4. In this project area, the reconnaissance and semi-detailed geochemical survey for stream sediments was conducted in the first half of the survey period and detailed geochemical soil survey on the second half. The results of the first survey showed numerous Cu anomalous zones along the marginal parts of the plutonic mass, which are well consistent with distribution of mineralized zones. In case of the latter, the anomalous zones were detected around the mineralized zones containing copper minerals without relation to the plutonic rocks. Thus, it was confirmed that geochemical stream sediments survey is effective in

ascertaining the rough outline of mineralized zones which geochemical soil survey is more effective in determining the approximate extent and strength of mineralization.

5. Geophysical survey was carried out in the Bucloc area where there is distribution of numerous disseminated-networked zones of pyrite and in the Manikbel area where pyrite-disseminated outcrops with abundant secondary copper minerals are exposed. In the Bucloc area, the results showed a high IP anomalous zones in a extensive area that includes the distribution area of outcrops which in the Manikbel area no IP anomalous zone was obtained in the main mineralized zone but significantly detected on the eastern and western sides of the mineralized zone. From these results, it was confirmed that IP method detects high anomalous zones in areas with large amount of sulfide minerals, especially on fine-network type rather than in disseminated-type of deposits.

6. In the Manikbel area, the IP anomalous zone detected on the eastern side of the outcrops was observed to be induced by numerous film- to hair-shaped fine network of pyrite in andesite. The dissemination zone of pyrite and small amount of chalcopyrite, considered to be the extension of mineralized zone confirmed on the surface, was encountered in the RPJ-1 hole but no mineralization was observed in the other RPJ-2 and RPJ-3 holes.

7. Those described above are summarized as follows:

The project area is characterized by the vigorous plutonic activity. After intrusion of the batholithic plutonic mass, stocks and/or dykes of hypabyssal rocks intruded into the marginal part of the plutonic mass and its periphery. These rocks are accompanied by Cu mineralization, and formed dissemination-network type mineralized zones consisting of pyrite and a small amount of chalcopyrite.

For the prospecting and exploration of these deposits, it can be said that the following process is the most effective method of survey: (1) to make clear the outline of distribution area of mineralized zone by geochemical stream sediment survey, then (2) to clarify the lateral and vertical extent of mineralized zone and intensity of mineralization by geochemical soil investigation and geophysical survey, and (3) finally to confirm the ore deposits by drilling exploration.

2. CONCLUSION

2–1 Conclusion

The systematic mineral exploration survey was conducted in the Northwestern Project area within a period three years from 1979 to 1981, and the following conclusion was obtained on the basis of the survey results.

1. In the project area, a great number of ore deposits and mineralized zones are distributed. Among them, the Manikbel mineralized zone which is one of the most promising mineralized zone is selected as the target for geophysical survey and drilling exploration in final phase of the project.

From the results of the survey, it is concluded that the mineralized zone is low grade dissemination of pyrite and small amount of chalcopyrite though it shows the high grade of Cu content on outcrops and it seems to be unfeasible for future development at this status.

2. Although it was initially planned to conduct the final phase survey of the project in the two mineralized zones, Malibcong and Lacub, which were considered to be the same potential for ore deposits as the Manikbel mineralized zone, the survey could not be conducted due to peace and order situation problems. If the surveys were carried out on initial schedule more interesting results might have been obtained.

3. Through the surveys conducted for three years, plenty of basic data on the stratigraphy, igneous activity and age of intrusive rocks were accumulated. It is considered that these data will be utilized as important informations for the exploration in the surrounding areas in future.

4. The distribution of ore deposits observed in this area shows the close relation with the plutonic activity, and the marginal parts of the plutonic masses, especially the stocks and/or dykes of hypabyssal rocks intruding into the marginal portions of the mass are the most suitable places for formation of ore deposits. Therefore, it is most effective for the exploration of ore deposits to clarify the places representing the above-mentioned geological environment.

2–2 Recommendation for Future Study

1. As for the mineralized zone in which the drill exploration was carried out in Phase III, the continuity of the mineralized zone toward the northeast and southwest has not yet fully been confirmed. Since a high IP anomalous zone was obtained in a relatively shallow depth

and is remained unexplored, it is necessary to confirm the deeper part of that anomaly by drilling in future.

2. For the two mineralized zone for which the surveys were suspended because of peace and order problem although they had been selected as the object of the final phase survey. The actual state of mineralized zone should be made clear as soon as possible after the restoration of peace and order situation.

3. The western basin of the Chico River still remained as the unsurveyed area although that area is considered to be the most promising area for ore deposits on the basis of the complilation of existing data. According to the data of BMG, there are many significant mineralized zones in that area. Therefore, it is also necessary to conduct geological and geochemical survey to elucidate geology and distribution of mineralized zones.

4. The Complex Resistivity survey conducted in Phase III showed insufficient results because of poor amount of chalcopyrite in the target mineralized zone. However, since interesting information are contained in the data obtained by this survey, it is considered that this method will be an effective survey method in future by the accumulation of basic data by carrying out the tests on various ore samples and measurement and analysis of the known ore deposit as well as by promoting the theoretical research in the near future.

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