REPUBLIC OF THE PHILIPPINES

DEPARTMENT OF NATURAL RESOURCES

BUREAU OF MINES

REPORT ON GEOLOGICAL SURVEY

OF

EASTERN MINDANAO

PHASE III

GEOLOGICAL, GEOPHYSICAL SURVEYS, AND

DRILLING EXPLORATION

JULY 1974

METAL MINING AGENCY

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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Preface

The Government of Japan, intending to perform geological and other related surveys, in response to the request by the Republic of the Philippines, for the purpose of confirming the potentialities of occurrence of mineral resources in Eastern Mindanao of the Philippines, delegated the implementation of such surveys to the Overseas Technical Cooperation Agency. This Agency, in turn, requested Metal Mining Agency of Japan to carry out rhe said surveys in view of the project touching, in particular, specialized fields such as geology and mineral resources surveys.

This year was the last to complete a series of surveys extending over three years, and for this, a survey team was formed comsisting of 19 members headed by Mr. Kanae Niwa, Chief of Planning Section, Overseas Dept., Metal Mining Agency, and was dispatched to the Philippines for a period from September 18, 1973 to February 25, 1974. The surveys at site were completed as planned with cooperation extended by agencies concerned of the Government of the Republic of the Philippines.

The Report comprises the results of the third year surveys and the generalization of those obtained through the period of three years.

In conclusion, I wish to express my heartfelt appreciation for all that has been dedicated to the completion of the surveys by agencies concerned of the Government of the Republic of the Philippines, the Mininstry of International Trande and Industry, the Ministry of Foreign Affairs, Metal Mining Agency and each corporation concerned.

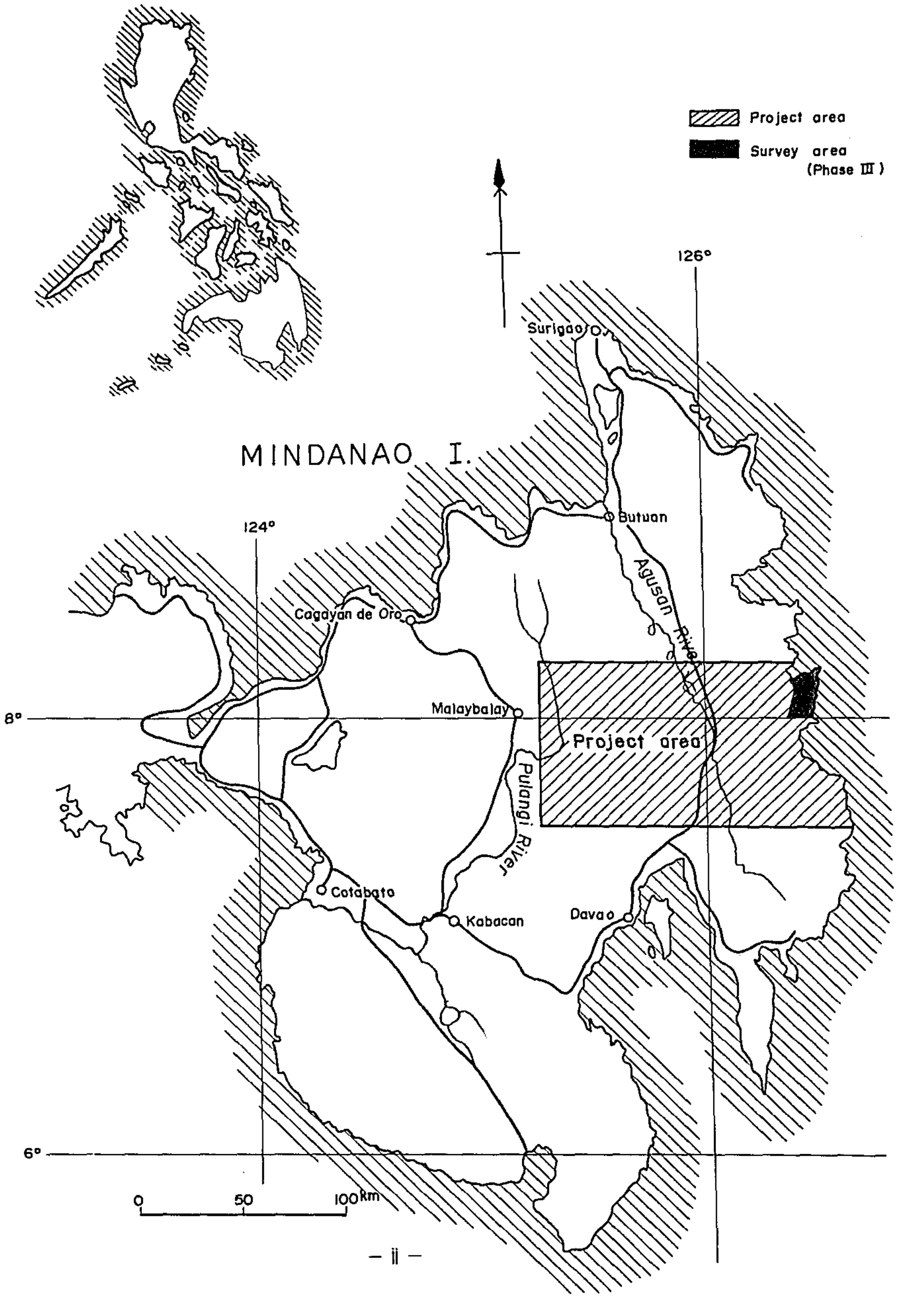
July, 1974

Keiichi Tatsuke

Director General

Overseas Technical Cooperation Agency.

Fig. 1 Location map of the Survey area



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ABSTRACT

In the Phase III (last Phase) of the survey of eastern Mindanao, Philippines, the detailed geological survey with geochemical method, geophysical survey (IP method) and diamond drilling were carried out over the Bislig area of about 170 km^2. This area was selected by the Phase II survey as having high potential for mineral deposits. The main purposes of this Phase were to clarify the features of mineralization and the geological structures.

The structures of the Barcelona group covering the whole survey area was clarified, and it is decided that the Barcelona group was formed in the Cretaceous to the Paleocene period. Moreover, some problems on the diorite intrusion were also solved.

IP geophysical survey, carried out in the northern half of Taon mineralized zone, made clear that the IP anomalies in the northern half disappeared rapidly towards the south. No geochemical anomalies were detected in this area, so that the further explorations on the south were considered to be of less importance.

Five vertical diamond drill holes, each 250 m in depth, were sunk in the northern mineralized area which shows geochemical and geophysical anomalies. No. 1 hole, the first from the north, hit the dissemination of porphyry copper type deposits. The copper content of 150 m thickness from 100 m to 250 m in depth is 0.397% ; 26 m thickness from 224 m to 250 m in depth shows 1.006%. Analyses of every 2 m length of drilling cores show the copper tends to increase towards depth.

Judging from the studies based on the other drillings, geophysical surveys and geochemical surveys, this type of mineralization is believed to be local. But it has some possibility of developing towards depths. Therefore, it is advisable to carry

out the follow-up drill holes near and around the No. 1 hole for defining the scale and nature of mineralization.

GENERAL INFORMATION

1. Introduction

1-1 Purpose of Survey

The purpose of the survey in the Phase III was to make clear the features of mineral deposits in the area of about 170 km^2 selected by the Phase II survey. This area is believed having high potential for mineral resources. For the purpose stated above, the detailed geological survey with geochemical method, geophysical and diamond drilling were carried out.

1-2 Outline of Survey

Most of the area to be surveyed in the phase III is located in province of, Surigao del Sur and the rest in province of Agusan del Sur. It is only 10 km from barrio Mangagoy where PICOP (Paper Industries Corporation of the Philippines) factory is operating. Many private logging roads are passing through the area. As it was easy to make one day survey trip by jeep, the base camp was set up in the PICOP factory and one temporary storehouse for drilling machine was built in the barrio Mahabo the nearest barrio to drilling sites.

The geological team which arrived at the camp in advance was composed of four parties. Half of them were assigned to the mineralized area and the other half to the surrounding area for clarifing the features of mineral deposits and the geological structures. Each party consisted of one Filipino and one Japanese geologists.

After the geological survey, geophysical team began its field work and made clear the horizontal and vertical extensions of mineralized zone, using IP method. Three Filipino and five Japanese geophysists were engaged in this work.

Diamond drills were operated at the five sites which were selected on the basis of the results of detailed geological and geophysical surveys. Two sets of drilling machine were operating around the clock. The work was taken charge by two Filipino and six Japanses drilling engineers.

Fine weather facilitated the completion of the geological and geophysical surveys. Later, however, heavy rains which occured very often hindered the drilling operations. Due to the flood waters, the operation of drill hole No. 1 was forced to stop in the strongly mineralized zone.

During this survey, the world was affected by the oil crisis and it became very difficult to get fuel for drilling machines and jeeps. But owing to the great efforts of Bureau of Mines it did not hindered much the field works.

The total extent of survey routes, drilling length and field survey carried out in this Phase are shown in the following Table.

Table 1 Period of survey, length of survey route and drilling length

	Stay in the Philippines	Actual field work	Length of survey route or Drilling length
Geological team	Sep.18 1973 ~ Feb.18 1974 154 days	Oct.12 1973 ~ Nov.6 1973 26 days	385 Km
Geophysical team	Oct.22 1973 ~ Dec.1 1973 41 days	Oct.26 1973 ~ Nov.26 1973 31 days	22 Km
Drilling team	Nov.28 1973 ~ Feb.25 1974 90 days	Dec.1 1973 ~ Feb.10 1974 72 days	1,253.10 m

The writers are greatly indebted to Professor Yoshio Ueda, Tohoku University on chronologizing the intrusive rock. The helpfull discussions on volcanism with Dr. Koji Ono, staff of Geological Survey of Japan, are also gratefully acknowledged.

All the geological date, half the rock specimens and drilling cores obtained during the Phase III survey have been furnished the Bureau of Mines, Philippines.

1-3 List of Members

JUAN E. PILAC	Bureau of mines Philippines	KANAE NIWA	Metal Mining Agency of Japan
		REISUKE SHIGA	do
		MICHIHISA SHIMODA	Overseas Technical Coopera-tion Agency of Japan
		YUTAKE EDA	do
(Geological team)			
MAXIMO V. GARCIA	B. O. M.	HIROSHI FUCHIMOTO	O. T. C. A.
EMIL T. AVILA, Jr.	do	TERUYUKI TAKEDA	do
BERNICITO BALLESTEROS	do	IKUHIRO HAYASHI	do
ALBERTO ISSAC, Jr.	do	KEIJI NAKANO	do
JOSE N. ALMASCO	do		
(Geophysical team)			
CESAR V. RAMOS	B. O. M.	ASAHI HATTORI	O. T. C. A.
MARIO TORRES	do	OSAMU KUSAKA	do
ELIGIO Z. ARIATE	do	TOSHIAKI FUJIMOTO	do
		TOMIO TANAKA	do
		SABURO TACHIKAWA	do

(Drilling team)

CESAR LUCERO	B. O. M.	AKIO KATO	O. T. C. A.
RUSTICO BAYON	do	UTAJI SUZUKI	do
		TAKEO AKIMOTO	do
		MINORU NOMURA	do
		YUKIO TAKAHASHI	do
		SAKAE HIRONO	do

(Transportation team)

TEOFILO FRONDA	B. O. M.
ROLANDO DESTACAMENTO	do

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2. General Discussion

The fruitful results on geology, such as, determination of the age of the youngest member of the Barcelona group and elucidation of its geological structures, were obtained during the Phase III survey. However, only the results of various explorations carried out in the mineralized zone are brought up for discussion and the followup works are refered to in this chapter.

2-1 The Phase III detailed survey area

The mineralized zone in the headwaters of the Taon River is of large area which extends 4 km in N-S direction with 12 km in width. So the detailed geological, geochemical and geophysical surveys in the Phase II were carried out on the northern half of this zone and in the Phase III, on the southern half.

The area surveyed in this Phase is mostly composed of dacite and andesite. Surigao Mine which has some high grade ore stockpiles of Cu-Pb-Zn and Silver Bell Mine which was once explored for copper are located in this area.

Geochemical survey by soil sampling disclosed the weak copper anomalies along the east side of main quartz diorite body. They extend in NE-SW direction and are connected smoothly with the anomalies obtained in the Phase II. However, copper contents decrease rapidly towards south. That is, copper anomalies of over 500 ppm spread more than 200 m around the intersection of the base line with line No. 9 of geophysical line, do not continue to line A which is set 300 m only to the south. Only weak copper anomalies containing 200～250 ppm in 200 m wide zone have been detected here.

Although IP anomalies corresponding to the copper anomalies have been disclosed, they are very weak compared with anomalies obtained in the Phase II survey which extend from Line No. 4 to Line No. 9. IP anomaly starts to weaken south of Line B until it finally disappears on Line E. The IP anomaly extending from points 40 to 46 of Line A seems to be caused by the filmy pyrite dissemination. It is observed along the joints in basalt of neighboring river at 20 cm ~ 30 cm intervals. Therefore, it can be concluded that the copper mineralization is limited within the Phase II survey area.

The other geochemical anomaly is found in a narrow zone near Surigao Mine. The direction of anomalous pattern may show the extension of ore deposits. However, it is difficult to expect a large scale mineralization without IP anomaly. Only weak anomalies were detected near Silver Bell Mine area.

As stated above, remarkable geochemical and geophysical anomalies were not found in the dacite area, inspite of strong argillization and silicification.

1. The compositions of clay are montmorillonite and α-quartz.
2. A lot of siliceous rock exposed on the surface are barren and colloidal.
3. Alteration is limited within dacite area.

From the above reasons it is probable that argillization and silicification are due to the hydrothermal alteration caused by dacite intrusion with a few limited mineralization overlapping them.

The Phase III survey area, therefore, has low potential for ore deposits and further explorations on this area are considered to be of less importance.

2-2 The Phase II detailed survey area

Five drill holes were made in the geochemically and geophysically anomalous zones selected by the Phase II detailed survey. In consequence, No. 1 drill hole in the northern site hit a good copper dissemination. Copper and molybdenum assays of each hole are shown in Fig. 3.

Figure 2. Compilation map of the detailed survey results, Bislig Area

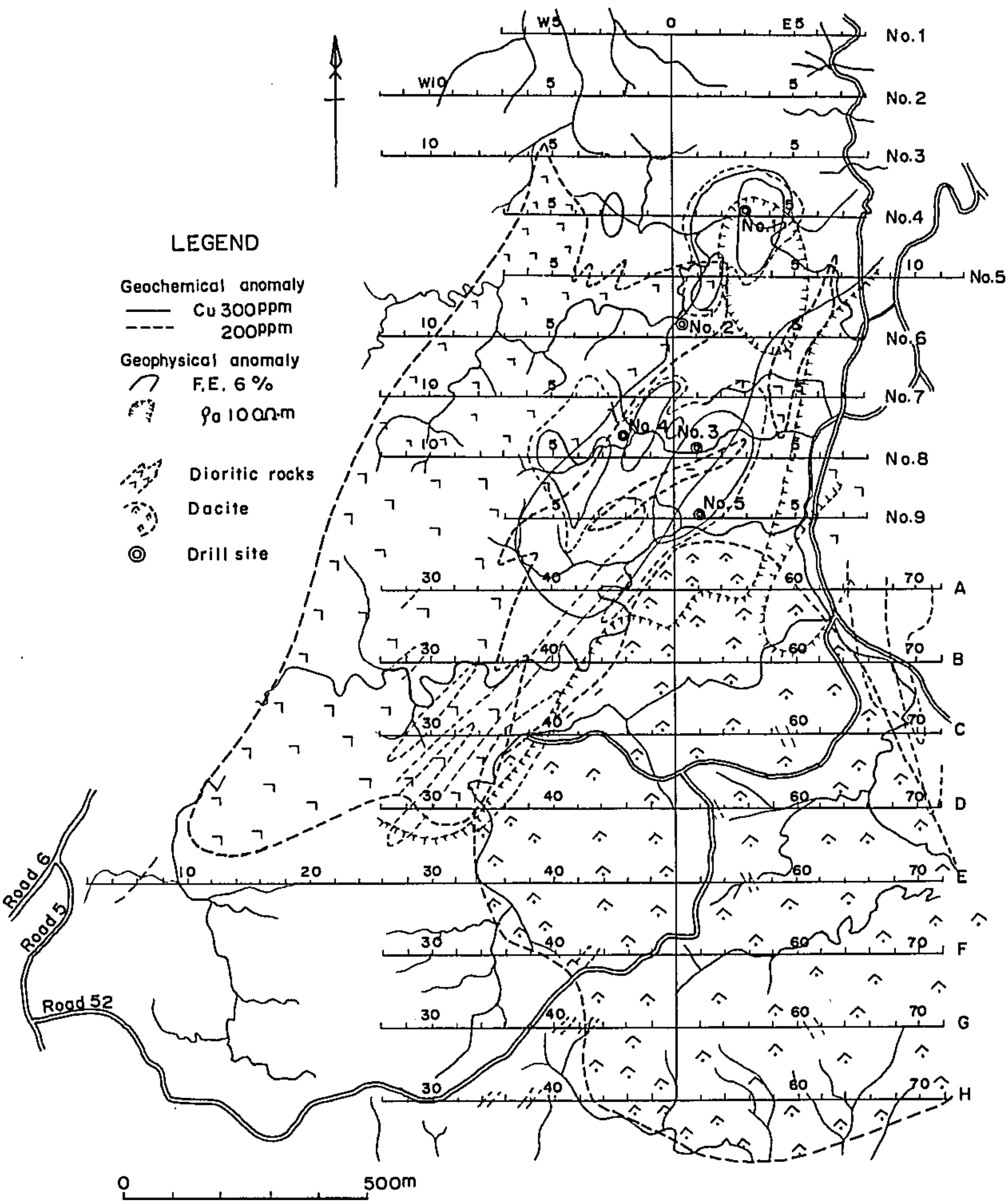
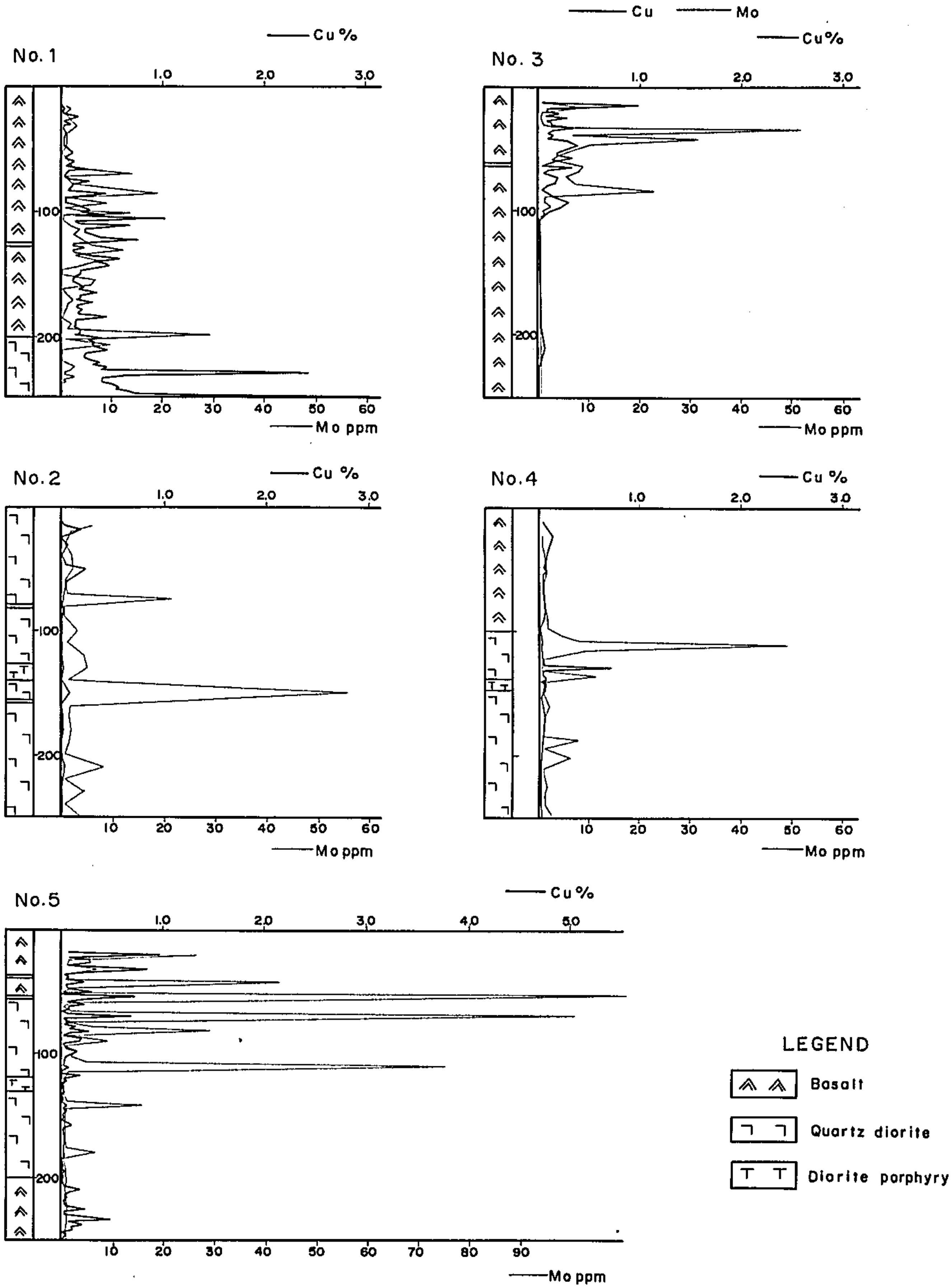


Figure 3. Diagrams of Cu & Mo contents of drilling cores



The outlines on each hole are as follows:

No. 1 hole ——Both copper and molybdenum show better contents than the other holes. The first peak of copper is at 100 m in depth and from 200 m copper grade increase towards bottom. On the other hand, the trend of molybdenum resembles that of copper in shape, although molybdenum appears, as a whole, about 30 m earlier than copper. It has also high peak at 200 m in depth where the boundary between quartz diorite and basalt lies, and decreases suddenly towards depths unlike copper. In this hole, there is a diorite porphyry dike of 2 m in width at 125 m depth. Therefore, the first peaks of copper and molybdenum may be closely related with the dike.

From the surface to 100 m, epidote-chlorite alteration is remarkable and lower than 100 m, strong quartz-sericite alteration is noted.

No. 2 hole ——This hole is located in the main quartz diorite body. The contents of both elements are persistently very low. Molybdenum has only one peak at the diorite porphyry dike. Few alteration can be observed.

No. 3 hole ——There is the highest grade of copper near surface and a few contents continues to 100 m in depth. Molybdenum shows local anomalies in this zone. The diorite porphyry dike of 2 m in width cuts the center of the anomalous zone as well as Nos. 1 and 2. Only weak epidote-chlorite alteration is visible.

No. 4 hole ——This hole reaches the main quartz diorite body at the depth of 91 m. Copper and molybdenum contents are persistently very low except molybdenum at the boundary between quartz diorite and basalt. The narrow quartz-sericite alteration zone occurs near the boundary.

No. 5 hole ——This hole cuts the quartz diorite of 140 m in thickness. Both copper and molybdenum show high values near the upper boundary of the dike but no mineralization near the lower boundary. Local chloritization can be observed in some places.

The common features observed on the No. 2, No. 3, No. 4 and No. 5 drilling cores are as follows:

1. In the case of the main quartz diorite body, molybdenum contents show high values at the boundary but decrease rapidly towards the center of the body. Silicification is also seen near the boundary.
2. In the case of the diorite dike, both copper and molybdenum contents become high and do not decrease rapidly towards the center probably due to large dispersion halo.

From these features, it looks possible to suppose the underground shape of quartz diorite.

On the quartz diorite of No. 1 hole,

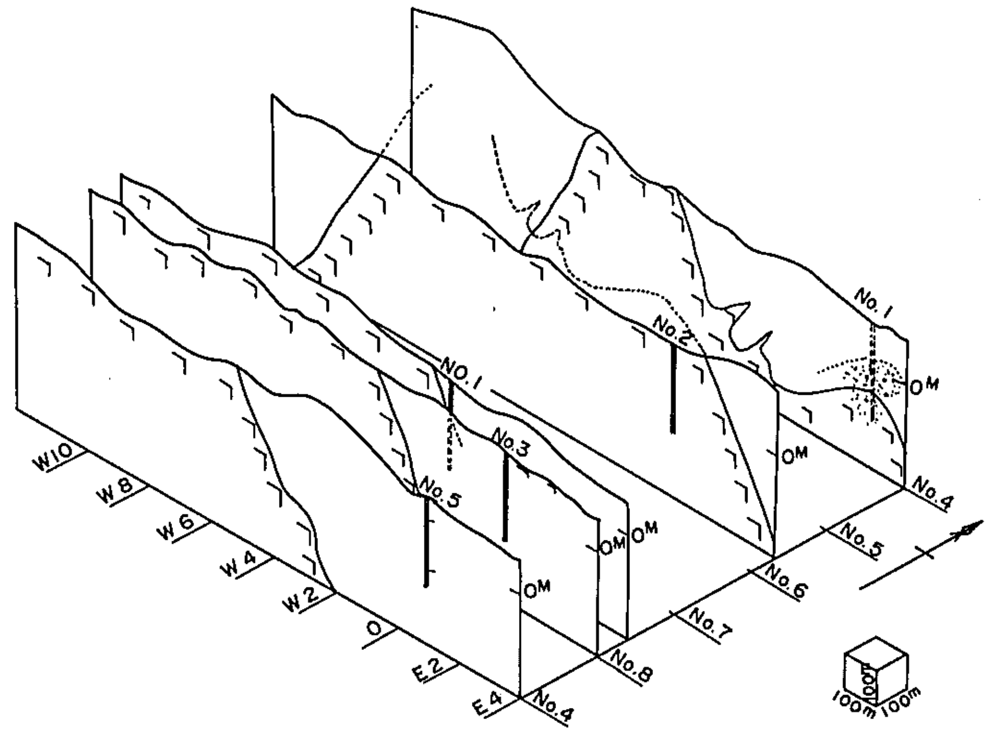
1. Quartz-sericite alteration is remarkable near the boundary.
2. Molybdenum contents decrease rapidly towards depths after the boundary.
3. There are no contradictions though the main body's dip, comfirmed by No. 4 hole, is applied to that of the quartz diorite here.

From the foregoing reasons the obtained quartz diorite has a high possibility to be the main body.

The configurations of the quartz diorite body as deduced from 5 drilling results are shown in Fig. 4.

The copper dissemination of No. 1 hole is still strong in the quartz diorite body and it is increasing towards depths. On the other hand, other holes show low copper contents and weak alteration. Therefore, the copper mineralization shows to be local. As shown in Fig. 4, however, it is probable that the most significant mineralization starts from the vicinity of No. 1 hole.

Figure 4. Panel diagram showing the relation between quartz diorite & mineralization



LEGEND
Quartz diorite
Copper mineralization
Diamond drill hole

3. Conclusions and Recommendations

Detailed geological survey with geochemical method, geophysical survey and diamond drilling were carried out on the Bislig area. From the systematic studies based on these surveys, the conclusions are as follows;

1. The Barcelona group was divided into three formations by the features of volcanic activities. All of them are composed of basaltic or andesitic rocks formed in a sub-aerial and subaqueous environment. The uppermost member of the group belongs probably to Middle Oligocene.
2. The anticlinal and synclinal structures trending NNE-SSW are prominent in this group. Drag faults with same directions had been formed after folding, and quartz diorite and dacite intruded along the faults or the fissures caused by the faults.
3. As the geochemical and geophysical anomalies recorded by the Phase II detailed survey do not extend towards south, the mineralization is likely to be limited within the northern half of the altered zone. Especially in the northern half, low resistivity zone (less than 100Ωm) detected on Line No. 4, No. 5 and No. 6 is considered also interesting (as it indicates the hydrothermal alteration).
4. Since montmorillonitization in dacite is considered to be caused mainly by hydrothernmal alteration related to the dacite intrusion, therefore, it is of little value to carry out further exploration on this area.
5. The mineralization detected by No. 1 drill hole is a porphyry copper type and consists of chalcopyrite and pyrite. The zoning, such as epidote-chlorite alteration zone and quartz-sericite alteration zone, is remarkable.
6. The mean copper content of disseminated zone from 224 m to 250 m shows

1.006% and copper tends to increase towards depths.

7. Judging from the data of geological survey and other drillings, the copper mineralization is considered to be concentrated at the eastern margin of the quartz diorite. It is probable that the most significant mineralization starts from the vicinity of No. 1 hole. Therefore, the follow-up drillings will be desirable at the vicinity of No. 1 drill hole.

PART I INTRODUCTION

1. General Remarks

In the Phase III survey, a great emphasis was placed on defining the porphyry copper type mineralization which was found by the Phases I and II surveys and on clarifying the geologic structures of this area.

Geochemical survey was carried out together with geophysical survey in the alteration zone so as to start the drilling exploration immediately.

Consequently, the following facts are disclosed.

1. The Barcelona group, mainly composed of basalt and andesite lavas with pillow structure, was roughly devided into three formations according to their occurrences and textures. However, they appear to have the same composition and to have been formed by a series of volcanic activities.
2. They were laid in a sub-aerial and subaqueous environment. The youngest member of this group, which is composed of tuff and clastics, is overlain conformably by the Mangagoy formation. Therefore, the age of the youngest member is middle Miocene.
3. Geologic structure of this area was made clear and some problems on igneous rock intrusion were solved.
4. Average Copper content of 26 m thickness of No. 1 drill hole from 224 m to 250 m in depth shows 1.006% and it is increasing towards depth.

2. Geology

The survey of this phase was executed within the area where Barcelona group is distributed. So that there are few rock types which occur in the area.

2-1 Stratigraphy

A generalized stratigraphic section in the survey area is shown in Table I-1.

Table I-1. Generalized stratigraphic section in the survey area

Geological age			Group or Formation	Columnar section	Rock facies	Structural movement	Igneous activity	Mineralization
Quaternary	Recent		Alluvium			Epeirogenetic movement		
Quaternary	Pleistocene		Agtuuganon F. (0~50m)		Coral reef Limestone			
Neogene Tertiary	Pliocene							
Neogene Tertiary	Miocene	Upper						
Neogene Tertiary	Miocene	Middle					Dioritic rocks	Porphyry copper type
Neogene Tertiary	Miocene	Lover	Bislig F. (20m)		Silt, Sandstone and Basalt Lava		Dacite	
Neogene Tertiary	Oligocene		Mangagoy F. (0~1,000m)		Limestons, Basalt Lava and Pyroclastics	Structual movement		
Paleogene ~Cretaceous			Barcelona G. (III) (1,000m)		Basalt Lava, Small amount of Pyroclastics and Clastics			
Paleogene ~Cretaceous			(II) (100~700m)		Andesite Lava, Dacite Lava and Pyroclastics		Andesite	
Paleogene ~Cretaceous			(I) (1,900m)		Basalt Lava, Sheet, Pyroclastics and Clastics		Basalt	

2-1-1 Barcelona Group

The Barcelona group are well exposed along the eastern seashore. Barrio Barcelona, the type locality of the group, is located in the survey area. There are few key beds in this group, therefore, it is hard to subdivide it in detail. It was roughly devided into three formations.

Formation I ——This is composed of basaltic rocks distributed from barrio Barcelona to barrio Tombog. A few amount of clastics intercalated in the basalt lavas, constitutes a characteristic feature of this formation. They are exposed typically at the seashore near barrio Barcelona and the chiff behind PICOP factory. Most of this formation are lava flows with pillow and columnar structures. A few amount of volcanic breccia ~ tuff breccia, shale and mudstone are intercalated in them. The general strike trends N60°W ~ N80°W and dips 10° ~ 20° southwards in the eastern area. However, the strike varies greatly in the western side of the central part because of folding.

Basalt lava is a darkgray to black in colour and compact. One unit of the lava is usually 15 ~ 20 m in thickness. Waterfalls are commonly observed at the contact between lava and tuff or lava and another lava flow.

The individual pillow in the lava is ellipsoidal and measures 1m x 2m ~ 3m in diameter. The intervening spaces are usually filled with blueish green, muddy sedimentary materials. Radial and concentric joints develop from the center to the outside of pillows which have glassy skin. Under the microscope, acicular phenocrysts (2 ~ 3 mm in length) of quenched plagioclase (albitized) and augite are characteristically observed in a very fine grained matrix of plagioclase laths, augite, opaque minerals (most of them are magnetite and ilmenite) and glass. Secondary minerals are calcite, chlorite, pumpellyite, yellowish green clay mineral (Fe-saponite?) and rarely, fair green celadonite.

Lavas with columnar structure usually coexist with lavas with pillow structures. Under the microscope, lavas with columnar structure are porphyritic and their textures are coarser than that of pillow lavas.

Pyroclastic rocks are composed of essential or accindetal tuff ~ tuff breccias. They are well sorted. In the lower reaches of the Taon River, pisolites occur in basaltic tuff beds. Thin alternations of tuff, sandstone and cherty mudstone are also intercalated in the basalt lavas. No fossils can be observed in them. Although ultramafic rocks and limestone do not occur, the combination of basalt lava, dolerite and cherty rock suggests this formation might be an ophiolite group.

The thickness of Formation I is more than 1, 900 m.

Formation II ——The Formation II is distributed in the southern side of the Formation I. It is characterized by intercalation of pyroclastic rocks and overlies the Formation I conformably. This formation is typically hornblende-augite-andesite rock. In some places hornblende is absent. A few augite-basalt can be seen in the formation. Formation II is not intercalated by clastics unlike Formation I. It occurs typically in the northern side of barrio Anibugan and in the middle course of the Hagamitan and the Bahayan Rivers. The wide, argillized zone in the upper reaches of the Taon River belongs to this formation, too. The top of the formation is a dacitic tuff which is observed near Soriano Mine.

General strike trends N50W ~ N70W in the eastern area and N20E ~ N30E in the northern area. Therefore, a clear anticlinal structure is indicated at the headwaters of the Taon River.

The andesite is gray and compact and contains phenocrysts of plagisclase and augite (1 mm in length). Usually andesite lavas show columnar or autobrecciated structure and in some places, hyaloclastic structure.

Most of the pyroclastic rocks are composed of essential or accidental tuff breccia ~ lapilli tuff and are poorly sorted and classified. The pyroclastic rock in the branch of the Hagamitan River, down from Lepanto Mine, may be called volcanic conglomerate, consisting of subrounded to rounded andesite pebbles (100 mm in diameter). From the occurrences, it is considered that volcanic center at this period was in a sub-aerial environment. Volcanic pebbles were carried to deep sea bottom by turbidity current and then deposited there.

Under the microscope, andesite shows a porphyritic texture. Phenocrysts of zoned and twinned plagioclase (3 mm in length) and prismatic augite (2 ~ 3 mm in length) are arrenged irregularly in a matrix of plagioclase laths (0. 05 mm in length), opaque minerals and glass. The matrix shows generally a felty texture and sometimes a trachytic one. It is always affected by albitization. Phenocrysts of euhedral hornblende or a small amount of corroded quartz and biotite can be seen only in the uppermost horizone of this formation.

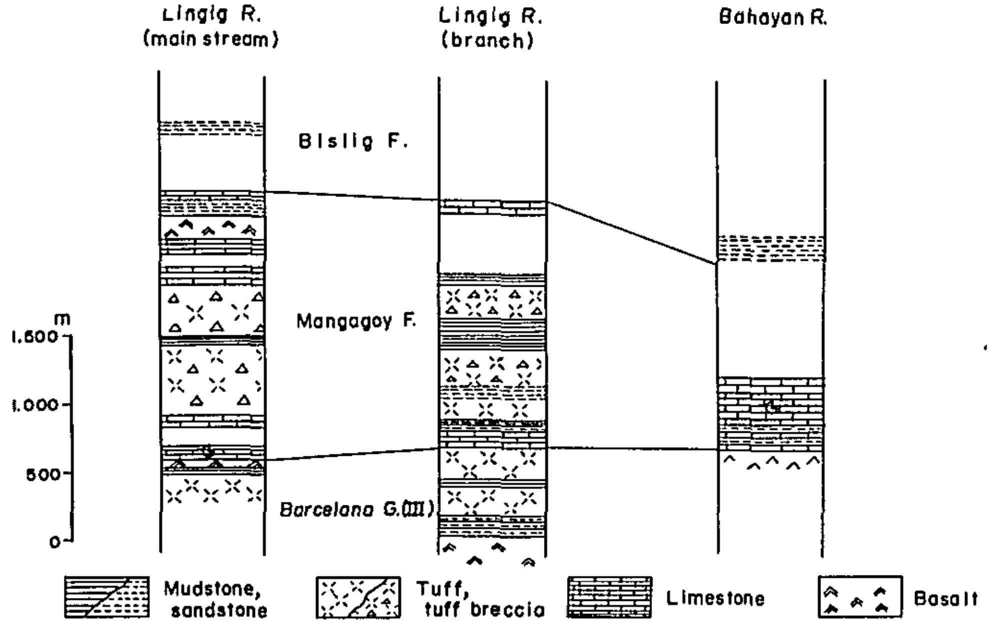
The Formation II shows maximum 700 m in thickness at the center part and thins off towards both sides, that is, 500 m in the eastern seashore and 100 m in the north.

Formation III ——The Formation III overlies the Formation II conformably and is distributed widely in the southern side of the latter. The top of this is overlain by the limestone of the Mangagoy formation. This formation is mainly composed of basaltic pillow lavas and accompained by the fine alternated beds of sandstone and shale or tuff breaccia ~ tuff at the top. General strike trends E-W and dips 25^{o} ~ 30^{o} towards S.

The relation between the Mangagoy formation and the Formation III can be observed in the main course of the Lingig and the Bahayan Rivers. There are no evidences of uncomformity between them such as basal conglomerate, therefore, the Formation III is believed to be overlain conformably by the Mangagoy formation. In the Lingig River, a thin bed of the Mangagoy limestone of 0. 5 ~ 2. 0 m in thickness can be traced about 1. 5 km laterally parallel with the bed of tuff breccia of the Formation III. In the Phase I survey, volcanic conglomerate was considered to be basal conglomerate and unconformity was supposed to occur between two formations. But it became clear by the Phase III survey that the volcanic conglomerate lay on (not under) the limestone. The same relation occurs in the southern branch of the Lingig River. In the Bahayan River, pillow lava of the Formation III is overlain by the limestone of Mangagoy formation. The flowages are quite parallel to the bedding of limestone and it is hard to suppose unconformity between two formations as well as shown in the Lignig River. The basal unit of the limestone was already determined as middle Oligocene by the Phase II study, therefore, the geological age of the uppermost member of the Formation III could also be middle Oligocene.

The relations between two formation are shown in Fig. I-1.

Figure I-1. Columnar sections showing the relation between Barcelona G. & Mangagoy F.



Under the microscope, the basalt of this formation is quite similar to that of the Formation I. But the rock in the northern side of quartz diorite is rather andesitic than basaltic. Its matrix shows hyalopilitic texture and does not contain pyroxene.

The thickness of the Formation III is about 1,000 m.

2-1-2 Mangagoy Formation, Bislig Formation and Agtuuganon Formation.

The Mangagoy formation is distributed widly in the western side of the survey area. The general strike is N-S and dipping $20^{\circ} \sim 30^{\circ}$ westward. As stated before, it overlies the Barcelona group conformably.

The Bislig formation, occuring as prominent low hills in the east side of the Taon River, consists of bluish gray mudstone and sandstone. It is inclined gently towards east and covers the Barcelona Formation I unconformably.

The coral reef limestones in Sanco point and barrio Dahica are correlated to the Agutuuganon formation. Their geological age is Pleistocene.

2-2 Intrusive Rocks

2-2-1 Gabbro

Several dikes of gabbro are exposed in the upper reaches of the Taon River. They are considered to have intruded along the fissures caused by faulting. Most of the dikes are $10 \sim 20$ m in width and cut dacite and quartz diorite which will be mentioned later. The fresh gabbro is a grayish black, medium grained, holocrystalline rock. Weathered gabbro shows yellowish brown so that it is easy to distinguish it from other rocks. Microscopically, prismatic plagioclase (4 mm in length), subhedral or intersertal augite and completely chloritized olivine are main consituents. It is usually accompained by biotite. Alteration is very weak and a small amount of green clay mineral, sericite and kaolinite are recognized as secondary minerals.

In the northern part of the survey area, the gabbro crops out near barrio Denipas. It belongs to the dolerite group which is mentioned later and does not contain biotite and olivine crystals. Megascopically, it looks like diorite owing to its leucocratic and coarse grained texture. Under the microscope, prismatic or tabular plagioclase, 2 mm in length, subhedral or intersertal augite and secondary, brownish green clay mineral can be recognized.

2-2-2 Dolerite

The dolerite dykes are exposed along faults. Under the microscope, phenocrysts of plagioclase (1 mm in length) occur glomeroporphyritically in a matrix of tabular or prismatic plagioclase and intersertal or prismatic augite.

Secondary mineral pumpellyite occurs with brownish green clay mineral.

Judging from the microscopic observations, there are some similarities on the consituent minerals and the textures of the Barcelona basaltic rocks, dolerites and a few gabbros. They are, therefore, considered to be genetically related to each other.

2-2-3 Dacite

The dacite was referred to as porphyrite in the Phase II report. It is exposed in one place in the headwaters of the Taon River. Usually it is gray in color. Large plagioclase phenocrysts (5 ~ 10 mm in length) occur characteristically in a completely argillized matrix. In a rather fresh rock, sericitized and carbonitized plagioclase, hornblende (altered to carbronate, chlorite and sericite) and corroded quartz are recognized as phenocrysts. Granular quartz, sericitized plagioclase, chlorite, ilmenite and opaque minerals make up its matrix.

This rock occurs as a circular body measuring 2 km in diameter. Argillization and silification are found everywhere. By X-ray diffractive analysis, montmorillonite and low quartz have been detected. The dacite mass is presumed to be a intrusive rock from its occurrence. But the distribution of aparent resistivity measured by geophysical survey indicates the dacite dips steeply toward west in the north and shows a lava form in the south.

2-2-4 Quartz diorite

The quartz diorite crops out in the upper reaches of the Taon River intruding into the Barcelona basaltic rocks. As the diorite porphyry dike (which is belived to intrude with the quartz diorite) cuts the dacite, therefore quartz diorite intruded after the dacite activity. It is cut by the above-mentioned olivine gabbro.

The main body of quartz diorite measures 750 m in width and 2,500 m in length and trends NNE. There are also small scale dikes parallel to the main body and another dike trending NNE-SSE.

The quartz diorite is generally medium grained and leucocratic (15 ~ 20% in color index). But rock facies vary from place to place. For example, fine grained melanocratic rock (60% in color index) and porphyritic rock with long plagioclase phenocrysts (8 mm in length) were obtained from the drill core. Pyrite disseminations are commonly observed along fissurres in them.

Under the microscope, it shows a subhedral and equigranular texture. Main consituents are plagioclase, hornblend, biorite and quartz with accessory apatite, sphene and magnetite. Plagioclase is tabular or prismatic and shows a zonal or twinning structure. It is usually rimmed by alkali feldspar and alters partially into sericite, chlorite and kaolinite. Hornblende is subhedral and prismatic. The quartz diorite does not contain hornblende in some places and contains few kali-feldspar.

The absolute alteration age of quartz diorite is $454 \times 10^6 \sim 494 \times 10^6$ years by K-Ar method. These figures are too old as well as the figure measured in the Phase II. As stated in the section 2-1-1, the age of the uppermost member of the Balcelona basaltic rocks is middle Oligocene. Therefore, the age of the quartz diorite, enclosing the basalt as a xenolith, should be younger than middle Oligocene. In this report, it is described as late Miocene because, from geological point, it looks most reasonable to relate the quartz diorite to the orogenic movement which occurred after the deposition of the Bislig formation (middle Miocene).

2-3 Some Studies on the Barcelona Group

The Balcelona basaltic rocks in the survey area have been formed by the repetitions of similar volcanic activities, hence it is hard to find out their differences in the field. Some studies were made in the laboratory on the rock samples in order to understand the nature of the basaltic rocks and the sedimentary environments..

2-3-1 Twin Method

The types of plagioclase twinning are closely related to the genesis of rocks. Accordingly the genesis and the chemical composition of rocks can be discussed from the ratios of various twin types. For this purpose, plagioclase crystalls are usually classified into the following 3 types:

U-twin —— untwinned plagioclase

A-twin ——plagioclases twinned after albite-, pericline- and acline laws

C-twin —— plagioclases twinned after Calsbad-, albite-, Carlsbads-, Ala-, Manebach-, Baveno-, and albite-Ala B laws

Table I-2 and Fig. I-2A, 2B show the ratios of U, C and A measured on 52 samples of ralatively fresh rocks in the Barcelona formations.

The following can be concluded from these tables.

1. Each point (each rock) of the Barcelona formations falls in the andesite and basalt fields.
2. The points of the Formations II scatter largely. This evidence coincides with the fact that the igneous activity of the Formation II varied greatly from augite

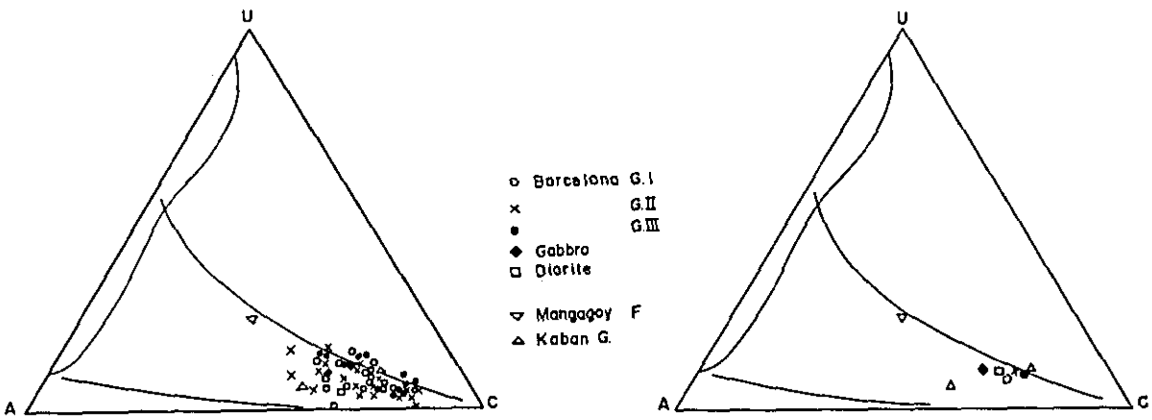
Table I-2. U:A:C ratios of twin forms in the plagioclases of Barcelona Group

Sample No.	Formation	Total	C-twin	A-twin	U-twin	Remarks	Sample No.	Formation	Total	C-twin	A-twin	U-twin	Remarks
N- 3	Barcelona I	17^{pcs}	$71^{\%}$	$24^{\%}$	$5^{\%}$	ba G	F- 37	Barcelona II	19^{pcs}	$74^{\%}$	$21^{\%}$	$5^{\%}$	an P
- 10	I	14	71	21	8	ba G	- 42	II	18	67	22	11	an P
- 13	I	14	57	29	14	an P	- 43	II	20	85	15	0	dol
- 50	I	10	70	20	10	an tf	- 51	II	19	53	37	11	an P
- 62	I	14	71	21	8	dol	P- 4	II	17	65	24	11	an P
- 92	I	19	63	32	5	an P	- 15	II	28	71	21	8	an P
-155	I	16	75	19	6	ba P	H- 18	III	21	67	19	14	dol
-162	I	16	63	25	12	ba P	- 20	III	23	78	13	9	dol
-183	I	14	64	21	15	dol	- 21	III	19	79	16	5	ba P
H- 2	I	9	67	33	0	ba P	- 30	III	20	80	15	5	ba P
- 4	I	23	78	17	5	ba P	- 50	III	17	82	12	6	dol
- 12	I	16	75	19	6	ba G	- 51	III	18	78	17	5	dol
- 15	I	15	67	27	6		- 52	III	19	74	21	5	
H- 6	II	14	50	34	16	tf	- 56	III	16	63	25	13	an P
- 34	II	16	69	25	6	ba P	- 60	III	21	81	14	6	an P
- 36	II	17	71	24	5	ba G	F- 46	III	15	67	20	13	ba P
- 39	II	22	73	18	9	an P	- 70	III	14	57	29	14	ba P
- 40	II	21	81	14	5	an P	- 74	III	19	58	26	16	ba P
- 41	II	18	83	11	6	an P	F- 14	Gabbro	17	65	24	11	
- 42	II	20	75	20	5	an P	P- 2	Gabbro	20	60	30	10	
- 43	II	25	80	16	4	an P	F-411	Q-diorite	10	60	30	10	
- 48	II	23	65	26	9	an P	P2- 2	Q-diorite	27	70	19	11	
F- 5	II	19	58	26	14	an P	P2- 3	Q-diorite	21	67	29	4	
-17B	II	20	60	35	5	an P	F- 88	Mangagoy F.	24	38	38	25	tf
- 26	II	15	67	20	13	an P	G- 96	Kaban G.	21	71	19	10	ba P
- 32	II	20	70	20	10	an P	G-127	Kaban G.	19	58	37	5	an P

ba- basalt dol- dolerite P- phenocryst
an- andesite tf- tuff G- ground mass

Figure I-2. U:A:C ratios in the plagioclases of Barcelona Group

(A) Individual U:A:C ratio (B) Average U:A:C ratios



to dacite.

3. The averages of each formation fall on the almost same point and the quartz diorite and the gabbro also fall near that point. In other words, the average compositions of plagioclase in all rocks are almost the same even if the mineral assemblages or textures differ a lot.

4. Considering the An% of plagioclases from the C-twin ratios, they correspond to labradorite ~ hytownite ranging from 50% to 90% of An.

5. The ratio of the Mangagoy formation falls apart from the point of the Barcelona formation. This fact suggests the igneous activity might have changed after the deposition of the Barcelona formation.

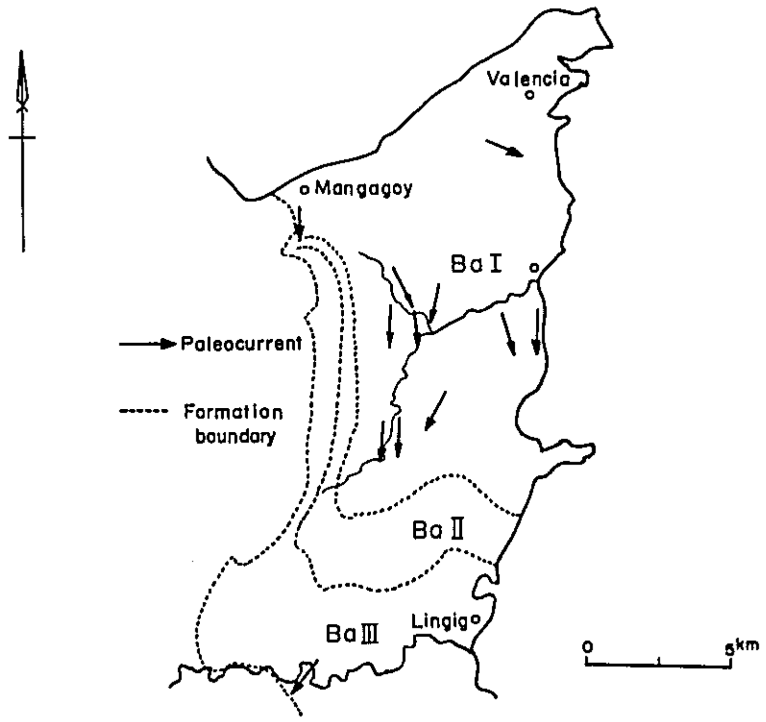
2-3-2 Paleocurrent System in the Barcelona Group

The current structures such as cross-bedding and arrangement of particles indicate the direction of current which carried the materials deposited.

In the clastic rocks, intercalated in the basalt lava flows of this area, cross beds are commonly observed. The current directions were measured from three-dimenensional study on the oriented samples. The results are shown in Fig. I-3.

What is evident from the figure is that paleocurrent system is N→S. Only current direction of cross bed in alternation of sandstone and mudstone in the south of barrio Valencia shows different direction as W→E. The discussion can not be made on that reason alone because of very few data available. But, generally speaking, it maybe considered that the paleocurrent system is N→S throughout the Barcelona group. When the intercalation of normalsedimentary rocks is also taken into consideration, it appears that the clastics were supplied from the northern land area during basaltic activities.

Figure I-3. Paleocurrent in Barcelona Group



2-4 Geological Structure and Geological History

The Barcelona group is well exposed not only along the eastern seashore but also along the main streams of the Lingig and Taon Rivers. But in the mountainous area the outcrops of this group are poor owing to thick vegetation cover. Besides, there are few key beds in this area. It is, therefore, very hard to make clear the geological structure. So, the geological structure and the geological development of this group are going to be discussed through evidences from pillow structures, which are characteristically develop in basalt lavas, and from a few pyroclastic and clastic rocks.

2-4-1 Geological Structure

The Barcelona group along the eastern seashore shows a monoclinic structure striking E-W and dipping $20^{o} \sim 30^{o}$S. But in other places the strike is disturbed by the following three folding structures.

That is, from the west to the east.

1. Synclinal structure passing in the direction of NNE-SSW from Bay View Hill behind PICOP factory to barrio Denipas.
2. Anticlinal structure passing from the junction of PICOP Logging Road 55 with Road 55B to Sanco point.
3. Synclinal structure passing northwards from barrio Lingig.

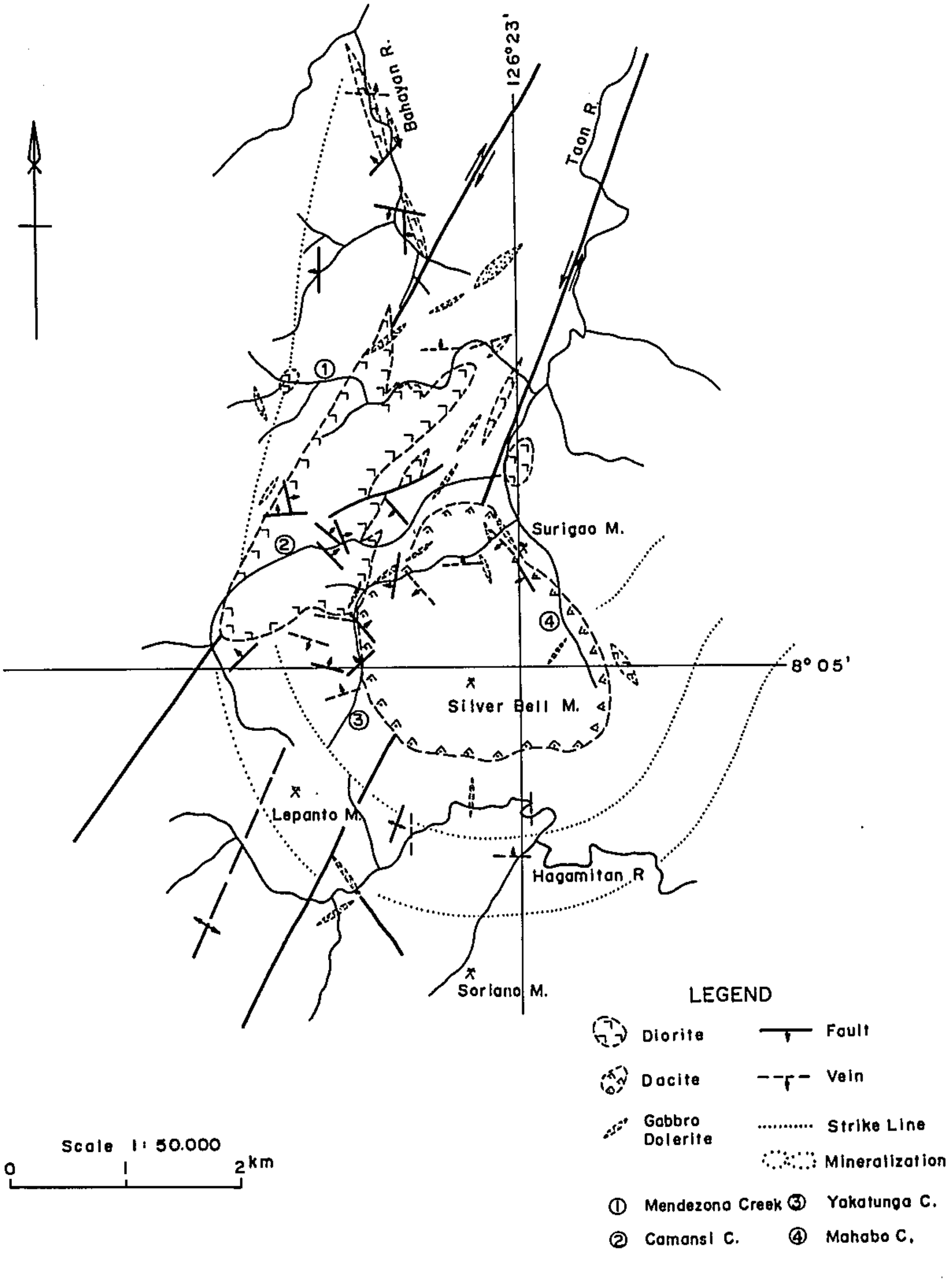
The former two are easily recognized in the Mangagoy formation which covers the Barcelona group. They are, however, not clear in the Bislig formation. This fact suggests the folding movement occurred at about the same time with the deposition of the Bislig formation.

The faults in the area are classified into three systems, viz, NNE-SSW, E-W and NNW-SSE directions. Above all the NNE-SSW system characterizes the geological structure in this area. Two faults of this systems are observed near the Taon River. Both of them are drag faults cutting the wings of folding structure. The block between two faults seems to move 1 ~ 2 km towards SSW, which makes the folding structure more prominent.

As shown in Fig. I-4, there are dykes, faults and quartz vein swarms in the mineralized area. They are arrenged regularly and most of them are closely related to the fissures caused by the drag fault. It looks clear that the quartz diorite main body and small-scale dykes striking NNE-SSW have been intruded along the shear cracks and that the dykes exposed along the Bahayan River with NNE-SSE direction have filled the tension cracks. The directions of dikes, faults and quartz veins near the dacite mass trend to intersect the folded beds at right angles. They are also related to the tension cracks produced by the folding.

Thus, the upper reaches of the Taon River where the igneous rocks are concentrated is the very place where the fault movements overlapped the folded struc-

Figure I-4. Dike, vein, fault swarms in the Bislig Area



tures. Therefore, it is considered that the complicated structures controlled the following igneous rock intrusions.

2-4-2 Geological History

The Barcelona group was devided into three formations by this phase survey. For lack of fossils, the age of each formation is still uncertain. So that, the geological history in this report is almost the same as that of the Phase II. The features of igneous activities in the area will be discussed with the field evidences.

The orogenic movement started probably at the end of Jurassic just as in other places in Mindanao. At first doming-up occured and then followed by block movement. The sedimentary basin in the area was formed during this period.

The following can be pointed out as the features of the Formation I of the Barcelona group.

(1) Most of the basalt lavas show pillow structure and contain some gas cavities.

(2) The pillows elongate in the N-S direction.

(3) The lava with columnar structure commonly coexists with the pillow lava.

(4) The basalt shows a quenched texture and contains ceradonite.

(5) Pisolites are found in some parts of basaltic tuff beds.

(6) There are many dolerite dikes having same mineral assemblage and similar texture to the basalt.

(7) Planeless faults strike E-W direction and dip southwards. All of them are normal gravity faults.

(8) A paleocurrent system, measured from the sedimentary structures in the clastic rocks, shows N-S direction.

(9) Very few differences on the features and occurrences of rocks are recognized throughout the Formation I.

(10) There are some secondary minerals indicating burial-metamorphism.

(11) Fine alternations of sandstone and mudstone are intercalated in this formation.

The foregoing evidences suggests that the Formation I was formed in a subaqueous environment by fissure eruption accompanying explosion and its sedimentary basin moved from north to south as the subsidence moved and that mud and silt were transported from the northern land during the development of Formation I.

The Formation II was formed by the volcanic activities with augite and hornblende andesites accompanying augite basalt.

The followings are its features.

(1) The lava with columnar structure are developed and some hyaloclastites are intercalated.

(2) It contains some poorly sorted volcanic comglomerates.

(3) It also contains some well classified and sorted pumice fall deposits.

From these evidences, the igneous activity during this period is considered to have occurred in a sub-aerial environment and others, in a subaqueous one. At the last stage, it changed from andesitic to dacitic. The sedimentary barite deposits of Soriano Mine was formed during this stage.

The volcanic activity during the deposition of Formation III occurred in the same environment as in Formation I. At the end of the activity, pyroclastic rocks were chiefly formed and their deposition continued untill the limestone of the middle Oligocene started to deposit.

Thus, the activity of the Barcelona group began at the middle of Cretaceous period and continued monotonously until the middle of Oligocene. Consequently, more than 3, 500 m thick of the lava flows accumlated. In the middle Oligocene, the whole of survey area was uplifted gently. On the other hand, the area west of the survey area sunk at the same time and the Mangagoy formation was developed conformably on the west side of the Barcelona group.

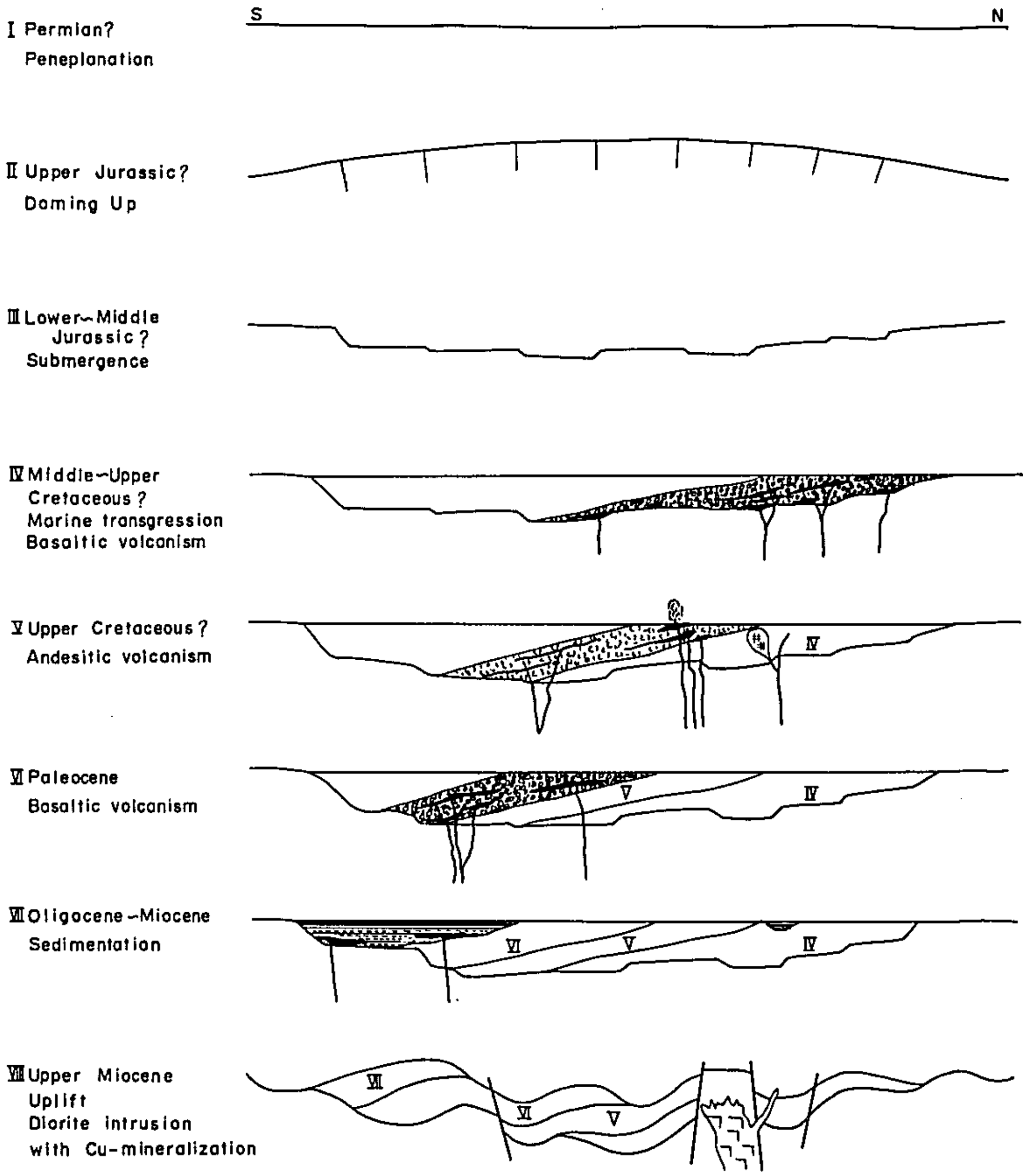
As a result of local subsidence, the Bislig formation deposited during middle Miocene. Later the area was disturbed by the tectonic movement during late Miocene; folding, faulting and fracturing occurred due to the compressional forces of E-W direction. Dacite, quartz diorite and gabbro intrusions followed. The mineralizations in the upper reaches of the Taon River are presumed to be late Miocene in age.

Thereafter, the whole area continued to be uplifted. Deposition of marine sediments, therefore, stopped.

During Quaternary time, limestone was deposited. Later marine regression consequently exposed the small limestone bodies along the eastern seashore.

The geological development of the Barcelona group is schmatically shown in Fig. I-5.

Figure I-5. Schematic sections showing geologic development of the Bislig Area



3. Economic Geology

In the central part of the survey area, the basalt is intruded by the quartz diorite, with accompanying porphyry copper type mineralization along its eastern rim.

Geological, geochemical and geophysical detailed surveys were carried out in Phase II on the northern half of this mineralized zone. The same methods were applied in Phase III on the southern half. Drilling was laid out immediately after these surveys, and therefore, studies on the results were made possible in the field.

3-1 Mineralized Zone

As shown in Fig. I-4, the Taon River branches off in the upper reaches into three creeks, Camansi, Yakatunga and Mahabo. The large scale alteration zone with 2 km in width and 2 km in length is extending from the Camansi creak to the Lingig River. The zone composed of andesite and dacite is so soft because of strong argillization and silicification that PICOP Logging Road 52, passing through the central part of this zone, is almost closed up during the rainny season.

As already reported, Surigao, Silver Bell and Lepanto mines are located in this zone. Additional 2 or 3 old test cross cuts and trenches were found during the surveys. They were excavated for exploring quartz veins, in which chalcopyrite, sphalerite, galena, pyrite and barite etc., were recognized to associate with.

Some descriptions may overlap those of Phase II report. However the features of main mineralized zones will be described.

3-1-1 Camansi Creek Mineralized Zone

This mineralized zone is a porphyry copper type located at the bank of the Camansi creek near point E-1 of Line No. 9 of geophysical survey.

The quartz diorite is exposed about 10 m in width around here and filmy or disseminated chalcopyrite, molybdenite and pyrite can be seen along joints developed in the quartz diorite at 10 ~ 20 cm intervals. Average grades are 0. 1 ~ 0. 3% of Cu and 0. 02 ~ 0. 05% of Mo but Cu is 3. 10% in better grade portion.

The country rock of quartz diorite is apparently very fresh. Under the microscope, plagioclase is partially altered to sericite, mafic minerals to chlorite and epidote. A few laumontite also occurs. Montmorillonite is detected by X-ray diffractive analysis although rock alteration is generally weak.

As the quartz diorite is exposed only at the riverbed, on the both hillsides, it appears to be the top portion of a dike. In the northern part of this zone, the geochemical anomalies of Cu, Mo and Ag and the geophysical anomalies (IP anomalies) were obtained but in the southern part, no interesting anomalies were detected by the Phase III surveys.

According to the geological survey along the stream, only pyrite dessemination can be seen along joints developed in the basalt or quartz diorite. Few Chalcopyrite and weak rock alteration are observed in the vicinity, and hence it is presumed that the geochemical and geophysical anomalies, extending in the direction of SSW from the Mendezona creek, begin diminishing rapidly at the Camasi creek.

3-1-2 Yakatunga Creek Mineralized Zone

In the drainage basin of the Yakatunga creek, there are two test levels. One is located near the junction with the Mahabo creek, and the other, near the main quartz diorite body.

The cross cut with 25 m length is excavated in the dacite and encounters quartz vein of 1 m width. The quartz vein is milky white in color and almost barren (Au 0. 1 g/t, Cu 0. 003% Zn 0. 04%). A few other veins with 0. 35 ~ 1. 0 m width are found near the pit mouth but all of them show low values as Au 0.1 ~ 0.2 g/t, Ag 2 ~ 4 g/t, Cu 0.01 ~ 0.24% and Zn 0.06 ~ 0.07%.

As the country rock of dacite is affected by strong alteration, only argillized plagioclase phenocrysts are recognized as an original texture. Under the microscope, corroded quartz of about 0.3 mm in size, plagioclase (altered almost to sericite and clay minerals) and mafic minerals (altered throughly to sericite and clay minerals) are in a carbonatized matrix. Very fine grained sphalerites are disseminated in this altered rock which shows Cu 0.04%, Zn 0.09% and S 3.2%.

The other level shows quartz vein with 0.20 m in width in the sheared zone. The vein does not contain sulphide minerals. The country rock is a bleached hornblende biotite dacite.

3-1-3 Surigao Mine

The adit of the mine is located at the western bank of the Mahabo creek. A tunnel was driven to explored high grade Pb-Zn deposits of either lens or vein type. As a inclined shaft is under water, the details of the deposits are unknown. Geochemical survey by soil sampling disclosed the Cu anomaly (200 ~ 450 m ppm) at the center of the shaft and extending narrowly in NNW-SSE direction. However, IP anomalies was not detected in this place so that the ore deposits are probably of very small scale.

3-1-4 Silver Bell Mineralized zone

This zone is located near Logging Road 52. The montmorillonitized dacite shows silicified zones which were once explored by trenching. Although some of the silicified zones have disseminations of chalcopyrite, sphalerite and galena, they are mostly almost barren. Accordingly, this mineralized zone can not be much expected to be promising.

Low Cu contents ranging 65 ~ 78 ppm were detected by the geochemical survey and few significant geophysical anomalies were detected.

The best and the average grades are shown below.

Sample No.	Width m	Cu %	Pb %	Zn %	S %	Remarks
f-100	0.50	0.14	2.1	5.9	-	best
t-18	1.00	0.18	tr	tr	4.36	average

3-2 Cu Contents in Soil

The geophysical survey lines almost covered the altered zone, so soil samples were taken along each line at 50 m intervals. They were analyzed for Cu by rubeanic acid method and further, all of them were checked by biquinoline method. The analytical procedure is shown in Appendices.

The analytical data are shown in PL I-6 and the results of the Phase II and III surveys are summerized in PL I-7.

What are evident from the plates are as follows:

1. Cu contents are low in the whole area.
2. Cu contents are very low (under 50 ppm) particularly in the strongly argillized and silicified zone.

The geochemical anomalous zone at the eastern end of geophysical lines is presumably due to the mineralization in the Surigao Mine. It extends about 500 m in the direction of N-S. Configuration of the anomalous zone shows a vein pattern, with maximum 450 ppm in Cu content.

The other anomaly strechs in SW direction from the Base Line of Line No. 9. The Cu anomalous zone of over 200 ppm is 300 m in width, its southern end reaching to Line D. It extends along the contact between the quartz diorite and the basaltic rocks, and connects smoothly to the geochemical anomalous zone detected during

Phase II. However, copper contents decrease rapidly towards south.

The anomalous zone at the western end of Line E is in the augite basalt of the Formation III. The outcrops of basalt around there are very fresh and limited mineralization can be observed, so that the 200 ppm of Cu is more or less due to the rock differences.

Cu contents in the Silver Bell mineralized zone are less than 50 ppm and the Cu anomaly at point No. 42 of Line G is probably caused by a silicified, pyrite disseminated zone with several meters in width, showing 0. 03% of Cu and 6. 8% of S.

4. Geology on Drill Holes

4-1 Outline of Drilling

From the systematic studies based on the results of the Phase II survey, the mineralized zone in the upper reaches of the Taon River is a porphyry copper type. A narrow geochemical anomalous zone of Cu and Mo along the eastern rim of the quartz diorite coincided with an IP anomalous zone and it was expected to extend towards depth. Phase III survey disclosed that the anomalous zone did not continue towards south, that is why drilling holes were set only in the area where the geochemical and geophysical surveys collaborated with each other in the Phase II survey.

The purpose of drilling was to investigate the mature of mineralized zone, so that drill holes were not concentrated in one place but were selected at 300 m intervals. All of them were vertical holes and 250 m in depth.

Location and reason for selecting site of each hole is as follows:

DDH-No. 1

The purpose of this hole was not only to test the geochemical anomaly located near point E-3 of Line No. 4 but also to investigate the northern limit of the anomalous zone. Although the anomaly is small and isolated, besides it does not show so high contents (ranging 300 ~ 400 ppm) of Cu, the drilling hole was sunk because of an argillized zone near the site accompanying pyrite dissemination in basalt.

The geophysical anomaly was interpreted as a shallow mineralized zone.

DDH-No. 2

This hole is located about 75m north from point E-1 of Line No. 6 neighboring the eastern rim of quartz diorite.

From geophysical point of view, this site was supposed to be most promising though geochemical anomalies of Cu were not detected around here. The No. 2 hole was drilled to investigate the IP anomaly.

DDH-No. 3

The hole is very closed to the point of Line No. 8. In the eastern side of Base line, remarkable geochemical anomalies of Cu, extending from Line No. 8 to No. 9, coincided with geophysical anomalies. The purpose of the hole was to secure information about mineralization at depth. At the bank of the river flowing down near this site, basalt is partly epidotized and pyrite disseminations are found along joints in the shape of thin film.

DDH-No. 4

The drill site is at the intermediate between points W-2 of Line No. 7 and of W-3 of Line No. 8 and in basalt near the contact with quartz diorite. The purpose of the drill hole was to explore the Cu anomaly extending along the contact. The Cu anomaly at this place coincides with the geophysical anomaly, too. The No. 4 site resembles No. 1 site in geological features.

DDH-No. 5

This site is at point E-1 of Line No. 9. It is in the geochemically anomalous zone of Cu shown by the DDH-No. 3. Mo contents show high values around here. The geophysical anomaly was interpreted to be caused by shallow mineralization. A small scale dike of quartz diorite with several meters in width is exposed at the riverside near the site. Filmy or disseminated chalcopyrite and pyrite with molybdenite can be seen along joints in the dike. The drill hole was sunk for defining the extension of this mineralization.

Thus, 5 drill holes were designed to test all geochemical anomalies overlapping geophysical anomalies in different geological conditions.

4-2 Geology on Drill Holes

The details on each hole are shown in PL III-1 III-5. Only their outlines are refered to in this section.

DDH-No. 1 (Depth: 250.00 m)

This hole encounters dolerite ~ basalt after 13.40 m thickness of overburnden. Then mineralized quartz diorite occurs from 197.50 m depth to bottom. From 166 m to 217 m in depth is a sheared zone. The dolerite~basalt is a dark gray black, compact and hard rock. It show a doleritic ~ intersertal texture but does not show flow texture.

The quartz diorite is grayish white in color and strongly altered. Therefore, it is very difficult to distinguish quartz diorite from other rocks. As the contact between quartz diorite and basalt is in the sheared zone and all cores are brocken, the dip of quartz diorite can not be estimated. But from granularity and distribution of the rock, it is considered that the quartz diorite of the core is a part of the main quartz diorite body.

Propylitic alteration shown by the mineral assemblage of chlorite-epidote-calcite is remarkable from the surface to 200 m depth; silicification can be observed with propylitic alteration from 100 m to 170 m in depth. In the quartz diorite extending from 200 m to the bottom, porphyritic alteration can not be observed because alteration has changed to strong quartz-sericite alteration accompanying weak kaolinization. Near the bottom, calcite and gypsum fill the fissures of the rock which are caused by shearing.

Pyrite is disseminated in whole drill hole section and pyrite stringers of several mm width are commonly observed along joints which are develop at a few cm ~ 10 cm intervals intersecting the drill hole at 40^{o} ~ 60^{o}. Chalcopyrite is usually accompanied by pyrite but rarely it is found alone in the form of vein or network. The mineral assemblages of pyrite-epidote and chalcopyrite-chlorite are common in the dolerite ~ basalt.

In the chalcopyrite disseminated zone which occurs below 220 m depth, a lot of chalcopyrite with less than 0. 05 mm in size is disseminated in the quartz diorite with pyrite and the amount of chalcopyrite is increasing towards depth. The network encountered at the bottom is chiefly composed of chalcopyrite. Under the microscope, fractures in the crushed chalcopyrite are filled with quartz, gypsum and calcite.

The ore minerals in the drill core are very simple, that is, chalcopyrite, pyrite and magnetite. Rarely sphalerite is observed even microscopically. No secondary oxide ore minerals can be detected.

Chemical assays of the chief mineralized zones are as follows;

depth m	width m	Au g/t	Ag g/t	Cu %	Mo %	Zn %
100 ~ 106	6	0. 0	0. 6	0. 53	0. 001	nd.
110 ~ 124	14	0. 0	0. 0	0. 40	0. 001	0. 00
134 ~ 146	12	0. 0	0. 2	0. 40	0. 001	0. 14
200 ~ 212	12	0. 0	0. 4	0. 35	0. 001	nd.
224 ~ 248	24	0. 1	2. 2	0. 68	0. 001	0. 06
248 ~ 250	2	0. 4	10. 0	4. 93	0. 001	0. 01

nd: no data

The average Cu grade from 100 m to 250 m depth is 0. 397%.

DDH-No2 (Depth: 250. 60 m)

After 11. 00 m thickness of overburnden, quartz diorite extends to the bottom. It is intruded by diorite porphyry dikes with 2 ~ 10 m in width at a few places. The quartz diorite is medium grained and shows 15 ~ 20% in colour index. It is lithologically uniform from the surface to the bottom, but large plagioclase prisms of 8 mm in length are observed.

The diorite porphyry is grayish white and contains large phenocrysts of plagioclase. It has always a chilled margin.

Weak prophylitic alteration occurs generally on the both rocks. A part of plagioclase and mafic minerals are altered to sericite, kaolonite, epidote and chlorite.

Mineralization is found along joints developing at 20 ~ 25 cm intervals and intersecting the drill hole at 60^{o} ~ 70^{o}; Pyrite-quartz films fill the joints. The density of the film is about 1/4 compared with that in the DDH-No. 1. Chalcopyrite is rarely seen with the pyrite film stated above, but its dissemination can not be observed unlike in DDH-No. 1.

Chemical assays show Cu 0. 16%, Mo 0. 001% from 16 to 20m depth; Cu 0. 24%, Mo 0. 001% from 48 to 50 m depth. Other parts are less than 0. 1% of Cu and very low in Mo content.

DDH-No. 3 (Depth; 250. 50 m)

After 9. 00 m thickness of overburden, the hole is throughout in basalt. The basalt is intruded at low angle (about 20^{o}) by small scale dykes of 1~ 10 m width; diorite porphyry at 60 m, dolerite at 110 m, 120 m and 130 m and quartz diorite at 200 m depth. This basalt is a little bit coarser, darke gray rock and shows the same texture as the DDH-No. 1. Although it is generally affected by weak cloritization, small amount of epidote and chlorite are noted unlike in DDH-No. 1.

The diorite porphyry is a grayish white, holocrystalline rock with porphyrite texture. Very fresh phenocrysts of plagioclase, hornblende and quartz are in an aggregate of secondary albite, chlorite, quartz and opaque minerals. This rock is presumed to be closely related with quartz diorite, however, only few pyrite dissemination are found compared to the other holes.

The quartz diorite is a fine grained, leucocratic rock. More than half of consituent minerals are hornblende; the rest are epidotized and sericitized plagioclase.

The dolerite is black grayish black in color. The megascopic features of this rock ressembles to the dolerite stated above. Half of consituents are mafic minerals which are throughly altered to epidote and actinolite.

The type and intensity of alteration are the same throughout and any trends of alteration, such as becoming strong towards depth, can not be recognized.

Most of mineralizations are pyrite disseminations along joints which are comparatively concentrated in the upper part from the surface to 80 m in depth. Although the highest Cu content was detected around here by the geochemical survey; only very few chalcopyrite disseminations are found in the cores. Pyrite-chalcopyrite stringers are merely observed at a few meters intervlas. Chemical analyses for copper show a little high value at these stringers. The highest Cu value is 0. 99% at 12 ~ 14 m in depth but the rest are low contents showing less than 0. 1% of Cu.

All contents of Au, Ag and Mo are traces.

DDH-No. 4 (Depth; 251. 20 m)

After overburnden of 7. 50 m in thickness, basalt ~ dolerite extends until 96 m depth and then quartz diorite to the bottom.

The former is a dark gray, compact rock and shows the same texture as the basalt dolerite of DDH-No. 1. Pyrite-quartz stringers are seen here and there along joints intersecting the drill hole at $45^{o} \sim 60^{o}$. But the joints are poorly developed as compared with other holes and Cu contents are generally low.

The quartz diorite is a medium grained rock showing equigranular texture. The appearance is uniform except the chilled margin of 0. 5 m width at the boundary with the basalt where silicification is conspicuous.

The diorite porphyry cuts the quartz diorite in small scale at 138 m and 216 m in depth. It is lithologically the same as DDH-No. 3. Secondary quartz occurs in its matrix.

Chemical assays show Cu 0. 69%, Mo trace and Au 0. 0 g/t at 128 m ~ 128 m in depth. The rest are always low grades of Cu, such as 0. 1%.

The main body of quartz diorite was supposed to incline eastwards by the geophysical survey in the Phase II. By this drill hole, it was confirmed that the inclination was $60^{o} \sim 70^{o}$.

DDH-No. 5 (Depth; 250. 50 m)

Below 15. 20 m thickness of overburden, dolerite extends to 69 m in depth, quartz diorite to 207 m in depth and then dolerite to the bottom.

The dolerite is dark gray. Microscopically, phenocrysts of plagioclase, augite and hornblende are in an aggregate of equigranular plagioclase (0. 05 mm in size), actinolite and chlorite. Alteration is propylitic and its intensity is the same as in DDH-No. 3 or No. 4.

The quartz diorite show 10% ~ 20% of colour index. In some places it does not contains hornblende crystals. Hydrothermal alteration is very weak. Only a very few parts of plagioclase are altered to sericite and kaolinite.

The 10 m thickness after overburden is disseminated by pyrite and chalcopyrite and local copper disseminations can be observed at 40 ~ 54 m and 67 ~ 80 m depth. Below 100 m in depth, some pyrite-epidote stringers with 1 ~ 2 cm width occur along joints intersecting the hole at $60^{o} \sim 70^{o}$. Narrow chloritized zone of 0. 5 ~ 2. 0 m in width are found near the stringers. Few chalcopyrite is disseminated.

Some chemical assays are shown below;

depth m		width m	Au g/t	Ag g/t	Cu %	Mo %
15.20	34	18.80	0.0	1.4	0.34	0.001
52	54	2	0.0	1.6	0.69	0.043
68	70	2	0.0	0.6	0.69	0.101
230	234	4	nd	nd	0.34	0.001

nd: no data

The rest are less than 0.01% of Cu and traces of Mo.

4-3 Summary of the Drilling

Five drill holes (each depth: 250 m) were sunk at the favorable sites which were selected by the results of the Phase II and III surveys. Consequently, the DDH-No. 1 hit the dissemination of porphyry copper type deposits. In this disseminated zone, Cu contents increase gradually towards bottom from the bowndary between quartz diorite and basalt. Besides, the rocks are strongly altered. That is, propylitic alteration shown by the mineral assemblage of epidote-chlorite is remarkable from the surface to 200 m in depth, and quartz-sericite alteration, from 100 m to the bottom.

The dissemination of chalcopyrite is dense in the quartz-sericite zone and from 200 m depth it tends to increase towards depth. Therefore, the deeper part can be expected for higher copper content.

The average assays of Cu calculating on various intervals are as follows:

depth m	width m	Cu %
Total	235	0.313
100 ~ 250	150	0.397

224 ~ 248	24	0.697
248 ~ 250	2	4.93

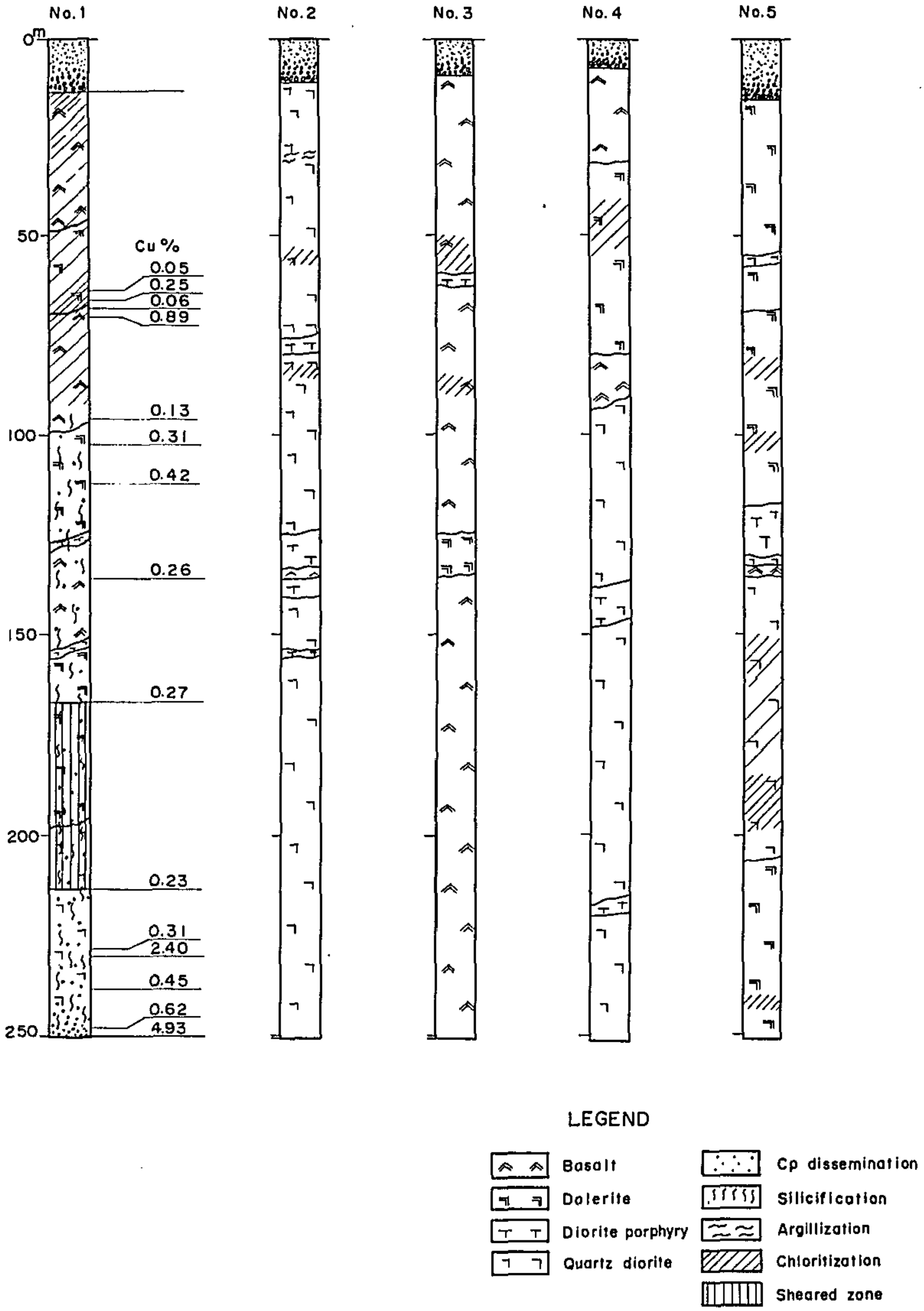
1. The other 4 holes show low grades of Cu and only very weak propylitic alteration is seen.

2. Large scale of geophysical and geochemical anomalies are not detected around DDH-No. 1.

The foregoing reasons suggest the mineralization extends locally.

From the result of DDH-No. 1, the quartz diorite can be estimated to incline eastward at 60^{o}.

Figure I-6. Compilation of core-logs



PART II GEOLOGICAL SURVEY

1. ABSTRACT

The results of the Phase II geophysical survey (Induced Polarization method) detected remarkable IP anomaly zone in the mineralized zone of the Bislig area, of which width is about 400 m and the zonal distribution of NNE direction is about 1,500 m. As this anomaly zone was expected to extend to the southwest of this area, the area to be surveyed in the Phase III was planned to extend southwards and the expansion of anomalous zone was surveyed by adopting IP method.

One of the objectives of this geophysical surveys was to select the effective drilling site in this area.

IP survey was conducted over 22.0 km of survey lines and the surveyed area was about 6 km^2 with 2,300 m East-West and 2,400 m North-South.

As a result of this survey, remarkable anomalous zone of 300 ~ 400 m length was recognized towards southwest, and the weaker anomalies were detected along the distribution of basalt. This anomalous zone dissapear in the southern end of quartz diorite and no anomalies are detected at all in the other district where diorite and hornblende andesite are distributed.

The strong FE anomaly zone coincide well with the high resistivity zone of basalt or quartz diorite, and the low resistivity zone due to hydrothermal alteration as detected in the Phase II was not confirmed. So, a promissing area was not found in this survey.

The mineral giving anomalous value was considered mainly due to pyrite judging from the surface mineralization and the drilling cores, however, chalcopyrite in the deeper zone may give also anomalous value which case is quite impossible for IP method of frequency domain to distinguish this difference.

Fruitful result of the IP survey was; remarkable anomalies in the region of low grade mineralization was detected which then was made as one of the basis of drilling.

2. Induced Polarization Method

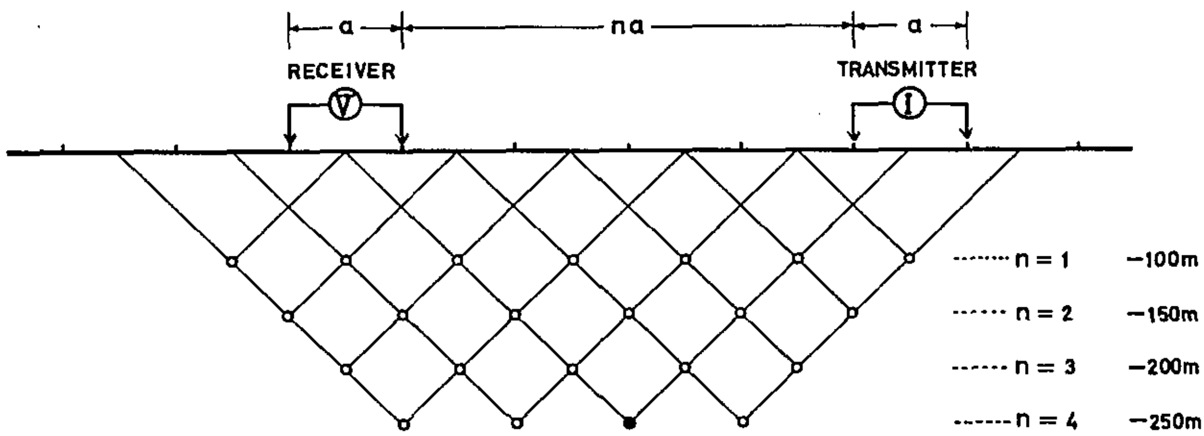
Induced polarization method conducted in this Phase is the same method and indications as that in the Phase II, so, general comparison and interpretation of both areas were done easily.

2-1 Method of Measurement

IP adopted in this survey is the variable frequency method and the electrode configuration is dipole-dipole with the electrode separation factor n = 1 to 4, then, the exploration depth h is,

$$h = \frac{a}{2}(n + 1) = 250 \text{ m}$$

Figure II-1. Method used in plotting dipole-dipole IP results



2-2 Indication of Results

As the topography of the surveyed area is comparatively gentle, the results are plotted in the method shown in Fig. II-1, with the indication of the topographic section on the upper part.

Frequency effect is defined as follows.

$$FE = \frac{\rho_{DC} - \rho_{AC}}{\rho_{AC}} 100(\%)$$

$$= AFE - (TD_{0.3} - TD_3) - RD - CAL$$

where,

FE---- The true frequency effect

Apparent resistivity for 0. 3 Hz

" " for 3. 0 Hz

AFE----- The apparent frequency effect at 0. 3 Hz read directly from the resceiver

TD0. 3----Transmitter deviation at 0. 3 Hz

TD 3 ---- " " at 3 Hz (final high frequency)

RD ------ Receiver deviation at 3 Hz

CAL----- Calibration correction for the receiver transmitter combination

Apparent resistivity

$$= \pi a n (n+1) \cdot (n+2) \cdot \frac{V}{I} \quad (\Omega\text{-m})$$

a ----- electrode distance 100 m

n ----- electrode separation factor 1, 2, 3, 4,

v ----- Input voltage of the receiver (volt)

i ------ Supplied current (amp)

Metal Conduction Factor

$$MCF = \frac{FE}{\rho_{DC}} \times 1,000$$

$$= (\sigma_{AC} - \sigma_{DC}) \times 1,000$$

ρ_{DC} ------apparent resistivity at 0. 3 Hz

σ_{AC} ------conductivity at 3 Hz

σ_{DC} ------ " at 0. 3 Hz

2-3 Physical Property of Rock Samples

Time domain IP method and variable frequency method were used at the same time for the measurement of physical property of the rock samples, and the analogue record were taken by the pen recorder for Time domain IP.

A small current supplied to the rock sample through constant current supply was 1 micro ampere and the measuring equipment was model YDC-441 and analogue IP receiver was YM-603.

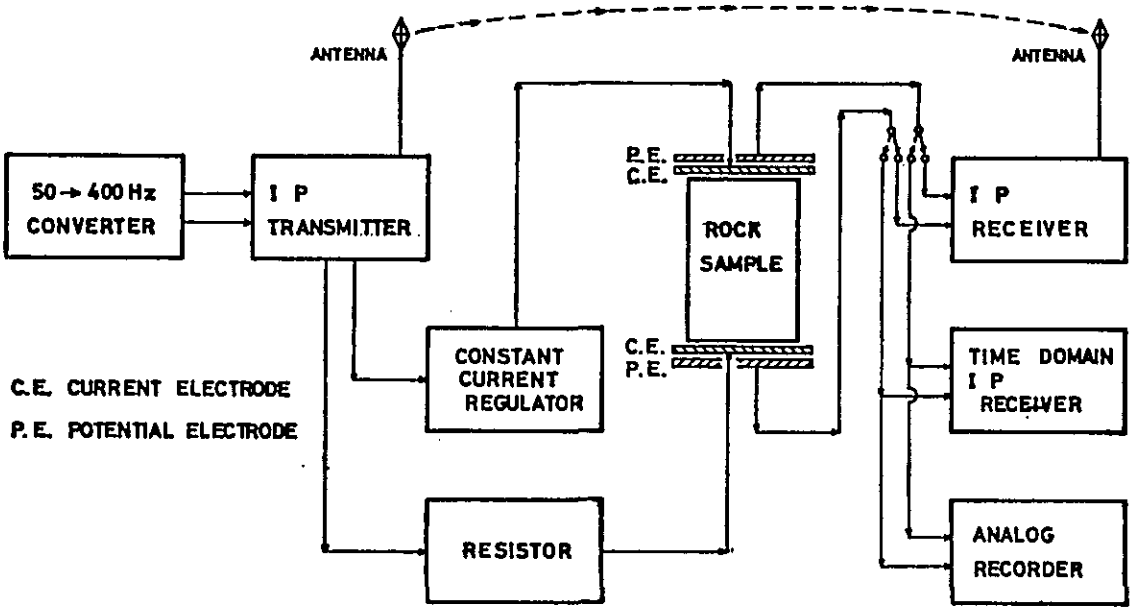
For time domain method, on time and off time were both 1, 250 milliseconds and for frequency domain method, 0. 3 and 3 Hz were used.

Chargeability m is a ratio of V_s and V_p, where V_s is the secondary residual voltage read from analogue record at 300 m sec after the current cut-off. Consequently, the chargeability is then expressed in % as follows;

$$m = V_S/V_p \times 100(\%)$$

Interpretation for the results of observation were mentioned in chapter 3-9.

Figure II-2. Schematic representation of circuitry



3. Results of IP Survey

3-1 Surveyed Area

The area surveyed is situated in the province of Surigao del Sur in Mindanao Island, south of the municipality of Bislig between barrio Mangagoy and the municipality of Lingig, around the valley of Taon.

This area is adjoining south of the eastern surveyed area in the Phase II geophysical survey.

It is bounded by;

Latitude 8^{o} 4'20" and 8^{o}5'40"N (2. 1 km north to south), and

Longitude 125^{o}21'30" and 126^{o}23'30"E (3. 6 km east to west).

The base station lies on the point O of No. 9 Line approximately at

Latitude 8^{o}5'40"N and Longitude 126^{o}22'38"E.

3-2 Period of Survey

The survey started October 22, 1973 and concluded on December 1, 1973 with 28 days of actual work during the 32 days of stay in the area.

3-3 Members of the Survey Team.

CESAR V. RAMOS	ASAHI HATTORI
MARIO TORRES	OSAMU KUSAKA
ELIGIO ARIATE	TOSHIAKI FUJIMOTO
	TOMIO TANAKA
	SABURO TACHIKAWA

3-4 Place and Transportation

As the surveyed area is adjoining south of the area surveyed in the Phase II, the base camp was set up again at PICOP Station Office of barrio Mangagoy, 8 km east of Bislig.

From this camp to the area of survey, it takes about 20 minutes by car using a logging road from Mangagoy.

The available roads in this area are the road to Lingig in the eastern part of the surveyed area, the logging Road 5 running North to South in the western side, and the unused logging road 52 connecting two roads in the center of this area.

3-5 Geological Features

The rocks of this area are composed of basaltic ~ doleritic rock of the Barcelona Formation I, andesite of the Formation II and intrusive rocks such as dacite, quartz diorite and gabbro, which are products of igneous activities during the late Miocene.

The basaltic rock of the Formation I is dark gray and compact, and lithologically same as the basalt in the detailed survey area of Phase II. It is distributed in the northern side of the Camansi creek. Colummar joints and filmy pyrite dissemination are commonly observed in this rock.

The andesit of the Formation II occupies the western half of the survey area. It is augite andesite which is usually accompanied with hornblende and is intercalated by several tuff-breccia ~ tuff beds. As folding and faulting occurred complicatedly in the area, neither strike nor dip of the strata tend to show the definite direction. Weak pyritization, argillization and silicification are generally observed.

The dacite covering the eastern half of the survey area, has probably intruded along faults and shows partially lava form. Due to montmorillonitization, nuch low temperature quartz occur throughout the dacite area. Surigao mine which was explored for Cu-pb-Zn, and Silver Bell mine which was tested for Au-Ag by trenching are located in this dacite body.

The quartz diorite with 750 m in width, stretches in NNE-SSW direction but does not stretch to Line E. Although a few pyrite dissemination occur on the eastern boundary of the diorite, chalcopyrite dissemination of rock alteration can not be seen.

The gabbro dikes which are probably the latatest intrusive rocks, cut the quartz diorite and the dacite and are distributed in small scale. They are considered to have intruded along the fissures trending NNE ~ NE and NNW, which are caused by faulting. No alteration can be recognized.

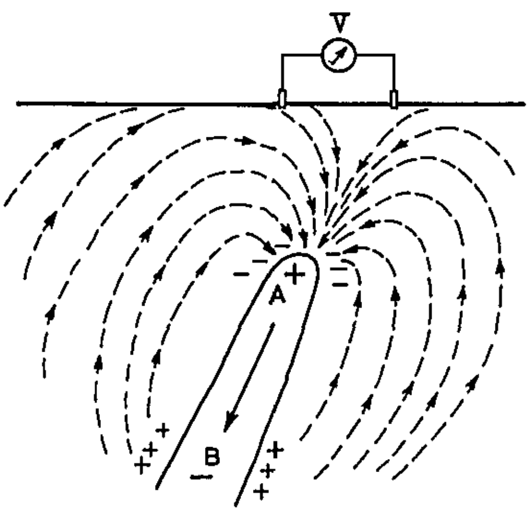
3-6 Others (SP method)

As SP method which has been used for a long time for the porphyry copper or vein type deposit which accompanies shallow mineralization, indicate a remarkable negative anomaly.

Especially when looking for sulfide ores, chemical action is continually going on, owing to the oxidation of the sulfides due to the action of surface or rain water which seeps through the ground. This chemical action sets up electrical currents in much the same manner as currents as produced by voltaic cells.

In the case of a vein of sulphide ore A B, as in Fig. II-3, covered with an

Figure II-3. Self potential produced by an oxidizing sulphide vein



overburden of some odd meters, the rain and surface water sinking into the ground reaches the sulphides and brings about oxidation.

The upper portion of the vein are usually more chemically active than the lower or deeper levels.

The upper portion A, where the activity is greatest, becomes the negative electrode, lower B becomes the positive electrode. As a result of this difference in potential, which may amount to more than 300 mV, currents of electricity flow down through the good conducting ore and return through the surronnding poorly conducting ground, making a complete circuit as in a battery.

So, negative center is detected on the surface above negative electrode A.

In the other hand, potential due to water flow in the porous rock and the oberburden is liable to become SP anomaly, such as negative potential on the mountain top and positive potential along the valley. So that topographical influence must be considered in the interpretation.

Self potential of the earth was measured in this survey when the remarkable IP anomalous zone was detected using non-polarizable porous pot electrode of Cu and electrolyte of CuSO4 and high sensitivity solid state SP instrument.

Self potential smoothed by the average of three measurements are shown on the section of line A of PL II-2.

3-7 IP Instruments

IP Transmitter

Model	506 made by CHIBA Electronic Laboratory
	Maximum output power 2. 5 A, 800V
Engine	Model 421 made by Briggs Stratton Co. , USA
	Maximum output power 3. 9 HP (at 3428 RPM)

Generator Model 421 made by Geotronics Co., USA

115 V, 17.3 A, 400 HZ, 2KW

IP Receiver

Model YDC-441 and YMO-605

made by YOKOHAMA Electronic Laboratory, JAPAN

SP Potentio meter

Model YM-501 made by YOKOHAMA Electronic

Laboratory, Japan with an accuracy of ±1 mV

Transceiver

Model CH-1330 made by HITACHI Co., JAPAN

Maximum output power 500 mW, 10 sets

3-8 The Survey

Lines and Bench Mark.

The IP survey lines were planned to extend to the south of the area of the Phase II survey based from the results of the geophysical survey of the Phase II and the detailed geological survey of the Phase III. So, the same base line of the Phase II survey was extended towards the south. (180^0 degree, magnetic south)

The base station was the point O of No. 9 Line (the intercept of the base line and No. 9 line) of which elevation is 118 m above sea level.

Although the interval of each survey lines of the Phase II was 250 m, while 300 m in this survey was adopted in order to investigate wider area by using Road 52.

Each survey lines intercept the base line at right angle.

The length of every survey lines are as follows,

A, B, C, D, F, G, H 7 lines each 2,300 m		16,100 m
Line E		3,500 m
Base Line		2,400 m
	Total	22,000

Topography of the surveyed area is moderately gentle with the elevation of the measuring points ranging from 90 to 260 m but the thick vegetation covers the area and all survey lines had to be brushed.

As for the name of the points, the initial point is designated as 20 while all the intercept points of the base line are designated 50, naming them continuous integer with every 50 m horizontal interval.

Measuring instruments were USHIKATA handy compass S-25 and eslon measuring tape with an accuracy of more than 1/50.

3-9 Interpretation of Results of Survey

The results of IP survey such as, profiles of topography with geology, frequency effect (FE), apparent resistivity and metal conduction factor are shown in PL II-2 ~ 10.

In this field metal conduction factor is not a significant parameter because FE anomalies coincide with the high resistivity zone. Interpretation for the metal conduction factor is not reffered to hereafter.

3-9-1 Interpretation of Profiles at Each Survey Lines

Line A (PL II-2)

The extentions of remarkable IP anomaly detected on line No. 9 in the Phase II survey are widely recognized in the western part of this line.

The width of anomaly is about 650 m from the point 34 to 47 and it shows a good agreement with the high resistivity zone.

The stronger mineralized area within this anomalous zone is found between point 45 and 47 stretching with a westward dip from the surface to the depth.

This zone with high resistivity and high frequency effect consists mainly of basalt and quartz diorite, and especially in the interface between basalt and diorite, the strong mineralization mainly by pyrite is supposed to continue to depths. Film shaped mineralization of pyrite are seen at the creek of point 47. There is no other portions in the surveyed area with such high FE values as above.

SP method are adopted on this anomalous zone and the average of three measurement are shown on the topographic section of Line A.

According to this results, SP anomaly is comparatively weak near the point 46 where the strongest IP anomaly was detected, while the strong negative anomaly was observed near the point 34 and 42.

This is considered to be partly because mineralization near the point 46 is very shallow and it becomes deeper towards west and partly because negative anomaly due to the topographic influence caused by flow potential which is overlapped at point 34 and 42 on the summit of the mountain.

If the topographic influence should be ejected, the anomalous source is considered to be very shallow near the point 45 ~ 47 and it becomes wide and deep near 34 ~ 43.

There are no IP anomaly at all in the dacite and basalt of Balcelona BA-I group. Argillized zone near the Lingig Road shows the shallow indication of low resistivity.

Line B (PL II-3)

Three to four percent FE anomaly was observed at points 38 ~ 42 but the anomaly is weak and its width is narrow compared to that of line A.

IP anomalous zone detected by the Phase II geophysical survey becomes unexpectedly weaker at the southern side of this line.

It is inferred that there are no mineralization in the quartz diorite of the western end of this line (west of point 35) and the mineralization in the basalt area in the NE-SW direction becomes very weak at the southern side of this line.

The interface between dacite (less than 100Ω m) and basalt (100 to 200 Ω m) lies near the point 44 and according to the results of simulation shown in PL II-15 the typical vertical interface is inferred.

Line C (PL II-4)

The weak FE anomaly accompanied by high resistivity zone were detected near the point 36. This anomaly of 3 ~ 4% FE indicate the shallow mineralization in the interface of basalt and diorite. (point 35 ~ 38)

Quartz diorite generally shows high resistivity from 400 to 1,000 Ω m and the gabbro shows higher resistivity more them 1,000 Ω m, so it brings an evident high resistivity anomaly.

High resistivity and high FE anomaly detected in the deeper zone about 200 m below the point 42, are supposed to be due to the diorite.

High resistivity detected at the point 56 is inferred to be the cause of gabbro occuring between line B and C.

Blind mineralized vein is expected to exist at about 150 m depth of point 60 ~ 62 where the weak FE anomaly were observed.

Line D (PL II-5)

Four to five percent FE anomaly observed in the distribution of diorite at west of point 34 shows the mineralization is shallower than 100 m, of which scale is very small.

In the dacite at point 50 ~ 62 very weak FE indication around 2 ~ 3% corresponds to weak mineralization.

Resistivity of diorite shows uniformly low resistivity from 50 ~ 100 Ω m.

Line E (PL II-6)

This survey line is the longest one which extends west to the Road 5 so as to verify the distribution of anomaly which might be considered extending south of this line.

However, no anomaly was observed at all at point 26 where southern end of anomalous zone was expected to be found, and high resistivity which corresponds to diorite and basalt was not also observed.

Line F (PL II-7)

No remarkable anomaly was observed except the slight anomalies found in dacite in the depth of 200 m at point 40 and in the depth of 150 m at point 55.

Both resistivity of andesite and dacite are 60 to 90 Ω m with no remarkable difference.

Line G (PL II-8)

Low resistivity zone less than 20 Ω m was observed near point 33, which is inffered to be due to tuff intercalated in the hornblend andesite. No FE anomaly was detected at all in this zone.

Two layer structures with the upper layer above 100 m of less than 50 Ω m and the lower layer of 50 ~ 100 Ωm were interpreted at points 46 ~ 54.

It might be due to the argilized quartz diorite at the surface which has much porosity.

Dacite is widely distributed in the eastern side of this line indicating 50 ~ 100 Ω m.

Line H (PL II-9)

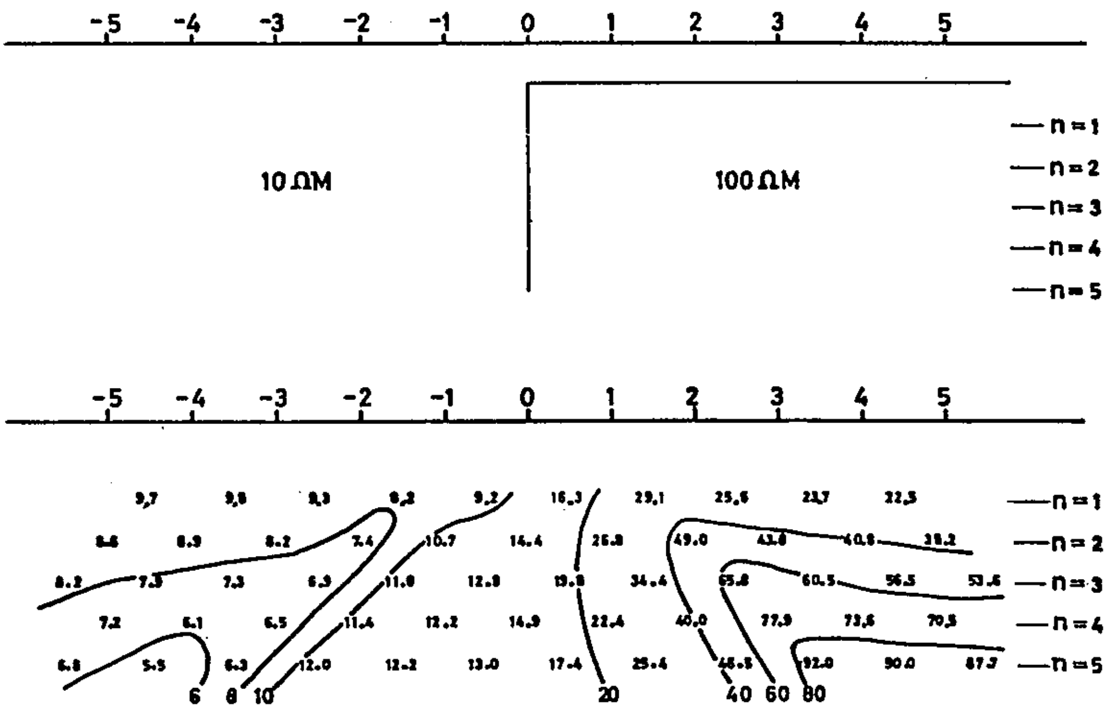
Remarkable IP anomaly was not detected at all in this line.

But the weak indication were recognized due to poor dissemination near point 42.

The boundary of hornblende andesite and dacite with the apparent resistivity of 50 Ω m comes near the points 44.

Typical vertical resistivity model is shown in Fig. II-4.

Figure II-4. Vertical model of resistivity



Base line (PL II-10)

Weak FE anomaly observed near the intercept of No. 9 line in the northern end of base line is caused by the shallow mineralization due mainly to pyrite.

No other anomaly was detected along this line as it runs over diorite in the direction of north to south.

The resistivity of diorite is generally low (50 ~ 100 Ω m) with a few exceptions of high resistivity zone caused by topographic influence. In this case, the location of the point where diorite thins out could not be inferred.

3-9-2 Plane Interpretation

Equi-apparent resistivity map and equi-FE map corresponding to 100 M (N=1) under the surface are shown in PL II-11 and PL II-12.

The remarkable FE anomaly observed near W-1 of No. 9 Line in the Phase II is getting weaker towards south west. The center of the anomalous zone passes line A point 44, line B point 40, line C point 35 and line D point 31 where the anomalous source is very shallow. No anomaly is detected at all on line E.

The anomalous zone mentioned above is overlapped with the high resistivity zone of the equi-resistivity map of more than 300 Ω m and it seems that the mineralization is found mainly in basalt.

Gabbro is so compact and lacking in porosity that it localy shows higher resistivity.

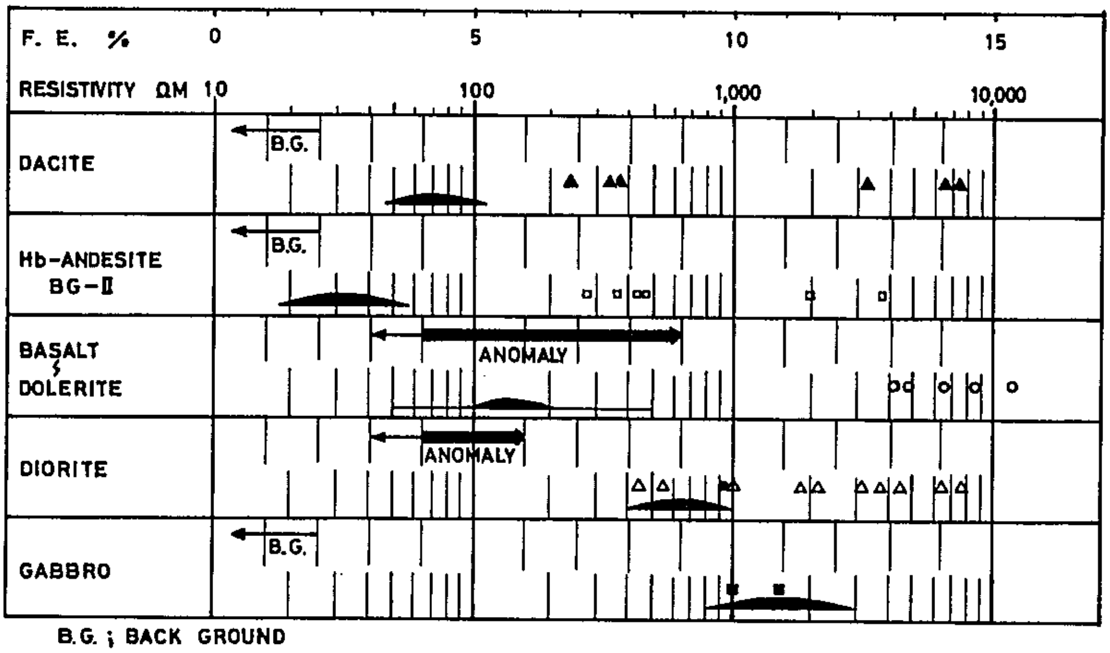
On the other hand low resistivity zone of less than 50 Ω m is widely distributed in southwestern part of the area. It agrees with the distribution of hornblende andesite of Balcelona group BA-II.

In the central part of the surveyed area where dacite is widely distributed, the resistivity is uniformely 70 to 100 Ω m and FE is monotonously less than 2%.

The change of resistivity and FE for each rock seen in this area are shown in Fig. II-5.

The resistivity shown by laboratory measurement of rock samples are shown on each column, indicating the higher resistivity than in-situ measurement with great amount of scatter.

Figure II-5. IP values from in-situ & laboratory measurement



3-10 Physical Property of Collected Rock Sample

Nineteen(19) rock samples collected on surface and 21 samples of drilling core are formed into a rectangular prism or cylindrical shape and resistivity, frequency effect and chargeability were measured after being bathed in water for 24 hours.

The results are shown in Fig. II-6 exhibiting graphically the correlation of FE and resistivity.

Diorite collected from the drilling core shows high FE anomaly and wide resistivity change. (Table II-1)

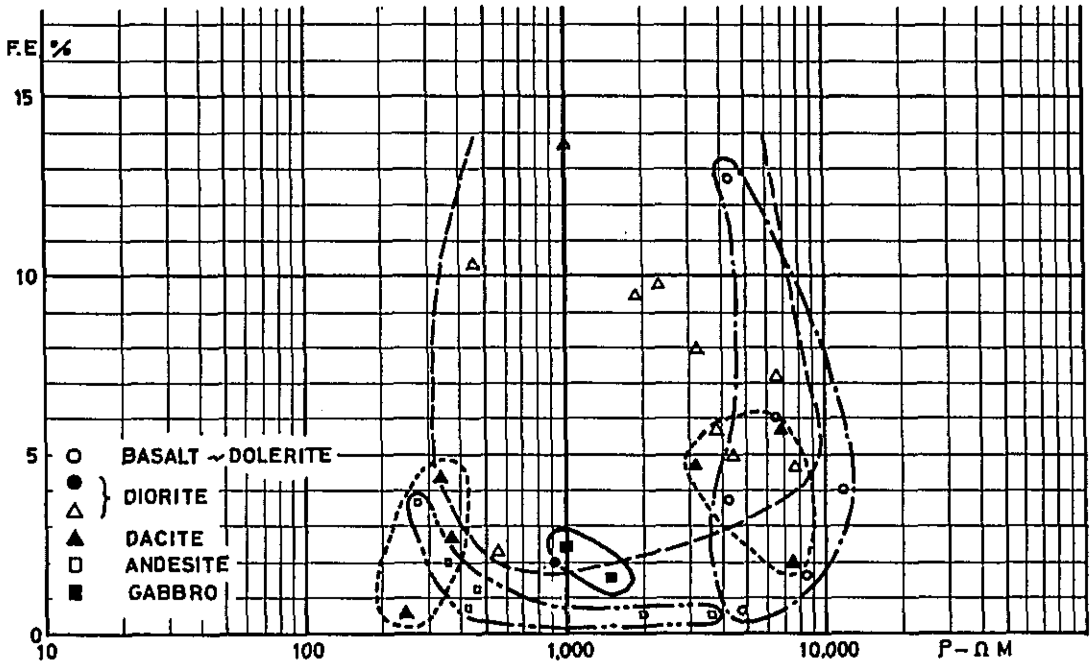
There is no difference in physical property between andesite and dacite indicating no FE anomaly. Some andesite show high resistivity due to silicification.

Resistivity of basalt is comparatively high and FE is more than 4%, however, the source of FE anomaly of diorite and basalt is pyrite.

Table II-1. Physical properties of rock samples

Sample No.	Rock	Resistivity (Ωm)	FE (%)	Chargeability (%)	Remarks	
P-1	gabbro	991	2.3		Line C-39	
P-2	gabbro	1483	1.7	0.84	Line B-38	
P-3	quartz diorite	916	2.0		Line B-28	
P-4	andesite	274	3.8	1.8	Line E-3	
P-5	altered andesite	1961	0.7		Line E-10	
P-6	silicified rock	3931	0.7		Line E-28	
P-7	dacite	7508	2.0		Line E-48	
P-8	andesite	363	1.3		Line D-28	
P-9	altered dacite	3669	0.5		Line C-44	
P-11	basalt	324	0.8		Line A-66	
P-12	dolerite	11600	4.0		Line A-44	
P-13	dacite	389	2.8		Line F-48	
P-14	andesite	7050	5.7		Line H-28	
P-15	andesite	368	2.0		Line H-42	
P-17	dacite	243	0.8	1.9	Line H-63	
P-18	dacite	329	4.5		Line F-59	
P-19	dacite	3096	4.8	1.2	Line D-61	
F-126	gabbro	3064	8.0		Line B-57	
1-1	dolerite	271	100	25.0	Drilling core; DDH-1	50.0m
1-2	dolerite	210	3.1			125.0m
1-3	diorite	462	10.3	4.3		245.0m
1-81	basalt (py)	1544	28.0	5.1		89.0m
2-1	quartz diorite	4315	5.0		DDH-2	40.3m
2-2	diorite porphyry	2250	9.8			137.0m
2-3	quartz diorite	14230	7.0			191.2m
3-1	diorite porphyry	7613	4.8	2.1	DDH-3	60.2m
3-2	dolerite	4263	3.8			110.5m
3-3	basalt	8408	1.7	4.7		174.05m
3-4	dolerite	6446	6.0			244.5m
4-1	dolerite	5065	43.5	39	DDH-4	77.0m
4-2	quartz diorite	1897	9.7	10.5		95.5m
4-3	quartz diorite	1019	13.7			166.0m
4-4	quartz diorite	3891	5.8	2.2		250.0m
4-5	basalt	1253	34.5	52		15.4m
5-1	dolerite	4190	12.8		DDH-5	29.0m
5-2	quartz diorite	549	2.2	3.6		200.05m
5-3	dolerite	802	1.7			220.7m
5-52	quartz diorite	6283	7.2			
5-87	quartz diorite	549	18.0	1.36		78.0m

Figure II-6. Correlation of resistivity and FE



Chargeability and FE are in positive correlation.

Typical decay curve of disseminated rock sample is shown in Fig. II-7.

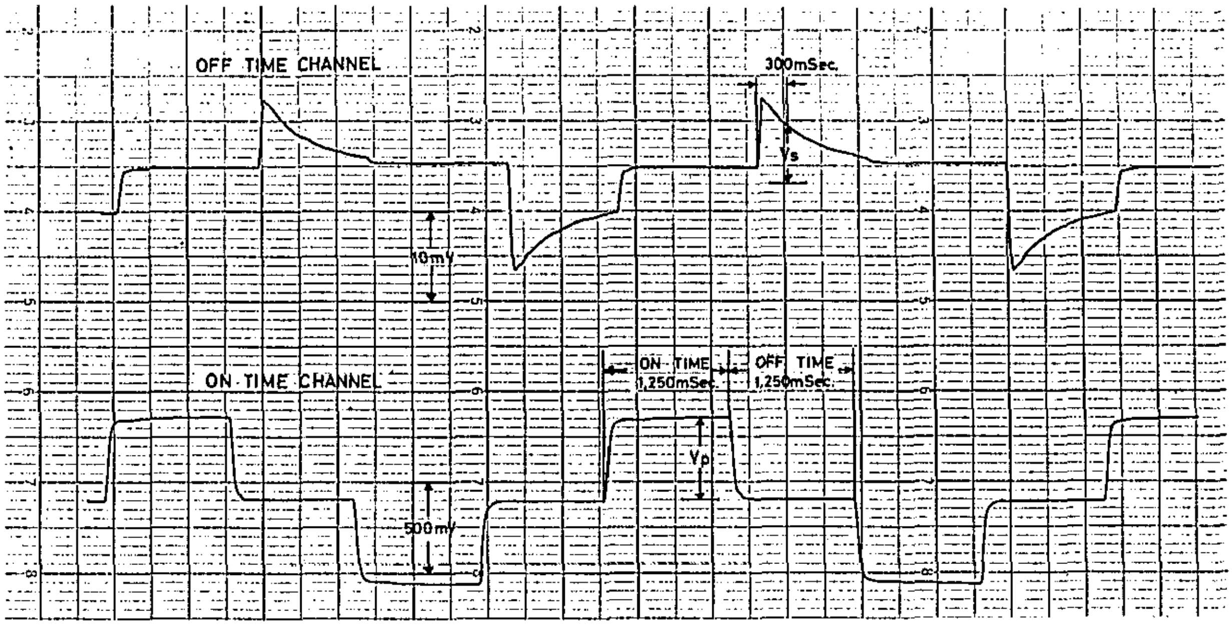
3-11 Model Calculation

For the two remarkable IP anomalies at lines A and B, two dimensional model caluculations using network of resistance were applied.

As shown in Fig. II-8, the underground was divided hypothetically into many grids and when a certain current electrode is given on the surface, the potential distribution is arrived at solving simultaneous equations which consists of deduction equations at 414 grid points.

Calculations were repeated several times by an IBM 360 MODEL 195K computer, so as to find an optimum solution by which the results of calculation comes

Figure II-7. Time domain wave form (Sample 5-87)

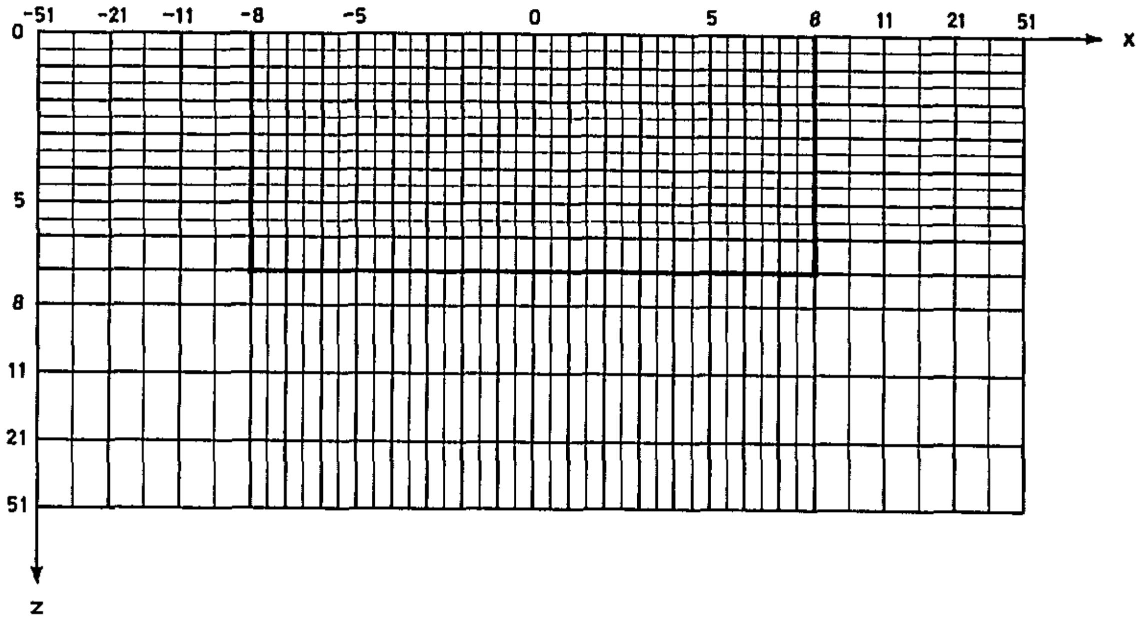


closest the observed value.

According to the Fig. II-14 and II-15, FE anomaly on both lines agrees well with the high resistivity zone of more than 400 Ω m indicating 8 or 9 by the code number.

Moreover, code number 2 shows an area of weak FE anomaly and high resistivity, corresponding to mineralized diorite.

Figure II-8. Two-dimensional resistance network for model calculation



4. Conclusion and Future Problem

Remarkable anomalous zone of a NE structure detected in Phase II is confirmed by adopting IP method, to extend 300 ~ 400 m to south west to line A. This anomaly becomes shallow on line D and disappears on line E. This is mainly due to the pyrite in basalt adjoining east of diorite, and FE anomalous zone are in good agreement with the distribution of basalt.

No remarkable anomaly was observed at all in the southeastern part of the surveyed area where decite and hornblende andesite are widely distributed.

Contrast of rock resistivity is considerably clear, that is, gabbro and diorite show high resistivity (more than 400 Ω m) and altered basalt show low resistivity (some 10 odd Ω m) generally ranging from 100 to 200 Ω m with partly high resistivity (more than 400 Ω m) due to silicification.

On the other hand dacite shows low resistivity (40 ~ 80 Ω m) and moreover hornblende and tuff is still show lower resistivity.

Judging from the mineralization of surface rock and drilling core, this anomaly is considered to be due mainly to disseminated pyrite.

Low resistivity zone accompanied by high FE anomaly, however, has not been detected in this area, so that the potential of prospecting would be low.

For drilling operation, stream junction about 100 m north of point 46 of Line B, is recommended as a drilling site in this area.

Geophysical logging such as resistivity logging or radioactive logging are recommended for the future drilling exploration so as to make interpretation easy.

PART III GEOCHEMICAL SURVEY

1. General Remarks

The drilling works were carried out for making clear the natures of mineralized zone disclosed by the Phase II and II surveys, from December 1, 1973 to February 10, 1974. Five (5) holes with a total of 1,253.10 m were sunk during the said period.

The operations were conducted in three shifts by two crews, these were, the drilling and hauling crews, including 2 supervisors (1 Filipino and 1 Japanese) and 6 drilling engineers (1 Filipino and 5 Japanese). Two (2) sets of drilling machines (TFM-2A and Longyear-34) were altenately used adopting wire-line process.

As it was the rainy season, heavy rains occurred everyday during operations. But the expected results were achieved by the great efforts of the team members and all personnel concerned.

2. Drilling Method and Drilling Machine

The drilling method was designed for the quartz diorite, which was supposed from the geological survey in the area, and for water running-out layer, sheared zone and partially argillized zone. Cutting oil was used for reducting drilling friction, extending bit life and raising drilling efficiency.

The types and specifications of the drilling machines used are shown in Table III-1.

Table III-1. Drilling equipment and consumed materials

A. Model "TFM-2A"

Article	Model	Specifications	Quantity
Drilling Machine	Model "TFM-2A" (Tone Boring, Co.)	Capacity: 400 mm Dimensions: Height 1,400 mm Length 1,800 mm Width 1,000 mm Weight (without Power Unit): 1,080 kg	1 set
	Swivel Head	Spindle Speed: 125, 304, 600, r.p.m.	
	Hoist	Type: Planetary Gear Hoisting Capacity: 2,000 kg	
	Oil Pump	Type: Gear Type, Two-setps Variable Delivery Vane Type Capacity: 60 /min Pressure: Max. 30kg/cm^2 Ord. 20kg/cm^2	
Moter	Model "E3L 812" (Mitsui Deuts, Co.)	Diesel Engine: 3 Cycle Air-cool Type Revolution: 1,500 2,000 r.p.m. Related Power: 31.5 41 P.S.	1 set
Drilling Pump	Model "NES-100B" (Tone Boring, Co.)	Duplex Cylinder Double Action Weight (without Power Unit): 325 kg Piston Diameter: 60, 70 mm Stroke: 50 mm Max. Capacity: 71, 100 /min Max. Pressure: 50, 35.5kg/cm^2	1 set
Water Supply Pump	Model "NS-110"	Diesel Engine (Yammer Diesel Co.) Revolution: 2,200 r.p.m. Related Power: 11 P.S.	1 set
Derrick			1 set
Drill Rod		NTQ – 3 m BTQ – 3 m	35 pcs 83 pcs
Casing Pipe		NX – 1.5 m NX – 1.0 m NX – 0.5 m BX – 3.0 m BX – 1.0 m BX – 0.5 m	5 pcs 10 pcs 10 pcs 45 pcs 15 pcs 5 pcs
Wireline Hoist		Attached to Drilling Machine	1 set
Rod Safety Clamps		RH – 85 Type	1 set
Water Swievel		DH Type	1 set
Travelling Block			2 pcs
Hoisting Swivel		B Type	1 set

B. Model "L-34"

Article	Model	Specifications	Quantity
Drilling Machine	Model "L-34" (Longyear Co.)	Capacity: 410 m Dimensions: Height 1,450 mm Length 2,150 mm Width 1,170 mm Weight (without Power Unit): 1,110 kg	1 set
	Swivel Head	Spindle Speed: 236 490 900 1510 r.p.m. 22 45 82 139 r.p.m.	
	Hoist	Type: Oil pressure Type (Power Up) Capacity: 2,460 kg	
	Oil Pump	Type: Variable Delivery Vane Type Capacity: 56 /min (1200 r.p.m.) Pressure Max. 70 kg/cm^2 Ord. 40 kg/cm^2	
Motor	Model "F3L-912"	Diesel Engine: 3 Cycle Air-cool Type Revolution: 1,800 2,000 r.p.m. Related Power: 33 36 P.S.	1 set
Drilling Pump	Model "NES-100B" (Tone Boring Co.)	Duplex Cylinder Double Action Weight (without Power Unit): 325 kg Piston Diameter: 60, 70 mm Stroke 50 mm Max. Capacity: 71, 100 /min Max. Pressure: 50, 35.5 kg/cm^2	1 set
Water Supply Pump	Model "NS-110"	Diesel Engine (Yammer Diesel Co.) Revolution: 2,200 r.p.m. Related Power: 11 P.S.	1 set
Derrick			1 set
Drill Rod		NTQ – 3 m BTQ – 3 m ATQ – 3 m	35 pcs 83 pcs 83 pcs
Casing Pipe		NX – 1.50 mm NX – 1.00 mm NX – 0.50 mm BX – 3.00 mm BX – 1.00 mm BX – 0.50 m AX – 3.00 m AX – 1.00 m	5 pcs 10 pcs 10 pcs 45 pcs 15 pcs 5 pcs 45 pcs 2 pcs
Wireline Hoist	WHL-3B (Tone Boring Co.)	Capacity: 300 m	1 set
Hoist Engine	NS-50	Diesel Engine (Yammer Diesel Co.) Revolution 2,200 r.p.m. Related Power 5 P.S.	1 set
Rod Safety Clamps		RH – 85 Type RH – 45 Type	1 set 1 set
Water Swievel		DH Type DRP – 9.5 Type	1 set 1 pcs
Hoisting Swivel		B Type	1 set

C. Consumed Materials

Article	Specification	Unit	Quantity					
			DDH-No. 1	DDH-No. 2	DDH-No. 3	DDH-No. 4	DDH-No. 5	Total
Gasoline								3,500
Light Oil			940	745	760	715	765	3,925
Mobil Oil	Engine		40	30	40	40	50	200
Misson Oil	Gear		10	10	10	10	20	60
Turbine Oil	Oil Pressure		130	70	30	40	40	310
Grease		kg	10	10	5	5	10	40
Cutting Oil			280	350	390	450	200	1,670
Metal Crown	HX	pcs						5
Single Core Tube	92. 1m/m x 0. 5m	set						2
Double Core Tube	NTQ-WL	set						2
do	BTQ-WL	set						2
do	ATQ-WL	set						2
Core Tube Head	HX	pcs						4
Casing Head	NX	pcs						2
do	BX	pcs						2
do	AX	pcs						2
Casing Metal Shoe	NX	pcs						3
do	BX	pcs						2
Cement		pack						15
Rag		kg						100
Core Box		pcs	28	36	36	36	36	172
Board	20m/m	m^3						5
Wire	# 10	kg						80
do	# 12	kg						80
Nail	2	kg						150
do	1	kg						40
Wire Rope	15m/m	m						700
do	18m/m x 25m	vol						5
Manila Rope	19m/m x 50m	vol						4
Binyl Rope	8m/m x 250m	vol						2
V-Belt	Engine	set						3
do	Pump	set						4
Wire Rope	5m/m x 500m	vol						2
Core-Lifter	NTQ-WL	pcs						17
do	BTQ-WL	pcs						25
do	ATQ-WL	pcs						13
Core-Lifter Case	NTQ-WL	pcs						8
do	BTQ-WL	pcs						12
do	ATQ-WL	pcs						6
Tension Pin	N. B. A. Size	pcs						5
Spring-Roll Pin		pcs						6
Ring	NTQ-WL	pcs						4
do	BTQ-WL	pcs						4
do	ATQ-WL	pcs						4
Rod-Inside-Tap	ATQ	pcs	2					2
Working Dress		set						40
Working Gloves		pair						120
Lighting Fixture	12V - 60W	set						1
Pressure Gauge	$80kg/cm^2$	pcs						3
Working Shoes	25, 26cm	pair						30

3. Drilling Operation

3-1 Preparatory Works

Before arriving at the camp, the drilling machines were planned to be carried in by self-moving method, based on the information obtained so far. The observation of the proposed drill sites judged, however, that it was impossible to complete the preparatory works within the scheduled period by the self-moving method only. Accordingly, a skyline aquipment was prepared immediately so as to carry in the machines using a skyline method.

At the same time, the TFM-2A type machine commenced to be carried in to the Drill Site No. 5 to where the transportation appeared to be completed in the shortest time by the self-moving only. Thus the drilling operation could be begun after 10 days. The Site No. 5 is located at the mountainside about 1 km apart from the bus road running from Bislig to Ligig.

The TFM-2A type machine was moved about 300 m in distance from Site No. 5 to Site No. 3 by self-moving, and then about 400 m into the interior from Site No. 3 to Site No. 4 using the skyline.

The L-34 type drill machine was carried in from the bus road to Site No. 1 using only a wireline hoist, which took about 17 days. From Site No. 1 to Site No. 2, it was carried in about 10 days using a simple skyline bought in Manila. Pipes were hauled to each hole almost by man power.

Sites No. 1 and No. 2 are located in a steep valley which are about 1. 5 km and 2. 5 km from the bus road, respectively.

Water supply for drilling was obtained from streams, through poly pipes, of the surrounding valley, or to install a drilling pump on the neighboring river bed.

3-2 Moving Operation

The moving operations of each hole are as follows:

3-3 Withdrawing Operations

L-34 Type Machine

Immediately upon completion of drilling work at Site No. 2 on January 25 in 1974, such works as pulling out casing pipes, dismounting a drilling machine and a derrick, etc. were conducted. Thereafter, skyline wires were strained. The skyline route differed from the route used in carrying in because the shortest route from site No. 2 to the road was chosen. It's distance was about 600 m in a straight line. After all equipments and supplies were assembled at the terminal of the skyline they were reconstructed and transfered by self-moving to the road, and on February 4,. brought by trucks to the provisional equipment warehouse, where packing works were carried out.

TFM-2A Type Machine

Immediately upon completion of drilling work at Site No. 4 on February 3 in 1974, such works as pulling out casing pipes, dismounting a drilling machine and a derrick, etc. were conducted. The equipment was withdrawn from Site No. 4 to Site No. 3 by mean's of skyline and carried out from Site No. 3 to the road by self-moving on the same way, and then, brought into the warehouse where packing were performed.

3-4 Coring Conditions and Hole-Wall Protection

As mentioned before, the drilling method, designed mainly for quartz diorite was generally proved to be satisfactory in obtaining the expected results.

Depths of overburdens in Bislig area for this phase were within the range of 7.5 ~ 15.2 m and metal crowns of H size were used to drill the overburden. Then,

Table III-2. Details of moving operation

Item		Hole No.	1		2		3		4		5		Total	
Moving Operation	In		3rd Dec. '73		29th Dec. '73		18th Dec. '73		20th Jan. '74		1st Dec. '73			
			21st Dec. '73		18th Jan. '74		7th Jan. '74		25th Jan. '74		12nd Dec. '73			
	Out				26th Jan. '74				3rd Feb. '74		23rd Dec. '73			
			8th Jan. '74		4th Feb. '74		19th Jan. '74		10th Feb. '74		28th Dec. '73			
			Day	Manday	Day	Manday	Day	Manday	Day	Manday	Day	Manday	Day	Manday
Preparations	Access Road		4	140	6	71	4	80	1	14	3	68	18	373
	Haulage		11	252	11	213	3	44	4	77	4	80	33	666
	Installation		2	28	0. 5	22	2	30	0. 5	27	3	64	8	171
	Test Run, etc.						1	11			1	46	2	57
	Total		17	420	17. 5	306	10	165	5. 5	118	11	258	61	1, 267
Removal	Dismantling				1	15			1	12	1	18	3	45
			2	9	0. 5	4	0. 5	4	0. 5	7	3	45	6. 5	69
	Haulage				7	112			5. 5	120			12. 5	232
	Road Reinestatement													
	Others				0. 5	12							0. 5	12
	Total		2	9	9	143	0. 5	4	7	139	4	63	22. 5	358
	Grand Total		19	429	26. 5	449	10. 5	169	12. 5	257	15	321	83. 5	1, 625

casing pipe of NX size were inserted down to a required depth, after drilling by NTQ, BPQ, APQ sizes in wire-line processes.

The drilling depths by NTQ-WL type process ranged from 86. 8 to 103. 1 m and averaged in 76. 7 m. Coring depths of the 5 holes range from 7. 5 to 251. 2 m. In hole No. 1, as stated in details in Article 3-5, sheared zones were encountered at about 134 m and 167 ~ 216 m depths. Consequently low of core recovery, caving and water gash-out were met in these sheared zones. But all these circumstances were overcome by changing to the ATQ-WL type which were available in field thus, enabling to continue drilling to the designated depth.

Mud-fluid was prepared for preserving the hole-wall. In No. 1 hole, water gash-out was too much (about 100 ℓ/min) for mud-fluid effect to be expected, so cutting oil, obtained in neighboring City was mixed with circulating water (1 ~ 3%) to reduce drill hole friction and prevent abrasion of drill tools. In the other 4 holes, cutting oil was used for the same purposes as well as No. 1 hole.

The drilling results are shown in Fig. 3-7, indicating drilling length per shift for the total works amounts to 9. 21 m with core recovery rate of 96. 3% in average.

3-5 Drilling Conditions

The results of 5 holes are summarized as follows:

3-5-1 DDH-No. 1

Drilling was commenced by using H size metal crown bit. It reached a basaltic hard gravel bed at a depth of 11 m which made it difficult to continue drilling using the metal crown. Then NX type casing pipes were inserted and drilling was continued by using NTQ-WL process.

From the coring conditions, it was judged to have reached a bed rock at 13. 70m depth. The base rock however, was unstable until 17. 00 m depth. Therefore, NK casing was inserted up to 17. 00 m depth to retain the hole-wall, drilled by NPQ-WL process from 11. 00 to 90 m, then BX casing pipes were inserted at the 90 m depth.

A sheared zone was encountered at approximate depth of 134 meters during drilling by BPQ-WL process, which caused drill hole friction to increase and consequently drilling was stopped for a while. So AX casing pipe were inserted down to the depth of 136. 40 m. The rock was stable to the depth of 167 m after the insertion but from 167 to 216 m depths a sheared zone with water-gash-out was again encountered. After 216 meters, the rock became stable, and the drilling was completed at 250 m in depth without considerable difficulties.

Efforts were made to retain the hole-wall using cutting oil between 11 and 250m.

From the time when the depth reached about 200 m, heavy rainfall continued, leading to rapid increase of water in the river. Consequently, the pump installed at the river side was likely to sink under the water and moreover, the working pass collapsed, so drilling was inevitably stopped at 250 m depth.

3-5-2 DDH-No. 2

Drilling commenced with H size metal crown bit. After reaching the bed rock at 11 m depth, NX casing pipes were inserted. As caving was recognized at the end of the pipe, the casing was inserted to 11. 50 m depth by reaming in order to retain the hole-wall. Drilled by NTQ-WL process from 11 to 101. 10 m, inserted by BX casing pipe down to a depth of 101. 10 m, then changed to BPQ-WL process. The rock is compact quartz diorite with few cracks. By BPQ-WL process, the depth from 101 to 250. 60 m was favorably drilled. Efforts were made to retain the hole-wall by using cutting oil after 11 m depth.

3-5-3 DDH-No. 3

Drilling commenced with H size metal crown bit. After reaching the bed rock at the depth of 9 m, NX casing pipes were inserted then changed to NTQ-WL process. The rock was basalt with abundant cracks. Core blocking occured but hole-wall was stable. A water gash-out layer (100ℓ/min) at about 100 m depth was encountered, but it was successfully surpressed by BX casing pipe inserted at 102. 70m as previously arranged. The length from 102. 70 to the planned depth was favorably drilled by BPQ-WL process. Efforts were made to retain the hole-wall by using cutting oil after 9 m depth.

3-5-4 DDH-No. 4

Drilling commenced using H size metal crown bit. After reaching the bed rock at 7. 50 m depth, NX casing pipes were inserted and changed to NPQ-WL process. Basalt occurred until about 90 m, thereafter, quartz diorite up tobottom. As rocks were generally hard, more bits in this hole were consumed than those in the others. The drilling operations were favorably carried out; drilled by NTQ-WL process from 7. 50 to 103. 10 m, inserted by BX casing pipes at 103. 10 m, thereafter changed to BPQ-WL process. Drilling was successfully completed at the depth of 251. 2 m without significant difficulties, except for the hard rock after 103. 10 m depth.

Efforts were made to retain the hole-wall by using cutting oil after 7. 50 m depth.

3-5-5 DDH-No. 5

Drilling commenced using H size metal crown bit. After reaching to bed rock at 15. 2 m, NX casing pipes were inserted then changed to NTQ-WL process. But the end of casing pipes was unstable, therefore casing pipe was inserted to 18 m depth by reaming. After drilled by NTQ-WL process from 15. 2 to 86. 8 m, BX casing pipes were inserted and changed to BPQ-WL process. Below 70 m depth the rock was chiefly composed of diorite and hole-wall became stable. In the lower part, the basalt with aboundant cracks occurred again. However, drilling was successfully completed at 250. 8 m depth.

Table III-3～III-7 show the summary records of drilling results while Table III-8 shows the generalized results of all holes.

Table III-3. Summary record of drilling results. DDH—No. 1

		Periods		Number of Days	Actual Working Days	Pay off	Total Number of Workers
Drilling Periods	Peraparation	3rd Dec. 1973	21st Dec. 1973	19	17	2	420
	Drilling	22nd Dec. 1973	7th Jan. 1974	17	13	4	179
	Removing		8th Jan. 1974	1	1	0	9
	Total	3rd Dec. 1973	8th Jan. 1974	37	31	6	608

Drilling Length	Planned Length	250^{m}		13.70^{m}
	Increase or Decrease in Length	0	Core Length	201.40^{m}
	Length Drilled	250^{m}	Core Recovery	85.2%

Core Recovery for Each 100m Section

Depth of Hole m	Section	Total	Depth of Hole m	Section	Total
0~100	95.8		600~700		
100~200	79.9	87.3	700~800		
200~300	77.7	85.2	800~900		
300~400			900~1000		
400~500			1000~1100		
500~600			1100~1200		

			%	%
Working Time	Drilling	123°05'	42.5	28.1
	Hoisting & Lowering Rod	30°05'	10.4	6.9
	Hoisting & Lowering I. T.	47°35'	16.4	10.9
	Miscellaneous	53°45'	18.5	12.3
	Repairing	11°50'	4.1	2.7
	Others	23°30'	8.1	5.4
	Total	289°50'	100	
	Re-moving: Pereparation	132°00'		30.1
	Re-moving: Moving	16°00'		3.6
	G. Total	437°50'		100

Efficiency of Drilling

250.00m/Work Period	6.76m/Day
250.00m/Working Days	8.06m/Day
250.00m/Drilling Period	14.71m/Day
250.00m/Net Drilling Days	19.23m/Day
Total Workers/608m	2.43
Total Drilling Workers/179m	0.72
Hoisting & Lowering Rod 4 Times	Hoisting & Lowering I. T. 195 Times

	Pipe Size & Meterage m	Inserted Length / Drilling Length (%)	Rcovery of Casing Pipe
Casing Pipe Inserted	NXC. S.G. 17.00	6.8 %	100%
	BXC. S.G. 90.00	36.0 %	100%
	AXC. S.G. 136.40	54.6 %	100%

Remarks

G = Grand
I. T. = Inner Tube

Table III-4. Summary record of drilling results, DDH–No. 2

		Periods		Number of Days	Actual Working Days	Pay off	Total Number of Workers
Drilling Periods	Preparation	29th Dec. 1973	18th Jan. 1974	21	18	3	316
	Drilling	18th Jan. 1974	25th Jan. 1974	8	8	0	89
	Removing	26th Jan. 1974	4th Feb. 1974	10	10	0	143
	Total	29th Dec. 1973	4th Feb. 1974	39	36	3	548

Drilling Length	Planned Length	250.00 m		11.00 m
	Increase or Decrease in Length	0.60 m	Core Length	238.60 m
	Length Drilled	250.60 m	Core Recovery	99.6%

Core Recovery for Each 100m Section

Depth of Hole m	Section	Total	Depth of Hole m	Section	Total
0~100	98.9		600~700		
100~200	100	99.5	700~800		
200~300	100	99.6	800~900		
300~400			800~900		
400~500			1000~1100		
500~600			1100~1200		

				%	%
Working Time	Drilling		94°05'	59.9	24.5
	Hoisting & Lowering Rod		11°20'	7.2	2.9
	Hoisting & Lowering I. T.		27°05'	17.2	7.0
	Miscellaneous		17°10'	10.9	4.5
	Repairing		0	0	0
	Others		7°30'	4.8	2.0
	Total		157°10'	100	
	Re-moving	Preparation	143°00'		37.2
		Moving	84°10'		21.9
	G. Total		384°20'		100

Efficiency of Drilling

250.60m/Work Period	6.43m/Day
250.60m/Working Days	6.96m/Day
250.60m/Drilling Period	31.3m/Day
250.60m/Net Drilling Days	31.3m/Day
Total Workers/548m	2.19
Total Drilling Workers/89m	0.36
Hoisting & Lowering Rod 9 Times	Hoisting & Lowering I. T. 116 Times

	Pipe Size & Meterage m	Inserted Length / Drilling Length (%)	Recovery of Casing Pipe
Casing Pipe Inserted	NXC. S. G. 11.50	4.6	100%
	BXC. S. G. 101.10	40.3	100%

Remarks

G = Grand

I. T. = Inner Tube

Table III-5. Summary record of drilling results. DDH–No. 3

		Period		Number of Days	Actual Working Days	Pay off	Total Number of Workers
Drilling Periods	Preparation	18th Dec. 1973	7th Jan. 1974	21	10	11	165
	Drilling	8th Jan. 1974	18th Jan. 1974	11	10	1	125
	Removing		18th Jan. 1974	0.5	0.5	0	4
	Total	18th Dec. 1973	18th Jan. 1974	32.5	20.5	12	294

Drilling Length	Planned Length	250.00 m		9.00 m
	Increase or Decrease in Length	0.50 m	Core Length	237.50 m
	Length Drilled	250.50 m	Core Recovery	98.3%
Working Time			%	%
	Drilling	114°40'	52.6	37.7
	Hoisting & Lowering Rod	16°30'	7.6	5.4
	Hoisting & Lowering I. T.	38°00'	17.4	12.6
	Miscellaneous	22°00'	10.1	7.2
	Repairing	10°20'	4.7	3.4
	Others	16°30'	7.6	5.4
	Total	218°00'	100	
	Re-moving: Preparation	80°00'		26.3
	Re-moving: Moving	6°00'		2.0
	G. Total	304°00'		100

Core Recovery for Each 100m Section

Depth of Hole m	Section	Total	Depth of Hole m	Section	Total
0～100	97.7		600～700		
100～200	98.1	97.9	700～800		
200～300	100	98.3	800～900		
300～400			900～1000		
400～500			1000～1100		
500～600			1100～1200		

Efficiency of Drilling

250.50m/Work Period	7.7m/Day
250.50m/Working Period	12.2m/Day
250.50m/Drilling Period	22.8m/Day
250.50m/Net Drilling Days	25.1m/Day
Total Workers/294 m	1.2
Total Drilling Workers/125m	0.5
Hoisting & Lowering Rod 14 Times	Hoisting & Lowering I. T. 184 Times

	Pipe Size & Meterage m	Inserted Length / Drilling Length (%)	Recovery of Casing Pipe
Casing Pipe Inserted	NXC. S.G. 9.00	3.6	100%
	BXC. S.G. 103.20	41.2	100%

Remarks

G = Grand

I. T. = Inner Tube

Table III-6. Summary record of drilling results, DDH–No. 4

		Periods		Number of Days	Actual Working Days	Pay off	Total Number of Workers
Drilling Periods	Preparation	20th Jan. 1974	25th Jan. 1974	6	6	0	118
	Drilling	25th Jan. 1974	3rd Feb. 1974	10	10	0	107
	Removing	3rd Feb. 1974	10th Feb. 1974	10.5	10.5	0	139
	Total	20th Jan. 1974	10th Feb. 1974	26.5	26.5	0	364

Drilling Length	Planned Length	250m		7.50m
	Increase or Decrease in Length	1.20m	Core Length	243.60m
	Length Drilled	251.20m	Core Recovery	99.9%

Core Recovery for Each 100m Section

Depth of Hole m	Section	Total	Depth of Hole m	Section	Total
0~100	100		600~700		
100~200	99.9	99.9	700~800		
200~300	100	99.9	800~900		
300~400			900~1000		
400~500			1000~1100		
500~600			1100~1200		

			%	%
Working Time	Drilling	120°35'	56.9	35.0
	Hoisting & Lowering Rod	30°10'	14.2	8.7
	Hoisting & Lowering I. T.	30°05'	14.2	8.7
	Miscellaneous	10°40'	5.0	3.1
	Repairing	4°00'	1.9	1.2
	Others	16°30'	7.8	4.8
	Total	212°00'	100	
	Re-moving Preparation	48°00'		13.9
	Re-moving Moving	85°00'		24.6
	G. Total	345°00'		100

Efficiency of Drilling

251.20m/Work Period	9.48m/Day
251.20m/Working Days	9.48m/Day
251.20m/Drilling Period	25.12m/Day
251.20m/Net Drilling Dyas	25.12m/Day
Total Workers/364m	1.45
Total Drilling Workers/107m	0.43
Hoisting & Lowering Rod 20 Times	Hoisting & Lowering I. T. 152 Times

	Pipe Size & Meterage	Inserted Length / Drilling Length (%)	Recovery of Casing Pipe
Casing Pipe Inserted	NXC. S. G. 7.50m	3.0	100%
	BXC. S. G.	41.0	100%

Remarks

G = Grand

I. T. = Innar Tube

Table III-7. Summary record of drilling results, DDH–No. 5

		Periods		Number of Days	Actual Working Days	Pay off	Total Number of Workers
Drilling Periods	Preparation	1st Dec. 1973	12nd Dec. 1973	12	11	1	258
	Drilling	13rd Dec. 1973	22nd Dec. 1973	10	10	0	149
	Removing	23rd Dec. 1973	28th Dec. 1973	6	4	2	63
	Total	1st Dec. 1973	28th Dec. 1973	28	25	3	470

Drilling Length	Planned Length	250.00m		15.20m
	Increase or Decrease in Length	0.80m	Core Length	230.45m
	Length Drilled	250.80m	Core Recovery	97.8%

			%	%
Working Time	Drilling	109°15'	52.5	33.3
	Hoisting Lowering Rod	25°00'	12.0	7.6
	Hoisting & Lowering I. T.	27°55'	13.4	8.5
	Miscellaneous	27°50'	13.4	8.5
	Repairing	0	0	0
	Others	18°00'	8.7	5.5
	Total	208°00'	100	
	Re-moving: Preparation	88°00'		26.8
	Re-moving: Moving	32°00'		9.8
	G. Total	328°00'		100

Core Recovery for Each 100m Section

Depth of Hole m	Section	Total	Depth of Hole m	Section	Total
0~100	98.4		600~700		
100~200	96.7	97.5	700~800		
200~300	99.0	97.8	800~900		
300~400			900~1000		
400~500			1000~1100		
500~600			1100~1200		

Effciency of Drilling

250.80m/Work Period	8.96m/Day
250.80m/Working Days	10.0 m/Day
250.80m/Drilling Period	25.1 m/Day
250.80m/Net Drilling Days	25.1 m/Day
Total Workers/470m	1.87
Total Drilling Workers/149m	0.59
Hoisting & Lowering Rod 17 Times	Hoisting & Lowering I. T. 138 Times

	Pipe Size & Meterage	Inserted Length / Drilling Length (%)	Recovery of Casing Pipe
Casing Pipe Inserted	NXC. S. G. 18.00m	7.2	61.1%
	BXC. S. G. 86.80m	34.6	100

Remarks

G = Grand
I. T. = Inner Tube

Table III-8. Generalized results of diamond drilling

Drill Hole No.	Type of Machine	Drilling Period	Drilled Length	Core		Number of drilling Shift			Drilling Speed	
				Length	Recovery	Drilling	Casing.etc	Total	*m/Shift	**m/Shift
			m	m	shift	shift	shift	shift		
1	L-34	Dec. 22, 1973 ~Jan. 7, 1974	250.00	201.40	85.2	34	2	36	6.94	7.35
2	L-34	Jan. 18, 1974 ~Jan. 25, 1974	250.60	238.60	99.6	20	1	21	11.93	12.53
3	TFM-2A	Jan. 9, 1974 ~Jan. 18, 1974	250.50	237.50	98.3	26	1	27	9.29	9.63
4	TFM-2A	Jan. 25, 1974 ~Feb. 3, 1974	251.20	243.60	99.9	26	0	26	9.66	9.66
5	TFM-2A	Dec. 13, 1973 ~Dec. 22, 1973	250.80	230.80	97.8	26	0	26	9.65	9.65
Total	5 Holes	Dec. 13, 1973 ~Feb. 3, 1974	1,253.10	1,151.90	96.3	132	4	136	9 21	9.49

Notes: * Drilling length per one shift covering total works conducted.
** Drilling length per one shift covering net drilling operations.

APPENDICES

I. **Analytical method used for the geochemical survey**

Copper analysis by α - α' Biquinoline method

a) Sample Attack

1. Weigh 0. 2 gr. (-80 mesh) into Pyrex test tube.
2. Add 3 scoops (0. 6 gr.) of Pyrosulphate $K_2S_2O_7$.
3. Fuse them above propene torch.
4. Add 4 ml of 1% HCl.
5. Dissolve residue by heating.

b) Cu – Determination

6. Add Keno Buffer Solution 10 ml and make pH 5. 0.
7. Add 2 ml Biquinoline.
8. Compare with standards.

Keno Buffer Solution

150 gr. Sodium Acetate (Anhydrous) if it is a crystal, 250 gr. and Hydroxylamine hydrochloride (10 gr.) make up Keno Buffer with 500 mls of demineralized water.

0. 4 gr. Biquinoline in 2 l of Amyl Alcohole.

Preparation : Warm up 800 mls of Amyl Alcohol to dissolve Biquinoline properly. Let it cool and make up to 2, 000 ml with further addition of Amyl Alcohol.

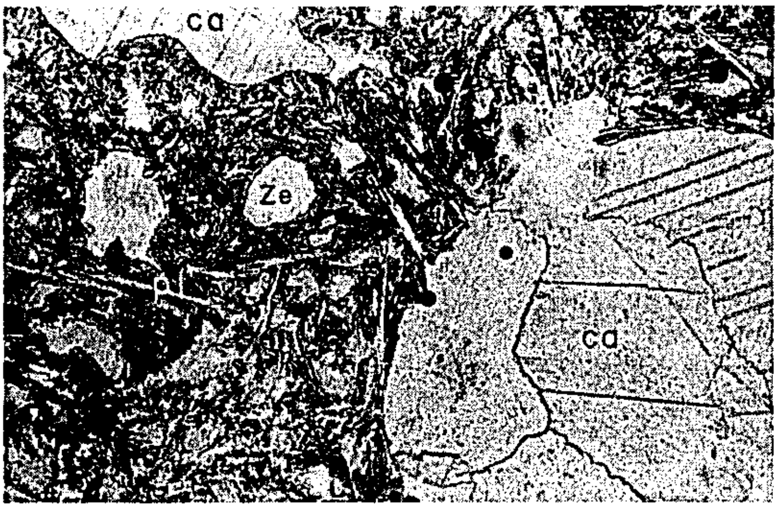
PL- 1

A: Andesitic tuff breccia
(Sample No. N-43)

Lithic fragments of porphyritic augite andesite (and) and christal fragment of augite (au) are welded with chlorite and tuffaceous material.

X–nicols

x 70



B: Aphyric andesite
(Sample No. N-177)

Secondary calcite (Ca) occurs in a matrix of acicular plagioclase (pl), brown glass and minute ilmenite. Amygdals are filled with zeolite (ze).

X–nicols

x 70

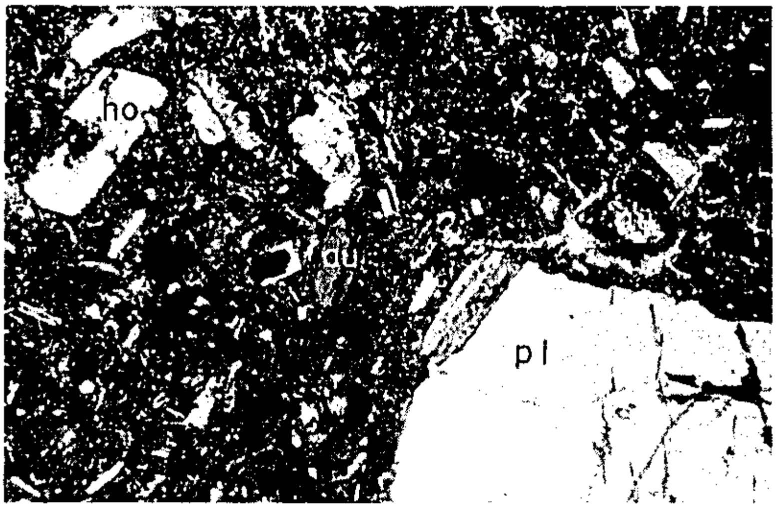
C: Augite basalt
(Sample No. 192)

Phenocrysts of plagioclase (pl) and augite (replaced by calcite) occur in a matrix of prismatic plagioclase (pl) and augite (au).

X–nicols

x 70

PL-2 Barcelona Group II

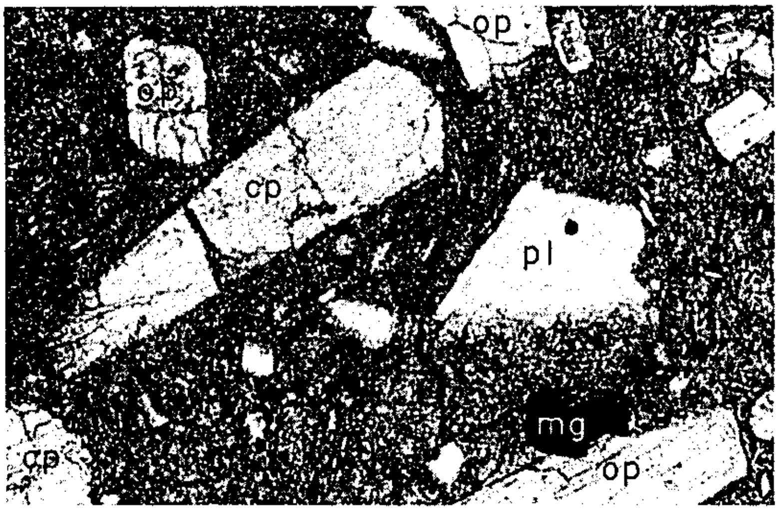


A: Hornblende augite andesite (Sample No. H-42)

Phenocrysts of plagioclase (pl), augite (au) and hornblende (ho) are distributed in a hyalopilitic matrix.

X–nicols

x 70



B: Two-pyxone andesite (Sample No. F-5)

Phenocrysts of orthopyroxene (op) clinopyroxene (cp) and plagioclase (pl) in a matrix of plagioclase microlites and glass.

X–nicols

x 70

Barcelona Group III

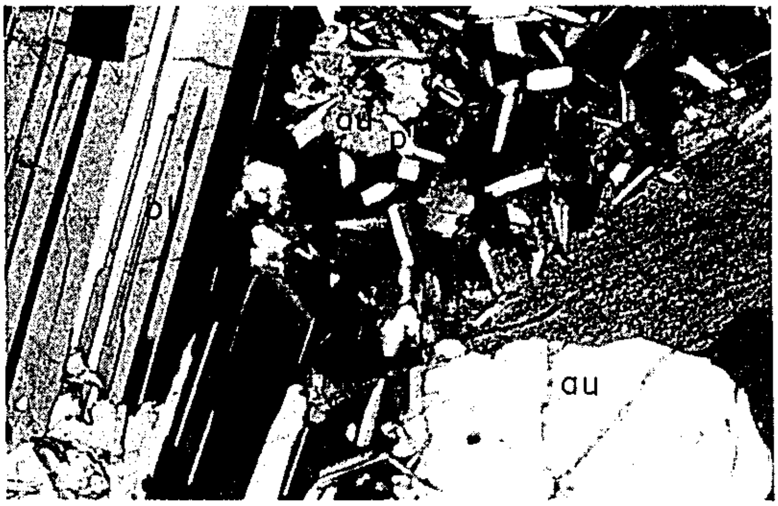
C: Augite basalt (Sample No. H-53)

Phenocrysts of euhedral augite (au) and plagioclase (pl) occur in a matrix of plagioclase laths, acicular augite and a few glass.

X–nicols

x 70

PL-3



A: Dolerite
(Sample No. H-21)
Large crystals of plagioclase (pl) and augite (au) are enclosed in a fine grained holocrystalline matrix showing ophitic texture.
X–nicols

x 70

Bislig Formation

B: Augite basalt
(Sample No. F-93A)
Tabular plagioclase (pl) and granular augite (au) occur in a glassy matrix which is full of acicular plagioclase and ilmenite.
X–nicols

x 70

Intrusive Rocks

C: Dolerite
(Sample No. N-93)
Laths of plagioclase (pl) and ophitic augite (au) are the principal minerals.
X–nicols

x 70

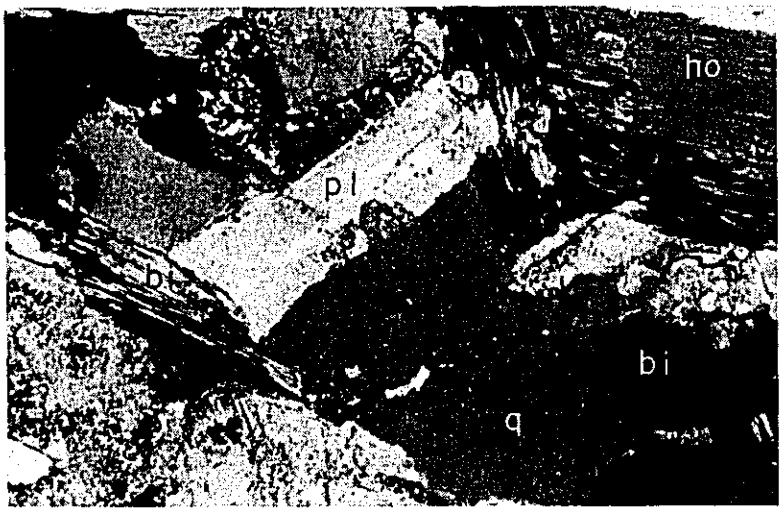
PL-4

A: Altered hornblende dacite (Sample No. T-13)

Coroded quartz (q) and chloritized, sericitized hornblende (ho) crystals are distributed through a matrix of sericite, chlorite and quartz.

X–nicols

X 70



B: Quartz diorite (Sample No. D-2-40)

Quartz (q), plagioclase (pl), hornblende (ho) and biotite (bi) are the main constituents. Alkali-feldspar rims on plagioclase crystals.

X–nicols

x 70

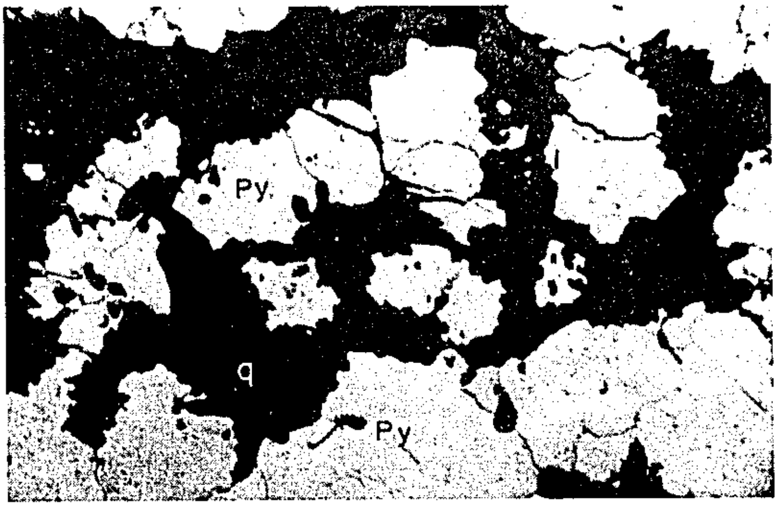
C: Olivine augite gabbro (Sample No. F-14)

The essential minerals are plagioclase (pl), augite (au) and olivine (out of this field). A little amount of magnetite (m).

X–nicols

x 70

PL-5 Ore



A: Pyrite-quartz (Sample No. T-11)

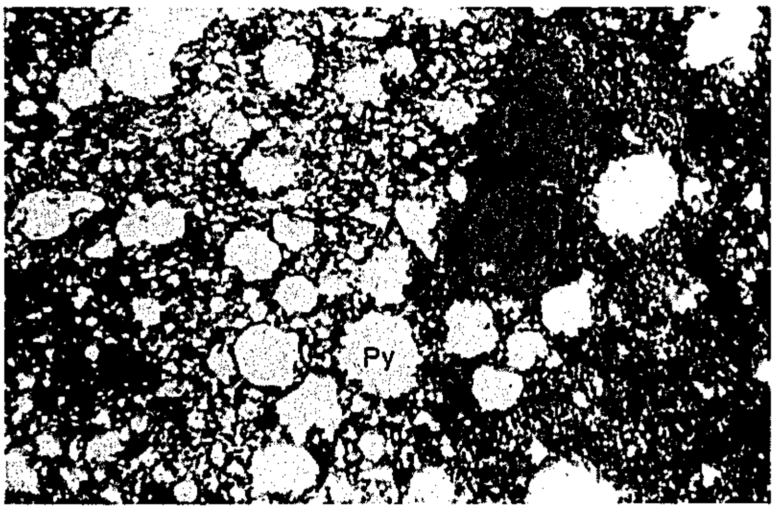
Aggregates of pyrite (Py) grains in quartz (q) vein.
//–nicols

x 40

B: Disseminated chalcopyrite--sphalerite-galena (Sample No. T-14)

Chalcopyrite (Cp), sphalerite (Sph) and galena (Ga) are in a silicified matrix.
//–nicols

x 40



C: Disseminated pyrite (Sample No. T-21)

Pyrite (Py) is disseminated in grey muddy matrix.
//–nicols

x 40

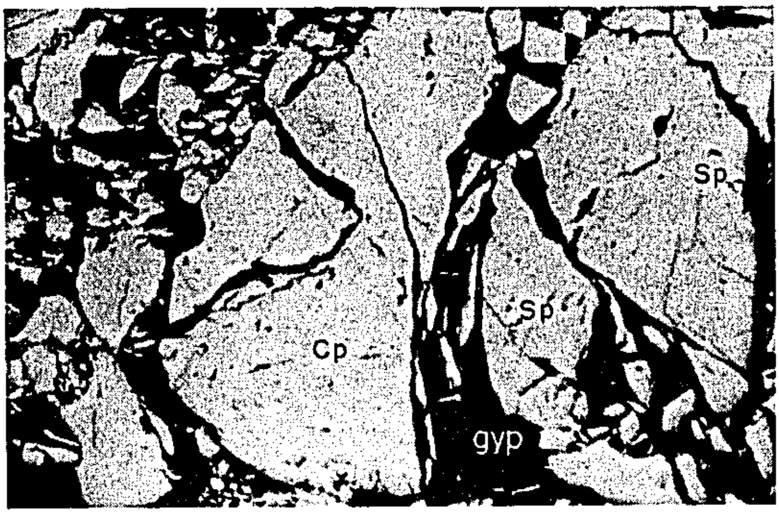
PL-6

A: **Chalcopyrite-galena-pyrite (Sample No. T-27)**

Chalcopyrite (Cp) is enclosed in galena (Ga). Weak pyrite (Py) dissemination is also observed.

//–nicol

x 40



B: **Chalcopyrite-sphalerite (Sample No. D-1-250)**

Fractured and brecciated chalcopyrite (Cp) is healed with gypsum (gyp). A few sphalerite (Sp) are visible.

//–nicol

x 40

Table I-1. Microscopic observations

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
N-3	Barcelona	Barcelona G. I.	Augite basalt	Dark green, glassy rock with large plagioclase prisms.	Phenocrysts of prismatic ~ tabular plagioclase (max 7mm in length) occur in a felty matrix of minuts acicular clino-pyroxene,, plagioclase, opaque minerals and glass. In this section, there is a partially coarse grained matrix composed of prismatic ~ tabular plagioclase (0.4mm in length), acicular ~ granular clino-pyroxene (0.2mm ~ 1.0mm in size) and opaque minerals.	
N-4	do	Intrusives	Micro-gabbro	Yellowish green, coarse grained rock.	Holocrystalline. Main constituents are prismatic ~ tabular twinned plagioclase (max 3mm length), hypidiomorphic ~ intersertal clino-pyroxene (max 1mm in size) and magnetite. Brownish green clay minerals are accessories.	
N-9	Estern coast	Barcelona G. I.	Andesitic coarse tuff	Yellowish grey, rock. Well sorted.	Lithic fragments of andesitic rocks and crystal fragments of plagioclase and clino-pyroxene occur in a black ~ brown ground mass. The grains are max 2mm in size. Laumontite and chlorite are also recognized.	
N-10	Salvacion	do	Augite-basalt	Pale yellowish grey rock with white spots. Hard.	Phenocrysts of prismatic ~ tabular plagioclase (max 3mm in length), prismatic ~ granular clino-pyroxene (max 5mm in size) and magnetite occur in a matrix of plagioclase laths, granular or accicular, altered clino-pyroxene (max 0.3mm in size), opaque minerals and glass. Most of plagioclase phenocrysts are dirty because of secondary albite and epidote.	
N-13	Taon R.	do	Porphyritic andesite	Pale greenish grey rock with white spots.	Phenocrysts of prismatic ~ tabler plagioclase (1mm in length) are scattered glomeroporphyritically in a matrix of brown glass, a few acicular plagioclase (0.1mm in length), granular clino-pyroxene and dusty opaque minerals. Chlorite and pumpellyite occur secondarily.	
N-15	do	do	Lapilli tuff or tuff breccia	Greenish grey, poorly sorted.	Lithic fragments of several kinds of andesite and crystal chips of plagioclase and clino-pyroxene make up this rock. Calcite and chlorite are secondary minerals.	
N-20	do	do	Andesitic fine tuff	Greenish grey rock with pisolite (5mm in diameter)	Crystal fragments of plagioclase and hornblende occur in a muddy matrix. Well sorted. Pumpellyite and zeolite are recognized.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
N-28	Taon R.	Intrusives	Micro-gabbro	Grey holocrystalline.	Holocrystalline. Prismatic ~ tabular, idiomorphic plagioclase (2mm in length) and hypidiomorphic ~ intersertal clino-pyroxene (0.5mm in length) are main constituents. Strong pleochroic, green ~ pale yellowish green clay minerals and opaque minerals are secondarily recognized.	
N-41	do	do	Micro-gabbro	Dark green grey rock with pyrite dissemination.	Holocrystalline. Plagioclase and uralitized augite are main components. Mean grain size is 0.3mm. Epidote, actinolite, chlorite and opaque minerals are recognized as secondary minerals. Some of actinolite are very close to hornblende in chemical composition from strong pleochroism.	
N-43	do	Barcelona G. I.	Andesitic tuff breccia	Poorly sorted. Greenish grey, soft rock.	Abundant lithic fragments of andesitic rock and a few crystal fragments of plagioclase and clino-pyroxene compose this rock. The biggest fragment in this section is porphyritic augite andesite (20mm in size). The sorting is poor.	See PL-1 A
N-46	Salvacion	do	Andesitic coarse tuff	Grey, poorly sorted rock with pyrite dissemination.	Lithic fragments of andesite and augite basalt occur in a muddy matrix.	
N-48	do	do	Augite basalt	Dark green, hypocrystalline rock with pyroxene needles.	Holocrystalline and glomeroporphyritic textures are observed in this section. The former is composed of prismatic ~ tabular plagioclase (max 3mm in length), prismatic or xenomorphic clino-pyroxene (max 1mm in length) and opaque mineral (0.5mm in size). The latter occur in a felty matrix. Calcite, chlorite, albite and epidote are recognized as secondary products.	
N-50	do	do	Glassy tuff	Black glassy rock with rounded lithic fragments.	Abundant glass with perlitic texture and a bit of fragment (max 2mm in size). Druses develop in this rock.	
N-56 ·	do	do	Fine grained Crystal tuff	Dark green, fine grained rock.	Crystal fragments of feldspar and clino-pyroxene (max 0.2mm in size) are welded with few argillaceous materials.	
N-57	Taon R.	Intrusives	Micro-gabbro dolerite	Greyish green rock with zeolite veinlets.	Idiomorphic plagioclase (max 2mm in length) and hypidiomorphic ~ intersertal clino-pyroxene (fair green) show almost holocrystalline texture. The grain sizes are not equal. Greenish brown clay minerlas and laumontite are secondary produced.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
N-62	Taon R.	Intrusives	Micro-gabbro dolerite	Greyish green, holo-crystalline. White acicular crystals.	Grain sizes vary very much. Holocrystalline. Main constituents are tabular, idiomorphic plagioclase and hypidiomorphic ~ intersertal clino-pyrite (augite). Much pumpellyite.	
N-74	do	Barcelona Group I.	Augite basalt	Pale greenish grey rock with pyroxene needles.	Prismatic plagioclase (1mm in length) and augite are scattered in a matrix of prismatic ~ clappers-like plagioclase (0.3 ~ 0.5mm in length), prismatic, pleochroic clino-pyroxene and glass. Much greenish brown clay minerals and a few zeolite (stilbite) are secondarily observed.	
N-76	do	do	Augite basaltic andesite	Grey, compact rock with white spots.	Polyporphyritic. Phenocrysts of tabular plagioclase (1mm in length) and clino-pyroxene (6mm in length) occur in a matrix of plagioclase laths (max 0.5mm in length), weak pleochroic clino-pyroxene and dark green glass. A few ilmenite and magnetite. Laumontite and fair green fibrous mineral replace the glass and mafic mineral.	
N-79	do	do	Basic coarse tuff	Greenish grey rock with reddish brown lithic fragments.	Lithic fragments of basalt ~ andesite with phenocrysts of augite and ilmenite, and much crystal fragments of augite are welded with tuffaceous material.	
N-82	do	do	Lapilli tuff	Brownish grey rock with rounded lithic fragments.	Most of lithic fragments are tracky andesite and basalt. A matrix is very few.	
N-92	do	do	Porphyritic augite andesite	Black hard glassy rock with plagioclase phenocrysts.	Phenocrysts of tabular plagioclase (max 3mm in length) and augite (max 2mm in length) occur in a matrix of microcrystalline plagioclase, glass and opaque minerals. This rock is very fresh, as a whole, except that plagioclase is partially altered to brownish green clay mineral.	
N-93	do	Intrusive	Dolerite	Grey rock with pyroxene needles.	Phenocrysts of plagioclase (1mm ± in length) and clino-pyroxene (0.5mm in length) occur glomeroporphyritically occur in a matrix of tabler or prismatic, euhedral plagioclase (0.5mm in length) and intersertal, prismatic augite. Texture is holocrystalline. Secondary fibrous, brownish green clay mineral occurs.	See PL-3C

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
N-103	Eastern coast	Barcelona G. I.	Basic coarse tuff	Yellowish grey, soft rock with rounded lithic fragments.	Most of lithic fragments consist of basalt with intergranular texture. They are cemented by abundant carbonate.	
N-105	do	do	Andesitic ~ basaltic coarse tuff	Greyish green rock with angular lithic fragnents.	Lithic fragments (max 6mm in size) mainly composed of trachy andesite and basalt are cemented by much carbonate and zeolite. Poorly sorted.	
N-106	do	do	Augite basalt	Yellowish green rock with calcite stringers.	Similar to N-110.	
N-110	do	do	Basaltic augite andesite	Dark grey rock with pyroxene needles.	Polyporphyritic. Phenocrysts of plagioclase (max 3mm in length) and clino-pyroxene (max 2mm in length) occur in a matrix of acicular plagioclase (0.2mm in length) prismatic ~ granular clino-pyroxene (0.1 ~ 0.3mm in length), opaque minerals and glass. Clino-pyroxene has weak pleochroism. Brownish green clay minerals occur abundantly.	
N-112	do	do	Andesitic coarse tuff	Yellowish green, soft rock. Poorly sorted.	This rock is composed of serveral kinds of andesite fragments accompanying crystal fragments of augite. Most of matrix are altered to much zeolite.	
N-114	Salvacion	do	Andesitic fine tuff	Dark greenish grey rock with hematite bands.	Glassy material and crystal fragments of plagioclase are embedded in a tuffaceous matrix.	
N-118	do	do	Augite basalt	Dark grey, porphyritic rock.	Phenocrysts of plagioclase (max 4mm in length) and augite (max 0.7mm in length) are observed in a matrix of prismatic plagioclase (max 0.5mm in length), acicular pheochroic clino-pyroxene (quenched), magnetite, ilmenite and glass. It shows glomero-porphyritic texture. Greenish brown to greenish yellow clay mineral (Fe-saponite?) and calcite are also observed.	
N-119	do	do	Augite basalt	Dark greenish grey rock with pyroxene needles.	Phenocrysts of prismatic ~ tabular plagioclase (max 2mm in length) and clino-pyroxene (2mm ± in length) occur in a matrix of acicular ~ prismatic plagioclase (max 0.3mm in length), prismatic ~ granular clino-pyroxene (max 0.3mm in size) and glass. Secondary minerals are albite, chlorite and brown glass.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
N-125	Salvacion	Barcelona G. I.	Augite basalt	Pale grey rock Abundant black columnar minerals.	Large phenocryst of columnar and platy plagioclase (1.5mm in length) and micro-phenocrysts of augite are scattered in a plagioclase laths (max 0.5mm in length) acicular clino-pyroxene, ilmenite and glass. Pumpellyite and clay minerals are observed as secondary minerals.	
N-128	Taon R.	do	Basaltic andesitic coarse tuff.	Greyish green rock.	Similar to N-105.	
N-130	do	do	Augite basalt	Grey compact rock with gas pores.	Phenocrysts of columnar plagioclase and augite (max 1mm in length) are scattered in a glassy matrix.	
N-135	do	do	Aphyric andesite	Dark grey, compact rock.	Very few phenocrysts of augite (max 1mm in length) and plagioclase. Matrix is composed of plagioclase lath (0.2 ~ 0.3mm in length) altered glass, magnetite and ilmenite. Secondary minerals are epidote, actinolite and chlorite.	
N-139	Bahayan R.	do	Andesite	Bluish grey, aphyric rock with calcite stringers.	A few prismatic crystals (max 2mm in length) are scattered in a matrix of plagioclase laths (0.2 ~ 0.3mm in length, arrenged regularly), minute granular magnetite and ilmenite. Although the crystals are throughly altered to calcite and chlorite, they are probably plagioclase.	
N-142	do	do	Andesite	Grey, rock with calcite network.	Phenocrysts are not so large that it is difficult to distinguish them from matrix. Larger crystals (1mm in length) of plagioclase, smaller prismatic plagioclase (0.5mm in length), glass (completely altered) and magnetite are consituent minerals. Secondary calcite, chlorite and albite are also observed. Calcite networks develop.	
N-145	do	Barcelona G. III	Andesite	Dark grey rock. Weakly chloritized.	Short columnar phenocrysts (1mm in length, plagioclase?) are completely altered to chlorite and calcite. A matrix is composed of plagioclase laths (0.2mm in length, mostly altered to calcite) and brown glass. Secondary minerals are chlorite, calcite and albite.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
N-147	Bahayan R.	Barcelona G.III.	Aphyric andesite	Parplish grey rock with chlorite & calcite spots.	Phenocrysts are a few and tiny. They (plagioclase?) are altered to calcite and albite. A matrix consists of intertwinned plagioclase laths (max 1mm in length), altered glass and minute ilmenite. The plagioclase crystals show partly a radial aggregate. Secondary chlorite, calcite and albite are observed.	
N-155	Taon R.	Barcelona G. I.	Augite andesite	Grey compact rock.	Phenocrysts of prismatic ~ tabular plagioclase (max 4mm in length) and prismatic ~ granular, weakly pleochroic clino-pyroxene (max 0.4mm in length), acicular or granular clino-pyroxene, opaque minerals (ilmenite and magnetite) and brown glass. Secondary calcite also exists.	
N-157	do	Intrusives	Dolerite	Dark grey medium grained rock.	Similar to N-110 but a little bit finer. A little amount of glass are observed.	
N-158	do	do	Micro-gabbro	Greenish grey, holo-crystalline.	Similar to N-28	
N-162	do	Barcelona G. I.	Augite andesite	Greenish grey, porphyritic rock.	Phenocrysts of prismatic ~ tabler plagioclases (1.5mm in length) and clino-pyroxene (augite) occur in a matrix of prismatic clappers-like plagioclase (0.1 ~ 0.4mm in length), yellowish brown glass and ilmenite. Brownish green clay minerals are recognized as secondary mineral. Phenocrysts of plagioclase are mostly altered except the rimb of the crystal.	
N-166	Mangagoy	do	Aphyric andesite	Brownish grey rock with calcite druses.	Similar to N-147	
N-167	do	do	Basaltic coarse tuff	Brown, fragile rock with lithic fragments.	This rock is mainly composed of essential fragments of basalt ~ dolerite. Limestone fragments are also observed.	
N-171	Bislig Bay	do	Basaltic coarse tuff	Pale greenish grey. Well sorted.	Similar to N-167.	
N-177	Denipas	do	Aphyric andesite	Darkgreen, glassy rock with much amygdals.	Similar to N-147 but amygdals are more than in N-147.	See PL-1B

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
N-183	Denipas	Intrusives	Gabbro ~ dolerite	Greyish green, holo crystalline rock.	Holocrystalline rock composed of prismatic ~ tabler, strongly idiomorphic plagioclase (max 2mm in length), hypidiomorphic ~ intersertal clino-pyroxene and a few biotite. It shows an ophitic texture. Brownish green clay minerals are recognized.	
N-188	Eastern coast	do	Gabbro	Grey, holocrystalline rock.	Coarse grained holocrystalline. Main consituents are prismatic ~ tabular idiomorphic plagioclase (2mm in length) and hypidiomorphic ~ intersertal clino-pyroxene. Brownish green clay minerals occur as secondary minerals.	
N-192	do	Barcelona G. I.	Augite basalt	Black compact rock with white and black needles.	Phenocrysts of plagioclase (1mm ± in length) and colorless clino-pyroxene (max 3mm in length) are observed. A matrix consists of prismatic ~ clappers-like plagioclase (0.1 ~ 0.2mm in length) and intersertal clino-pyroxene. The texture is almost holocrystalline. The clino-pyroxene is probably Ti-ferous because of brown in color and hour-glass structure. Calcite, chlorite and pumpellyite are recognized as secondary minerals.	See PL-1C
F-3	Alteration zone	Intrusives	Dolerite	Dark grey, holocrystalline rock.	Crystals of plagioclase (4mm in length) occur in a matrix of feldspar laths with intersertal augite, magnetite and biotite. Secondary minerals are pale green clay mineral, sericite, zeolite and chlorite.	
F-5	do	Barcelona G. II.	Two pyroxene andesite	Dark green, hypocrystalline rock.	Phenocrysts of euhedral plagioclase (An 45 ~ 50), augite and hypersthene are in a felty matrix of plagioclase laths (0.1mm in length) with magnetite and glass.	See PL-2B
F-7	do	Intrusives	Altered dacite	Grey siliceous rock with pyrite grains.	Phenocrysts of plagioclase (altered partially to calcite), mafic minerals (altered completely to calcite and chlorite) and corroded quartz are in an aggregate of alkali feldspar, quartz and calcite.	
F-13	do	do	Olivine augite gabbro	Greenish grey, holocrystalline rock.	Holocrystalline. Euhedral plagioclase, intersertal augite and granular olivine (altered to chlorite) are the main constituents. Similar to F-3. Secondary minerals are pleochroic green-colored clay mineral, sericite and kaolinite.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
F-14	Alteration zone	Intrusives	Olivine augite gabbro	Greenish grey, holo-crystalline rock.	Similar to F-13. There is a small amount of biotite. Two type of clay minerals, that is dark green colored and yellowish brown colored minerals, can be observed.	See PL-4C
F-16	do	do	Olivine augite gabbro	do	Similar to F-13. Plagioclase is partially altered to kaolinite and alkali feldspar.	
F-17A	do	Barcelona G.II.	Andesitic tuff	Grey rock with lithic fragments.	Subangular grains of trachy andesite and amygdaloidal andesite (1 ~ 2mm in diameter) are cemented by argillaceous material.	
F-17B	do	do	Augite andesite	Dark green, hypocry-stalline rock.	Texture is quite similar to F-5. Hypersthene is absent.	
F-25	do	Intrusives	Hornblende dacite	Grey compact rock with white spots.	Phenocrysts of plagioclase (8mm in length), hornblende (2mm in length) and rounded quartz (0.5mm in diameter) are in an altered matrix composed of plagioclase, quartz, chlorite and opaque mineral. Green colored clay mineral is observed in shape of feather.	
F-26	Alteration zone	Barcelona G.II.	Augite andesite	Grey, altered hypocry-stalline rock.	Similar to F-17B but a little bit coarser. Phenocrysts of plagio-clase 4mm in length) are in a felty matrix which is composed of plagioclase microlite, opaque and glass. Few secondary minerals.	
F-27	do	do	Altered andesite	Pale grey, altered porphyritic rock.	Strongly altered. Phenocrysts are completely changed to calcite and sericite. Matrix is an aggregate of 0.02mm sized quartz, clay mineral and opaques (mostly pyrite).	
F-32	do	do	Augite andesite	Bluish grey, altered rock.	Phenocrysts of zoned and twinned plagioclase (3mm in length), granular augite (2 3mm in size) and opeque are in a felty trachytic matrix of plagioclase laths (0.05mm in length), glass and opaque minerals. Texture is like to F-5. Pleochroic, green mineral occurs as a secondary product.	
F-35	do	do	Augite basalt	Grey rock.	Phenocrysts of plagioclase (maximum 4mm in length), granular augite and mafic minerals (completely replaced by calcite) are in a matrix of plagioclase laths, granular augite, magnetite, ilmenite and glass. Plagioclase is partially decomposed to calcite and sericite.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
F-37	Alteration zone	Barcelona G.II.	Augite andesite	Brownish grey, porphyritic rock.	Phenocrysts of plagioclase (1 ~ 4mm in length), augite (partially altered to calcite and chlorite) and quartz occur in a matrix of plagioclase laths, brown glass and magnetite. Texture shows felty and resembles F-5.	
F-41	do	Mangagoy F.	Limestone	Ocher rock.	Chips of andesite, clay and coral are cemented by calcite.	
F-42	Hagamitan R.	Barcelona G.II.	Augite basalt	Dark green, rock.	Phenocrysts of zoned and twinned plagioclase (An55) and augite (0.5mm in size) occur in a matrix of plagioclase laths and glass. Texture is rather andesitic than basaltic.	
F-43	do	Intrusives	Dolerite	Dark green, rock.	Holocrystalline. Euhedral plagioclase (0.2mm in length), granular or intersertal augite, chlorite and opaque minerals are main constituents. Some plagioclase crystals are replaced by pleochroic green colored clay mineral (Fe-saponite?).	
F-44	do	Mangagoy F.	Limestone	Pale brown, rock.	Chips of plagioclase and pyroxene crystals are cemented by calcite. The crystals are also replaced by calcite. No visible fossils.	
F-46	do	Barcelona G.II.	Augite basalt	Green and red, altered rock.	Very few phenocrysts of rectangular plagioclase and granular augite are in a matrix of plagioclase lath (0.1mm in length), granular or intersertal augite and brown glass. Ilmenite and magnetite are accessories. Pale yellowish green, pleochroic clay mineral occurs as a secondary mineral.	
F-48	Alteration zone	Barcelona G.I.	Altered andesitic rock	Greenish grey, altered rock.	Secondondary quartz, alkali feldspar, calcite, chlorite, epidote, magnetite and ilmenite make up this rock. Alteration is too strong to distinguish original minerals. Some epidote-calcite-quartz stringers exist.	
F-49	do	Intrusives	Dolerite	Grey, holocrystalline rock.	Fine grained holocrystalline rock. Sericitized plagioclase, intersertal augite, magnetite and biotite are essential minerals. Secondary minerals are calcite, chlorite and sericite.	
F-50	do	Barcelona G.I.	Altered basalt	Dark green, compact rock.	Aggregate of pyrite, sericite and chlorite. A few amounts of epidote is also visible.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
F-51	Alteration zone	Barcelona G.II.	Augite andesite	Grey, porphyritic rock.	Phenocrysts of chloritized and sericitized plagioclase (5mm in length) and augite (1 ~ 2mm in size) are in a matrix of plagioclase laths, intersertal augite and magnetite. Flakes of biorite are arranged regularly in the matrix. Secondary minerals are calcite, chlorite and pumpellyite.	
F-52	Lingig R.	Barcelona G.III.	Andesitic tuff	Dark grey, coarse grained rock.	Well sorted tuff. Grains (1 ~ 2mm in size) of glassy andesite, clino-pyroxene and opaque minerals are cemented by secondary calcite and chlorite.	
F-62A	do	do	Augite basalt	Greyish green, altered rock.	The matrix is composed of lath-shaped plagioclase (less than 0.3mm in length), needle-like augite and fair green clay mineral (celadonite). Phenocrysts are abundant plagioclase crystals (2mm in length) and a few amount of broken augite. Acicular ilmenite is also present.	
F-63	do	do	Sheared andesitic tuff	Dark brown rock with white patchs.	Rock fragments of trachy andesite, glassy andesite, amygdaloidal basalt and chips of plagioclase, quartz and augite are enclosed in an argillaceous matrix.	
F-70	do	do	Augite basalt	Dark grey, porphyritic rock.	Euhedral plagioclase crystals (An 70, 2mm in length) occur in a felty matrix of needle-like augite, plagioclase (both less than 0.1mm in length), brownish clay and magnetite. Brownish green clay mineral fills the crack of augite. This rock is very fresh and resembles F-62A in texture.	
F-73	do	do	Dolerite	Dark grey, porphyritic rock.	Glomeroporphyritic plagioclase crystals (1mm in length) are in a matrix of plagioclase laths (0.5mm in length) and intersertal augite which show a doleritic texture. Brownish green clay minerals replace pyroxene along fissures. Fe-saponite also exists.	
F-74	do	Intrusives	Augite basalt	Dark grey, porphyritic rock.	Large plagioclase phenocrysts (An55, 4mm in length) are in a matrix of plagioclase laths (0.3mm in length), mafic minerals (altered to chlorite and ceradonite) and glass.	
F-75	do	do	do	Grey, compact rock.	Phenocrysts of plagioclase (4mm in length) and granular augite (0.4mm in size) occur in an altered matrix of plagioclase laths (0.3mm in length), granular augite, chlorite and magnetite. Secondary minerals are calcite and chlorite.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
F-81	Lingig R.	Mangagoy F.	Dolerite	Reddish grey, porphyritic rock.	Phenocrysts are composed of tabular plagioclase and augite. plagioclase laths (0. 3mm in length), brown clay mineral after pyroxene?, and magnetite make up this groundmass.	
F-84	do	do	Hornblende dacite	Dark green, altered rock.	Brownish green clay mineral (Fe-saponite) has replaced phenocrysts of plagioclase (2mm in length) and hornblende. The matrix of plagioclase laths (0. 5mm in length) and brownish green clay mineral and a few quartz shows pilotaxitic texture.	
F-85	do	do	Pumice tuff	Yellowish white, poorly sorted rock.	Fragments (2 ~ 4mm in size), of tuff, plagioclase and pumice are embedded in an argillaceous materials.	
F-88	do	Barcelona G. III.	Andesitic tuff	Well sorted, yellowish grey rock.	Angular chips of plagioclase, hornblende and pyroxene, and rock fragments of limestone and aphyric andesite are enclosed by brown clay mineral. Well sorted.	
F-89·93A	Road	Bislig F.	Augite basalt	Greyish brown, porphyritic rock.	Large phenocrysts of tabular plagioclase (10mm in length) and granular augite (4mm in size) occur in a matrix of acicular plagioclase, augite and brown glass. The texture shows this rock was quenched by water.	See PL-3B
F-93B	do	do	Siltstone	Greenish blue, compact rock.	Aggregate of very fine grained particles (less than 0. 01mm in diameter).	
F-93C	do	do	Augite basalt	Greyish brown, glassy rock.	Phenocrysts of plagioclase (An60) occur in a matrix of tabular albite grains with intersertal augite and brown glass.	
F-126	Alteration zone	Intrusives	Micro-gabbro	Dark green rock.	The main constituents are plagioclase (3 ~ 4mm in length, An55), granular or anhedral augite (1mm in size). Biotite and magnetite are accessories. Secondary minerals are chlorite and brownish yellow clay mineral.	
P-1	do	do	Biotite gabbro	Dark green, medium grained rock.	Holocrystalline. Tabular plagioclase (An50 ~ 55, 4mm in length), ophitic augite and a little biotite. Granular opeque minerals are also present. Secondary minerals are brownish green clay mineral. Alteration is very weak.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
P-2	Alteration zone	Intrusives	Biotite gabbro	Greenish gray, medium grained rock.	Holocrystalline. Similar to P-1. Plagioclase (An65 ~ 70, maximum 4mm in length), ophitic augite and a little biotite are main constituents. Green clay mineral is also observed.	
P-4	do	Barcelona G.III.	Augite andesite	Yellowish green rock with zeolite lens.	Very fresh. Phenocrysts of twinned plagioclase (2mm in length), bipyramidal augite (1mm in size) are in a matrix of plagioclase microlites, opaque mineral, chlorite and blownish glass. Acicular ilmenite can be seen.	
P-5	do	Barcelona G.II.	Altered andesite	Yellowish grey rock.	Phenocrysts of plagioclase are changed to alkali feldspar. Ground mass, composed of plagioclase laths (0. 2mm in length), glass and clay minerals, is strongly altered. Zeolite and sericite are secondary products.	
P-11	do	Barcelona G. I.	Augite andesite	Dark, glassy rock with white spots.	Similar to P-4. Augite and plagioclase phenocrysts are embedded in a matrix of plagioclase microlite and glass. Some amygdules in the matrix are filled with calcite. Secondary minerals are calcite, chlorite and pumpellyite.	
P-12	do	do	Dolerite	Dark grey, coarse grained rock.	Plagioclase (0. 5mm in length), ophitic augite and abundant opaque minerals. Pleochroic, yellowish brown colored clay mineral and a few epidote are present. Secondary minerals are chlorite, epidote and brown clay minerals.	
P-13	do	Intrusives	Altered dacite	Greenish gray, soft rock with white & green spots	There is a few phenocrysts of plagioclase (4mm in length, altered to sericite and alkali feldspar completely) and granular quartz (2mm in size) in a matrix of secondary alkali feldspar, opaque minerals and glass.	
P-15	do	Barcelona G.II.	Augite andesite	Black, glassy rock.	Phenocrysts of zoned and twined plagioclase and granular augite are scattered in a felty matrix of plagioclase microlite and glass. Very few secondary minerals.	
P-17	do	Intrusives	Altered dacite	Greyish green, soft rock with pinkish white clay.	Strongly altered. Secondary minerals are kaolinite, sericite, calcite, chlorite and quartz. Corroded quartz (2mm in size) is present.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
P-18	Alteration zone	Barcelona G.II.	Altered dacite	Grey, hard rock with white spots.	Strongly altered. Sericite, calcite and kaolinite occur as secondary products.	
P-19	do	do	Altered dacites	Grey, hard rock with white spots.	Strongly altered. Plagioclase and mafic minerals are replaced by sericite kaolinite and calcite.	
T-5	do	Intrusives	Altered hornblende dacite	Grey, porphyritic rock with brown druses.	Porphyritic texture. Phenocrysts are composed of corroded quartz, plagioclase (partially altered to sericite and carbonate), hornblende (completely altered to carbonate, chlorite and partially sericite) and opaque minerals accompanying with titanite. A matrix consists of micro-granular quartz showing a mosaic texture, prismatic plagioclase (mostly altered to sericite), granular opaque minerals and a few titanite.	
T-6	do	do	Altered hornblende andesite	Green, porphyritic rock with weak pyrite dissemination.	Porphyritic texture. Phenocrysts are composed of plagioclase (partially altered to carbonate and sericite), hornblende (mostly altered to chlorite and sericite) and a few opaque mineral. A matrix consists of prismatic plagioclase (partially altered to sericite and carbonate), a few quartz, chlorite and opaque minerals.	
T-8	do	do	Altered hornblende dacite	Green andesitic rock.	Similar to T-5.	
T-10	do	do	Altered dacite	Gray hard rock with silicification and pyritization.	Strongly altered porphyritic rock. Silicification, sericitization and sulfide dissemination. Phenocrysts of sericitized plagioclase (max 1mm in length) are in a matrix of irregularly shaped quartz with mosaic texture and intersertal sericitized plagioclase. Quartz veinlets (1mm ~ 2mm in width) and pyrite dissemination are commonly observed.	
T-11	do	Ore	Dacite	Dense agregates of pyrite grains.	Aggregates of anhedral pyrite grains in quartz. In pyrite grains, irregularly spaced shrinkage cracks are developed suggesting the colloidal deposition. No other sulfides are present.	See PL-5A
T-12	do	Intrusives	Altered dacite	Gray, strongly altered, porphyritic rock.	Porphyritic texture. Phenocrysts of corroded bipiramidal quartz, plagioclase (completely altered to sericite, max 5mm in length), mafic minerals (altered to sericite and opaque minerals), opaque mineral (cubic in shape) and a few titanite (rhombic, brown, very high in interference color) occur in a matrix of abundant granular quartz, intersertal plagioclase (altered to sericite) and opaque mineral (pyrite).	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
T-13	Alteration zone	Intrusives	Altered hornblende	Gray, strongly altered, porphyritic rock.	Porphyritic texture. Phenocrysts are composed of sericitized plagioclase, corroded quartz (2mm in diameter) and chloritized hornblende. A matrix consists of much micro-granular quartz showing mosaic texture and plagioclase (mostly altered to sericite), chlorite (after mafic minerals) and a few granular opaque mineral.	See PL-4A
T-14	do	Ore	Dacite	Dissemination of sulfide minerals in white, siliceous rock.	Very fine cubic pyrite crystals and aggregates of anhedral galena, sphalerite and chalcopyrite are disseminated.	See PL-5B
T-18	do	Ore	Mudstone?	Poor dissemination of very fine-grained pyrite in dark grey muddy material.	Very fine grained pyrite crystals are disseminated in quartzose matrix. Pyrite crystals are locally gathered to form the skeletal aggregates. No other sulfides are present.	
T-19	do	Intrusives	Altered hornblende dacite	Greenish grey, porphyritic rock.	Similar to T-5	
T-21	do	Ore	Dacite	Very fine sulfide grains of white to creamy Yellow color are disseminated in grey muddy matrix.	Sulfide minerals comprise pyrite and marcasite. Pyrite is very fine grained, while marcasite forms radial, rounded aggregates of elongated crystals.	See PL-5C
T-22	do	Barcelona G.II	Andesitic tuff breccia	Dark grey rock.	Main consituents are crystal fragments, lithic fragments and cementing material. Crystal fragments: plagioclase (max 1mm in length, showing Calsbat or albite twinning) and short prismatic clino-pyroxene (showing relatively large extinction angle). Lithic fragments: several kinds of andesites such as porphyritic andesite and perlitic andesite. The cementing material is glassy (completely devitrificated to granular, colorless minerals).	
T-24	do	Intrusives	Altered dacite	Milky white compact rock with reddish brown limonite.	Phenocrysts of sericitized plagioclase (max 1.5mm in length) and mafic minerals (completely altered to sericite, muscovite and opaque minerals, max 0.6mm in length) occur in a matrix of irregular shaped quartz showing mosaic texture, intersertal sericitized plagioclase and opaque minerals.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
T-25	Alteration zone	Intrusives	Altered dacite	Grey, compact rock with goethite-quartz veinlets.	Altered porphyritic rock with quartz and goethite veins. Phenocrysts of sericitized plagioclase (max 2mm in length) are in a matrix of irregularly shaped quartz with mosaic texture, much intersertal plagioclase and tiny opaque minerals (granular to cubic in shape).	
T-27	do	Ore	Dacite	Pyrite and sphalerite are disseminated in a grey to white siliceous material.	Aggregate of anhedral crystals of sphalerite, galena and chalco-pyrite are disseminated in a quartzose material. Cubic pyrite of very fine grain are also dispersed.	See PL-6A
T-28	do	do	Altered augite ande-site	Green porphyritic rock.	Porphyritic texture. Twinned plagioclase (altered to chlorite and epidote) and mafic minerals (completely altered to chlorite, epidote and carbonate) are phenocrysts. A matrix is composed of pris-matic plagioclase (arrenged regularly), abundant granular opaque minerals and chlorite (pale green, after mafic minerals) accom-panying irregular-shaped druses filled with chlorite and partially secondary quartz.	
T-30	do	do	Altered hornblende dacite	Greenish grey, porphy-ritic rock.	Similar to T-5.	
T-31	do	Barcelona G.II.	Sandy tuff	Green altered rock.	Crystal fragments are cemented by green colored mineral (chlorite or glauconite). They are composed of subrounded plagioclase (max 0.5mm in length), clino-pyroxene, biotite and chloritized horn-blende.	
H-2	Lingig	Barcelona G.III.	Porphyritic augite basalt	Dark green, porphy-ritic rock.	Phenocrysts of corroded plagioclase (5 ~ 7mm in length) and glomeroporphyritic clino-pyroxene (max 1mm in size) occur in a matrix of acicular feldspar and clino-pyroxene (max 0.5mm in length). Secondary minerals are chlorite and brownish yellow clay minerals.	
H-3	Hagamitan R.	do	Augite basalt	Reddish grey rock.	Phenocrysts of plagioclase (1mm ± in length) and smaller clino-pyroxene occur in a matrix of needle-like or minute prismatic clino-pyroxene, intersertal feldspar (may be alteration product after glass) and needle-like ilmenite. Secondary minerals: albite, opaque mineral and pale brown clay minerals.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
H-4	Hagamitan R.	Barcelona G.III.	Augite Basalt Doleritic basalt	Dark green rock.	Phenocrysts of plagioclase (max 2mm in length) and smaller clino-pyroxene, showing a glomeroporphyritic texture, occur in a matrix of plagioclase laths, needle-like or granular clino-pyroxene and a bit of glass, accompanying needle-like ilmenite. Secondary minerals are chlorite, albite and brown clay minerals.	
H-5	do	Barcelona G.II.	Augite basalt	Dark grey, hard rock.	Phenocrysts of plagioclase (max 3mm in length) and a few clino-pyroxene with glomeropophyritic texture occur in a matrix of prismatic ~ tabular plagioclase (0. 1mm ± in length), needle like clino-pyroxene and a bit of glass. A secondary mineral is chlorite.	
H-6	do	do	Lapilli tuff	Greenish grey, coarse grained rock.	Lithic fragments of parlite and several kinds of andesite (max 10mm in diameter), and crystal fragments of plagioclase and clino-pyroxene make up this rock.	
H-7	Taon R.	Barcelona G. I.	Augite basalt	Grey compact rock.	Except a few prismatic clino-pyroxene (pleochroic, max 1mm in length), most of the phenocrysts which are prismatic and granular (1mm ± in length) in shape are throughly altered to albite, calcite and chlorite. The original minerals may be plagioclase and clino-pyroxene. A matrix consists of tabular feldspar, needle-like clino-pyroxene and a bit of glass. In addition to above mentioned minerals, pumpellyite and brownish clay minerals are also recognized as secondary minerals.	
H-8	do	do	Augite basalt	Grey amygdaloidal rock.	A few phenocrysts of plagioclase (max 1. 5mm in length), clino-pyroxene (max 1mm in length) and triangular or hexagonal shaped opaque mineral (max 0. 3mm in diameter) occur in a matrix of prismatic plagioclase, needle like clino-pyroxene and intersertal glass. Abundant amygdals filled with zeolite are also observed. Pumpellyite and brownish clay minerals are recognized as secondary minerals.	
H-11	Anibungan	Barcelona G.II.	Fine grained crystal tuff	Greyish green rock	This rock consists of crystal chips (max 0. 3mm in diameter) such as feldspar, pleochroic clino-pyroxene and opaque minerals. They are cemented by brownish clay.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
H-12	Dahican	Barcelona G. I.	Augite basalt	Greyish brown rock.	Phenocrysts of plagioclase (2mm ± in length) and weakly pleochroic clino-pyroxene (1mm ± in length) occur in a matrix of prismatic plagioclase (0. 2 ~ 0. 5mm in length), intersertal or granular clino-pyroxene (0. 2 ± in diameter) and glass accompanying minute needle-like clino-pyroxene. As secondary mineral, brown colored clay mineral is reeognized.	
H-13	do	do	Augite basalt	Pale brown weathered rock.	Similar to H-12.	
H-15	do	do	Amygdaloidal basalt	Dark green amygdaloidal rock.	Phenocrysts of prismatic ~ tabular plagioclase (max 3mm in length) and short prismatic clino-pyroxene (up to 2mm in length) occur in a matrix of minute clino-pyroxene and glass. Secondary minerals are chlorite, calcite and pale ~ dark brown clay minerals. Abundant amygdals filled with greenish clay mineral are also observed.	
H-16	Tambog Point	do	Porphyritic augite basalt	Dark grey porphyritic rock.	Phenocrysts of prismatic ~ tabular plagioclase (max 10mm in length) and tabular ~ granular clino-pyroxene (max 1mm in diameter) with glomeroporphyritic texture occur in a matrix of lath-shaped plagioclase, granular or lath-shaped clino-pyroxene (max 0. 5mm in length), granular or needle-like opaque minerals (may be magnetite and ilmenite) and minute, needle-like clino-pyroxene. A little chlorite is recognized.	
H-17	Lingig	Barcelona G.III	Doleritic augite basalt	Dark green rock.	It is micro-holocrystalline rock. Euhedral plagioclase (0. 2 ~ 0. 5mm in length), granular ~ intersertal clino-pyroxene and opaque minerals are main constituents. Some parts are coarser grained (about 1mm in length). Some calcite, chlorite and epidote occur.	
H-18	do	do	Doleritic augite basalt	Dark green porphyritic rock.	Phenocrysts of prismatic ~ tabular plagioclase (max 8mm in length) is recognized. A matrix is holocrystalline, consists of idiomorphic plagioclase (0. 3mm ± in length), hypidiomorphic ~ intersertal clino-pyroxene and opaque minerals. Secondary minerals of chlorite, pumpellyite and epidote are also recognized.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
H-19	Lingig	Barcelona G.III.	Augite basalt	Greenish grey, hard rock.	Phenocrysts of plagioclase (max 3mm in length) and a few granular clino-pyroxene (about 0.3mm in length) occur in a matrix of lath-shaped plagioclase (max 0.2mm in length), lath-shaped or granular clino-pyroxene and abundant minute opaque minerals. Chlorite and pale brown clay minerals occur as secondary minerals.	
H-20	Mandug R.	do	Augite basalt	Dark grey, aphanitic rock.	Phenocrysts of prismatic plagioclase (up to 1.5mm in length), prismatic ~ granular clino-pyroxene (up to 1mm in length) and opaque mineral, partially showing glomeroporphyritic texture, occur in a matrix of needle-like or minute granular clino-pyroxene, intersertal feldspar (alteration product?) and glass. A bit of chlorite and brown clay minerals are secondarily produced.	
H-21	do	do	Dolerite	Dark green rock.	The phenocrysts consists of prismatic plagioclase (0.5 ~ 4mm in length), weakly pleochroic clino-pyroxene and ortho-pyroxene. A matrix consists of lath-shped plagioclase (0.2mm ± in length), granular or intersertal clino-pyroxene and opque minerals, and shows ophitic texture. Brown clay minerals and a bit of chlorite are observed as secondary minerals.	See PL-3A
H-22	do	do	Augite basalt	Grey, amygdaloidal rock.	As phenocrysts, a few plagioclases (1 ~ 2mm in length) altered to albite are observed in a matrix of lath-shaped plagioclase (0.3mm ± in length) and opaque minerals. A matrix is almost holocrystalline. Secondary minerals are chlorite, albite, brown colored clay minerals and zeolite. Zeolite fills up amygdals scattered in the matrix.	
H-23	Hagamitan R.	Barcelona C.II.	Micro gabbro~ dolerite	Yellowish grey, holocrystalline rock.	This rock is holocrystalline and consists of larger crystals (2mm ± in length) and smaller crystals (0.1mm ± in length) of plagioclase, clino-pyroxene and opaque minerals. In some parts it shows a gabbroic texture, in the other parts, a doleritic texture.	
H-24	do	do	Augite basalt	Greenish grey rock.	As phenocrysts, plagioclase (max 2mm in length) mostly altered to albite, and weakly pleochroic clino-pyroxene occur in a matrix of plagioclase laths (0.1 0.2mm in length), lath-shaped or granular clino-pyroxene, opaque minerals and glass. Secondary minerals are albite, calcite, chlorite and brown minerals. Zeolite also occurs in amygdals and veinlets.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
H-28	Hagamitan R.	Barcelona G.II.	Coarse grained tuff	Greenish grey, coarse grained rock.	Crystal fragments of clino-pyroxene, plagioclase and opaque minerals, and lithic fragments of several kinds of andesitic rocks make up this rock. The grains (0. 5mm ± in diameter) are cemented by zeolite and the other clay minerals.	
H-30	do	Barcelona G.III.	Augite basalt	Dark grey aphanitic rock.	Phenocrysts of prismatic plagioclase (0. 5 ~ 2m in length), granular clino-pyroxene (0. 5 ~ 1. 0mm in diameter) and opaque mineral (may be magnetite) occur in a matrix of needle-like or granular clino-pyroxene and intersertal feldspar. As secondary minerals are pumpellyite and chlorite.	
H-31	do	do	Augite basalt	Browish grey altered rock.	Similar to H-30.	
H-34	Handamayan R.	Barcelona G.II.	Microgabbro ~ dolerite	Yellowish grey, altered holocrystalline rock.	Similar to H-23.	
H-36	do	do	Porphyritic augite basalt	Dark brown, porphyritic rock.	Similar to H-16.	
H-39	Hagamitan R.	do	Hornblende augite andesite	Pale green siliceous rock.	Phenocrysts of prismatic ~ tabular plagioclase (0. 5 ~ 3mm in length), strongly pleochroic hornblende (0. 5 ~ 1mm in length, mostly altered to pumpellyite and the other minerals), weakly pleochroic clino-pyroxene, opaque minerals (0. 5mm ± in diameter) and a bit of corroded quartz (1mm ± in diameter) are observed in a matrix of prismatic plagioclase (0. 1 ~ 0. 2mm in length), hornblende (up to 0. 2mm in length), granular clino-pyroxene and glass (mostly altered to feldspar).	
H-40	Soriano Mine	do	Augite andesite	Dark grey, aphanitic rock.	Phenocrysts of prismatic ~ tabular plagioclase (max 3mm in length) and clino-pyroxene (0. 5mm in length) are observed. Partially they show a glomero-porphyritic texture. The matrix consists of minute clino-pyroxene, plagioclase (max 0. 1mm in length) and glass, and shows a felty texture. As secondary minerals, chlorite and albite are recognized.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
H-41	Soriano Mine	Barcelona G.II.	Augite andesite	Dark green rock.	Phenocrysts of prismatic ~ tabular plagioclase (2mm ± in length) and prismatic ~ granular clino-pyroxene (0.5 ~ 1mm in length) occur glomeroporphyritically. A matrix shows a felty texture composed of a bit of clino-pyroxene, feldspar and glass. Many amygdals (0.5 ~ 3mm in diameter) filled with chlorite and brownish clay minerals occur in this rock. Secondary minerals are chlorite and albite.	
H-42	do	do	Hornblende augite andesite	Pale blue, altered rock with hornblende phenocrysts.	Phenocrysts of prismatic ~ tabular plagioclase (0.5 ~ 3mm in length), strongly pleochroic hornblende (0.5 ~ 1mm in length), weakly pleochroic clino-pyroxene, opaque minerals (0.5mm in diameter) and a bit of corroded quartz are observed in a matrix of prismatic plagioclase (max 0.2mm in length), hornblende (max 0.2mm in length), clino-pyroxene and glass. Some phenocrysts of plagioclase are partially altered to albite.	See PL-2A
H-43	do	do	Augite andesite	Reddish green, hypocrystalline rock.	Prismatic ~ tabular plagioclase (max 4mm in length) and prismatic ~ granular clino-pyroxene (max 1mm in diameter) are observed as phenocrysts. A matrix shows a felty texture composed of minute prismatic plagioclase, minute opaque minerals and glass. Secondary minerals of albite and calcite are recognized. Calcite veinlets are also observed.	
H-44	Hagamitan R.	do	Hornblende augite andesite	Greenish grey, porphyritic rock.	Phenocrysts of prismatic ~ tabular plagioclase (max 2mm in length), clino-pyroxene (max 1mm in length), chloritized hornblende (max 1mm in length) and a bit of corroded quartz (max 2mm in diameter) are observed in a matrix of prismatic plagioclase, clino-pyroxene, hornblende and glass. Chlorite and albite are secondary minerals.	
H-45	do	do	Andesitic tuff breccia	Greenish grey, coarse grained rock.	This rock consists of lithic fragments (maximum 25mm in diameter) and cementing material. Several kinds of andesite make up the lithic fragments. The cementing material is fresh green mineral (may be glauconite).	
H-46	do	Intrusives	Augite dolerite	Greenish grey, hypocrystalline rock.	Phenocrysts of prismatic ~ tabular plagioclase (3mm ± in length) and weakly pleochroic clino-pyroxene (max 1mm in length) are observed in a matrix of prismatic ~ tabular plagioclase (0.2mm ± in length), granular ~ intersertal clino-pyroxene and granular opaque minerals. The matrix is almost holocrystalline. Albite and chlorite are recognized as secondary minerals.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
H-47	Hagamitan R.	Barcelona G.II.	Strongly altered andesite	Bluish grey, altered rock.	Phenocrysts of prismatic plagioclase (completely altered to calcite and albite, max 1mm in length), a bit of clino-pyroxene (0.3mm ± in length) and quartz (max 0 3mm in diameter) are observed in a felty matrix. Secondary calcite, albite and opaque minerals are recognized.	
H-48	do	do	Augite andesite	Dark green rock.	Phenocrysts of prismatic ~ tabular plagioclase (max 1mm in length) and prismatic ~ granular clino-pyroxene (max 2mm in length) occur in a matrix. Partially, they show a glomeroporphyritic texture. The matrix shows felty texture and consists of minute plagioclase and glass. Secondary albite is recognized.	
H-50	do	Barcelona G.III.	Doleritic basalt	Pale green, altered rock.	Phenocrysts of prismatic ~ tabular plagioclase (0.5 ~ 1mm in length) partially showing a glomeroporphyritic texture and a bit of prismatic clino-pyroxene are observed in a matrix of lath-shaped plagioclase and granular or needle like clino-pyroxene. Secondary minerals are albite and pumpellyite.	
H-51	Hanipaan R.	do	Augite basalt	Greenish grey rock.	Phenocrysts of prismatic ~ tabular plagioclase (1 ~ 2mm in length) and clino-pyroxene occur in a matrix of prismatic or needle-like plagioclase and needle-like or granular clino-pyroxene (0.5mm ± in length). Small amygdals filled with zeolite are recognized abundantly.	
H-52	do	do	Augite basalt	Brownish grey rock.	Phenocrysts of prismatic ~ tabular plagioclase (0.5 ~ 2mm in length) and clino-pyroxene (0.5 ~ 2mm in length) occur in a matrix, partially showing glomeroporphyritic texture. The matrix consists of prismatic ~ needle-like plagioclase (max 0.2mm in length), needle-like or granular clino-pyroxene and glass. Secondary minerals are Chlorite, pumpellyite and albite.	
H-53	do	do	Two-pyroxene basalt	Greenish grey rock.	Phenocrysts of prismatic ~ tabular plagioclase (0.5 ~ 2mm in length), clino-pyroxene (0.5 ~ 2mm in length) and pleochroic orthopyroxene (0.5 ~ 2mm in length, mostly altered to pale brown clay mineral) occur in a matrix, partially showing glomeroporphyritic texture. The matrix consists of prismatic plagioclase, needle-like or granular augite, cubic opaque mineral and glass. Pumpellyite, chlorite, albite and pale brown clay mineral are recognized as secondary minerals.	See PL-2C

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
H-54	Hanipaan R.	Barcelona G.III.	Augite basalt	Greenish grey rock.	Similar to H-52.	
H-55	do	do	Augite basalt	Dark grey, compact rock.	Phenocrysts of prismatic ~ tabular plagioclase (1 ~ 2mm in length) and prismatic ~ granular clino-pyroxene (1 ~ 3mm in length) occur in a matrix. The matrix consists of prismatic plagioclase, granular ~ intersertal clino-pyroxene, granular opaque mineral. There is no needle-shaped clino-pyroxene. Secondary minerals are chlorite, pumpellyite and albite.	
H-56	do	do	Augite basalt	Greenish grey rock.	Phenocrysts of prismatic ~ tabular plagioclase (0.5mm ~ 3mm in length) and prismatic clino-pyroxene (0.5 ~ 1mm in length) occur in a matrix of needle-like clino-pyroxene (max 1mm in length), intersertal feldspar and a bit of opaque minerals. Epidote, pumpellyite and brown clay minerals are also recognized.	
H-59	Lingig R.	Barcelona G.III.	Augite basalt	Dark grey, hypocrystalline rock.	Phenocrysts of prismatic ~ tabular plagioclase and prismatic granular clins-pyroxene (max 1mm in length, partially altered to calcite) occur in a matrix of needle-like plagioclase, needle-like or granular clino-pyroxene and glass.	
H-60	do	do	Augite basalt	Dark grey, compact rock.	Phenocrysts of prismatic ~ tabular plagioclase (1mm ± in length) occur in a matrix. Partially they show glomeroporphyritic texture. The matrix consists of prismatic plagioclase (0.2mm ± in length) and needle-like or intersertal clino-pyroxene. Secondary minerals are albite, chlorite and pumpellyite. Fracture filling veinlets which are composed of zeolite and green clay mineral are also present.	
H-64	do	do	Augite basalt	Dark brown, porphyritic rock.	Phenocrysts of prismatic plagioclase (max 6mm in length, partially altered) occur in a felty matrix of needle-like or intersertal clino-pyroxene and other minute minerals. Chlorite and pale brown clay minerals are secondary minerals.	
H-65	do	do	Dolerite	Greenish grey, micro-holocrystalline rock.	Fine grained holocrystalline rock composed of prismatic ~ tabular plagioclase (0.5mm ± in length), granular or intersertal clino-pyroxene and intersertal opaque mineral. A secondary greenish yellow clay mineral is recognized.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
H-66	Lingig R.	Barcelona G.III.	Doleritic basalt	Greenish grey, amygdaloidal rock.	This rock consists of lath-shaped plagioclase (0.2mm in length) and lath-shaped or intersertal clino-pyroxene. In this rock, some amygdals (2mm ± in diameter) with zeolite are recognized. A pale brownish green colored clay mineral is secondary observed.	
H-67	do	do	Crystal tuff	Bluish grey rock.	This rock consists of crystal fragments such as plagioclase and clino-pyroxene. The sorting is very poor. Abundant amygdals (0.1mm ± in diameter) of zeolite occur in this section.	
H-69	do	do	Crystal tuff	Greenish grey, fine grained rock.	Similar to H-67.	
H-71	Pagtangnan R.	do	Augite basalt	Bluish grey rock.	Phenocrysts of prismatic ~ tabular plagioclase (partially altered to calcite, 1mm ± in length) and altered clino-pyroxene occur in a matrix of prismatic ~ tabular plagioclase (0.3mm ± in length) and intersertal clino-pyroxene. Calcite and chlorite are also recognized.	
H-72	do	do	Augite basalt	Dark grey, fine grained rock.	Phenocrysts of prismatic plagioclase (± 1mm in length, mostly altered to albite and chlorite) and prismatic ~ granular clino-pyroxene (max 1mm in length) are observed in a matrix of needle-like or granular clino-pyroxene and intersertal, pale green clay mineral (secondary product). The matrix is affected by weak ablitization.	
H-73	do	do	Augite basalt	Dark grey, aphanitic rock.	Phenocrysts of prismatic ~ tabular plagioclase (strongly altered, 1.5mm ± in length) and granular clino-pyroxene (0.5mm ± in length, partially altered to calcite) occur in a matrix of lath-shaped plagioclase and needle-like or intersertal clino-pyroxene (altered to calcite and yellowish brown clay mineral).	
H-75	do	do	Augite basalt	Greenish grey, altered rock.	Similar to H-72. Yellowish brown clay mineral is recognized.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observation	Remarks
H-77	Hanipaan R.	Intrusives	Dolerite	Greenish grey, altered rock.	Strongly altered rock. Phenocrysts of prismatic ~ tabular plagioclase (± 2mm in length, mostly altered to prehnite, calcite and albite) and granular clino-pyroxene (± 0.5mm in diameter, relatively fresh), showing glomeroporphyritic texture, are observed in a matrix of prismatic plagioclase (completely altered to albite and the other secondary minerals) and intersertal clino-pyroxene (relatively fresh). The matrix shows holocrystalline texture. Other secondary mineral is brown colored clay mineral.	
H-78	do	Barcelona G.III	Dolerite	Dark green, doleritic rock.	Holocrystalline rock with some larger crystals. This rock consists of idiomorphic plagioclase (1mm ± in length), hypidiomorphic ~ intersertal clino-pyroxene and opaque minerals. Secondary mineral are calcite and green clay mineral.	
H-79	do	do	Dolerite	Brownish grey, amygdaloidal rock.	Phenocrysts of prismatic ~ tabular plagioclase (2mm ± in length, altered to albite) and granular clino-pyroxene (1mm ± in diameter) occur in a matrix showing doleritic texture) of lath-shaped plagioclase (0.5mm ± in length) and lath-shaped or intersertal clino-pyroxene. As secondary minerals, albite, prehrite, zeolite and brown clay minerals are observed.	
H-80	do	do	Dolerite	Grey rock.	Similar to H-78. Secondary mineral are much calcite.	
D1-37	DDH-No. 1 core	Barcelona G. I.	Altered dolerite	Dark grey, compact rock with epidote stringers.	Plagioclase phenocrysts (altered to calcite, chlorite and epidote) are in a matrix of tabular plagioclase (0.4mm in length, An45 ~ 55), intersertal augite and opaque minerals. Much epidote and chlorite occur in massive or vein form.	
D1-50	do	do	Altered basalt	Greyish white rock with pyrite & epidote stringers.	Euhedral or subhedral crystals of plagioclase are embedded in a mesostasis of actinolite after pyroxene. Chlorite, a few epidote and calcite are secondary minerals.	
DI-95	do	do	Dolerite	Dark grey, compact rock with pyrite-quartz stringers	Ophitic texture. Ilmenite is an accessory. Actinolite (after pyroxene), chlorite, calcite and epidote are observed.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observation	Remarks
D1-115	DDH-No. 1 core	Barcelona G. I.	Dolerite	Grey, compact rock.	Euhedral plagioclase (An45 ~ 50) and ophitic pyroxene (altered to actinolite, chlorite and epidote) are main constituents of this rock.	
D1-125	do	do	Dolerite	Dark grey, compact rock.	Ophitic texture. Actinolite after pyroxene, epidote, chlorite, calcite and brownish clay mineral. Resembling to D1-115.	
D1-133	do	do	Aphyric basalt	Greenish grey, fine grained rock with a few pyrite stringers	Aggregate of tabular plagioclase (0.2mm in length) and foliated or lamellar chlorite. Much chlorite, quartz, epidote and a few calcite occur as secondary products.	
D1-163	do	do	Dolerite	Dark green, a little bit coarser rock.	Euhedral plagioclase (An65, 1mm in length) and ophitic pyroxene or hornblende (altered to actinolite). Alteration minerals are chlorite, epidote and calcite. A few quartz-chlorite-calcite stringers.	
D1-177	do	do	Dolerite	Dark green, a little bit coarser rock.	Holocrystalline. Plagioclase and ophitic pyroxene or hornblende. Mafic minerals are altered to chlorite, actinolite and few carbonate.	
D1-195	do	do	Dolerite	Dark green, a little bit coarser rock.	Fine grained holocrystalline. Tabular plagioclase (less than 0.5mm in length) and chloritized ophitic pyroxene. Quartz, chlorite, calcite and pyrite are secondary minerals.	
D1-223	do	Intrusives	Quartz diorite	Greyish white, silicified rock with calcite stringers.	Euhedral plagioclase (An30, altered to sericite and kaolinite), chloritized biotite and anhedral quartz are main constituents More than 50% of the field is occupied by granular quartz (0.02mm in size). Secondary minerals are sericite, kaolinite, chlorite and quartz.	
D1-245	do	do	Quartz diorite	Greyish white, silicified rock.	Subhedral plagioclase, granular quartz (1 ~ 1.5mm in size), foliated chlorite and secondary, irregular quartz. Accessory: sphene. Secondary minerals are sericite, kaoline and quartz which are derived from plagioclase.	
D1-250	do	do	Quartz diorite	Greyish white, strongly silicified.	Subhedral potash feldspar, plagioclase, quartz, pleochroic biotite and anhedederal quartz are main consituent minerals. Gypsum fills up the fissures in these crystals. Secondary minerals are calcite, sericite, quartz and gypsum.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
D1-250	DDH-No. 1 core	Ore	Quartz diorite	Brecciated, chalcopyrite -gypsum network.	Fractured and brecciated chalcopyrite healed with gypsum.	See PL-6B
D2-40	DDH-No. 2 core	Intrusives	Quartz diorite	Medium grained, leucocratic rock.	Euhedral ~ subhedral zoned and twinned plagioclase (An50 average 1mm, maximum 8mm in length), biotite (partially altered to chlorite and epidote) and hornblende (weakly chloritized). Alteration is very weak.	See PL-4B
D2-106	do	do	Quartz diorite	Grey, fine grained rock.	Fine grained holocrystalline. Tabular plagioclase (An40, 0.5 1mm in length), foliated biotite and prismatic hornblende are essential minerals. Very weak alteration.	
D2-115	do	do	Quartz diorite	Leucocratic, medium grained rock.	The main minerals are plagioclase, quartz and mafic minerals. Plagioclase is partially altered to sericite, calcite and kaolinite, and mafic minerals to calcite and chlorite completely.	
D2-137	do	do	Diorite porphyry	Greenish grey, compact rock with green hornblende needles.	Large phenocrysts of plagioclase (8mm in length and altered to kaolinite, calcite and sericite) are in a fine grained mixture of secondary plagioclase. Alkali feldspar rims on plagioclase phenocrysts.	
D2-191	do	Intrusives	Quartz diorite	Medium grained, leucocratic rock.	Plagioclase (4 ~ 5mm in length), biotite and quartz. Hornblende is absent. Plagioclase has zoning and twinning textures and is partially altered to kaolinite and sericite.	
D3-61	DDH-No. 3 core	do	Diorite porphyry	Grey porphyritic rock.	Porphyritic texture. Phenocrysts consists of zoned and twinned plagioclase (An35 5mm in length) and hornblende (2mm in length). Groundmass is composed of plagioclase laths, epidote and quartz. Secondary minerals are calcite chlorite and epidote.	
D3-110	do	do	Dolerite	Dark grey compact rock.	Ophitic texture. Plagioclase (altered to alkali feldspar, 0.3mm in length), actinolite after augite, epidote and opaque minerals. Weak epidote-chlorite alteration.	
D3-174	do	Barcelona G. I.	Augite basalt	Dark green compact rock.	Phenocrysts of plagioclase (5mm in length, altered to alkali feldspar, actinolite and opaque) are in an altered matrix which is composed of alkali feldspar, chlorite and opaque minerals.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
D3-201	DDH-No. 3 core	Intrusives	Hornblende quartz diorite	Medium grained, leucocratic rock.	The main minerals are plagioclase (partially altered to sericite and epidote) and chloritized hornblende. Biotite is absent. Weak epidote-chlorite alteration.	
D3-244	do	Barcelona G. I.	Doleritic basalt	Dark grey.	Similar to D3-174 but a little bit coarser.	
D4-15	DDH-No. 4 core	do	Doleritic basalt	Dark grey compact rock.	Plagioclase (1mm in length) is altered to alkali feldspar, sericite and chlorite; mafic minerals to chlorite perfectly. Moderate chlorite-epidote alteration.	
D4-77	do	do	Dolerite	Coarse grained, grey rock.	Coarser than D4-15. Weak chlorite-epidote alteration.	
D4-96	do	Intrusives	Quartz diorite	Leucocratic, pyrite disseminated rock.	Subhedral plagioclase (3 ~ 4mm in length, partially altered to sericite), anhedral quartz and foliated biotite (partially altered to chlorite). No visible hornblende.	
D4-166	do	do	Porphyritic quartz diorite	Leucocratic I. C. =5%	Glomero-porphyritic texture. Large plagioclase phenocrysts (3mm in length) occur in a fine grained matrix which is composed of plagioclase laths (0. 5mm in length), biotite flake and anhedral quartz. Some plagioclase are partially altered to sericite, and kaolinite, and are rimmed by alkali feldspar.	
D4-142	do	do	Diorite porphyry	Grey porphyritic rock.	Similar to D3-61. Secondary quartz is observed.	
D4-186	do	do	Quartz diorite	Pinkish white rock.	Plagioclase, hornblende, quartz and biotite are principal minerals. Few secondary minerals.	
D5-28	DDH-No. 5 core	do	Altered dolerite	Greenish grey, compact rock.	Strongly altered. Plagioclase changes to an aggregate of alkali feldspar, actinolite and chlorite; mafic minerals to chrorite and actinolite.	
D5-77	do	do	Diorite porphyry	Medium grained, leucocratic rock.	A few large plagioclase phenocrysts (2mm in length) occur in an equigranular groundmass (0. 5mm in size). Plagioclase (altered to sericite and kaoline), brownish green hornblende and foliated biotite make up the groundmass. Color index is around 20%.	

Sample No.	Location	Group or Formation	Rock	Macroscopic features	Microscopic observations	Remarks
D5-147	DDH-No. 5 core	Intrusives	Quartz diorite	Greenish grey, fine grained rock.	Similar to D5-77. Large phenocrysts of plagioclase (An55, 13mm in length) and smaller crystals of plagioclase (0.5 ~ 1mm in length), brown biotite and anhedral quartz are main minerals. Plagioclase is partially altered to sericite, chlorite and kaolinite, and is rimmed by alkali feldspar. C. I. is less than 10%.	
D5-200	do	do	Quartz diorite	Fine grained, leucocratic, C. I. =25%.	Similar to D5-77. A few part of plagioclase is altered to kaolinite. Hornblende is absent.	
D5-221	do	Barcelona G. I	Altered dolerite	Greenish grey, coarse grained rock.	Fine grained holocrystalline. Similar to D5-28. Mafic minerals are altered to chlorite, actinolite and epidote.	

Table I-2. Chemical analysis of rock samples

(A) Rock

Sample No.	Location	Formation	Rock	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	CO_2	H_2O^+	H_2O^-	Total
				%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
N-130	Taon R.	Barcelona Group (I)	Augite basalt	64.34	0.76	12.72	2.62	5.96	0.25	1.76	3.02	3.68	1.16	0.28	0.57	2.05	0.48	99.75
P-15	Hagamitan R.	B.G. (II)	Augite andesite	56.65	0.69	15.45	2.03	4.78	0.12	4.84	8.09	2.20	1.06	0.22	–	2.87	0.86	99.86
H-4	Lingig	B.G. (III)	Augite basalt	51.03	1.03	18.11	4.41	5.10	0.20	3.00	8.24	2.89	1.98	0.42	–	1.68	1.68	99.77
P-19	Mahabo C.	Intrusives	Dacite	59.51	0.50	14.70	1.20	3.66	0.13	3.17	5.97	2.50	1.37	0.15	3.37	3.23	0.20	99.66
D-5-52	Drill Hole No.5	do	Quartz diorite	64.34	0.50	15.71	1.88	3.34	0.07	2.58	3.92	3.91	1.09	0.18	–	2.24	0.14	99.90
P-2	Camansi C.	do	Biotite gabbro	49.45	1.02	17.78	3.56	7.55	0.28	3.96	7.78	3.47	1.70	0.34	–	2.78	0.18	99.85

(B) Mineralized rock

Sample No.	Location	Country rock	Au	Cu	Pb	Zn	$BaSO_4$	SO_3	S	Remarks
			%	%	%	%	%	%	%	
T-3	Mahabo R	Dacite	–	0.085	–	–	0.18	–	6.45	Very fine grained pyrite dissemination
T-4	do	do	–	0.094	–	–	–	–	9.04	Fine grained pyrite–quartz lens
T-11	do	do	0.1	0.16	–	tr	–	–	28.25	Pyrite dissemination, strongly silicified
T-14	do	do	0.2	0.02	0.05	0.37	–	–	0.50	Strongly silicified
T-17	Hagamitan R.	do	–	0.028	tr	tr	1.06	1.48	6.80	Pyrite–quartz stringers (Float)
T-18	do	do	–	0.18	tr	tr	–	–	4.36	Strongly silicified and argillized
T-20	do	Augite andesite	–	0.14	–	–	0.10	–	5.68	Pyrite dissemination
T-21	do	do	–	0.56	–	tr	–	–	21.93	Strongly silicified, pyrite dissemination
T-27	do	do	0.2	0.12	0.30	0.32	–	–	1.82	Strongly silicified. Cp-Ga-Sph-Py dissemination

Table I-3. X-ray diffractive analysis

Sample No.	Location	Group of Formation	Rock	Mont	Mus.	α-Qz	Adul	Plag	Mag	Remarks
F-39	Alteration zone	Intrusives	Dacite	O		O	O			Strongly argillized
F-45	do	do	Dacite	O		O		O	O	do
P-10	do	do	Dacite	O		O				do
D-2-66	Drill Hole No. 2	do	Quartz diorite		O	O				Weak argillized

Remarks:

Mont : Montmorillonite　α-Qz : α-Quartz　Plag : Plagioclase
Mus : Muscovite　Adul : Adularia　Mag : Magnetite

Table I-4 K-Ar Age on the quartz diorite (DDH-No. 2 core)

Analitic No.	Mineral	K %	Sample wt. g	$^{36}Ar^{T}/^{38}Ar$	$^{40}Ar^{air}/^{38}Ar$	$^{40}Ar^{R}/^{38}Ar$	$^{40}Ar^{R}/^{40}K$	Air contamination %	Age M. Y.
1204	Hr + Bi	0. 70	1. 0281	0. 01116	3. 18792	5. 68466	0. 029983	35. 76	454±35
1222	Hr + Bi	0. 75	0. 8525	0. 01029	2. 93040	5. 88017	0. 033382	32. 90	499±34

Hr : hornblende, $^{36}Ar^{T}$: total argon 36, $^{40}Ar^{R}$: radiogenic argon 40,

Bi : biotite, $^{40}Ar^{air}$: atmospheric argon 40,

$\lambda_e = 0.584 \times 10^{-10}\ yr^{-1}$, $\lambda_\beta = 4.72 \times 10^{-10} yr^{-1}$.

Note: The K-Ar ages on quartz diorite in this hole are $454 \pm 35 \times 10^6$ (late Ordovician) and $494 \pm 34 \times 10^6$ (early Ordovician) years. Both figures are unexpectedly too old. In the case of that Ar in the hyrothermal solution or gas was trapped in the sample at the alteration time, the K-Ar age is measured older than true age. As the period of quartz diorite intrusion is very important to clarify the features of mineralization, further study will be desirable.

Table III-1. Specifications of diamond bits, reaming shells and casing shoe bits

Item	Size	Type	Carats	Matrix	Diamond size	Water-way	Quantities (pcs)	Remarks
Bit	N X	NTQ WL	750.00	E, Z, T_1	1/20	6	25	
	B X	BTQ WL	700.00	E, Z, T_1	1/20	4	35	
	A X	ATQ WL	240.00	E, Z, T_1	1/20	4	20	
	Total		1,690.00				80	
Reaming-shell	N X	NTQ WL	52.80	D, Y, T_0	1/15 ~ 1/20	6	8	
	B X	BTQ WL	66.00	D, Y, T_0	1/15 ~ 1/20	4	11	
	A X	ATQ WL	31.50	D, Y, T_0	1/15 ~ 1/20	4	7	
	Total		50.30				26	
Casing-shoe	N X	N X	100.00	D, Y, T	1/20		5	
	B X	B X	75.00		1/20		5	
	A X	A X	50.00		1/20		5	
	Total		225.00				15	
	Grand total		2,065.30				121	

Table III-2. Drilling meterage by diamond bit, reaming shell and casing shoe bit

Item	Size	Bit No.	Drilling meterage					Unit : meter	Remarks
			DDH-1	DDH-2	DDH-3	DDH-4	DDH-5	Total	
Bit	NTQ WL	8965		20. 10				20. 10	Resetting
	"	8969				11. 40		11. 40	"
	"	8970		0. 50	27. 30			27. 80	"
	"	8971			22. 10			22. 10	"
	"	8972				33. 60		33. 60	"
	"	8973				17. 30		17. 30	"
	"	8974			15. 20			15. 20	"
	"	8975	78. 50				10. 50	89. 00	"
	"	8976				17. 00		17. 00	"
	"	8978			4. 60		11. 25	15. 85	"
	"	V5303				0. 50	17. 75	18. 25	"
	"	V5304					32. 30	32. 20	"
	"	V5305		16. 20				16. 20	"
	"	V5306			25. 00			25. 00	"
	"	V5307		53. 20				53. 20	"
	"	SCTN6				15/80		15. 80	"
	BTQ WL	V5308					13. 20	13. 20	"
	"	V5309				14. 50		14. 50	"
	"	V5310				33. 50		33. 50	"
	"	V5314					40. 20	40. 20	"
	"	V5316			41. 40			41. 40	"
	"	V5317					28. 30	28. 30	"
	"	V5318	1. 80					1. 80	"
	"	U13942	44. 60					44. 60	Abandonment
	"	72931		65. 90				65. 90	Resetting
	"	72397				20. 80		20. 80	"
	"	72398				19. 90		19. 90	"
	"	7916-1					49. 90	49. 90	"
	"	SCTB-7					27. 40	27. 40	"
	"	AB-2		51. 90				51. 90	"

Item	Size	Bit No.	Drilling meterage				Unit : meter		Remarks
			DDH-1	DDH-2	DDH-3	DDH-4	DDH-5	Total	
Bit	BTQ WL	AB-5			2. 70			2. 70	Resetting
	"	AB-6			52. 00			52. 00	"
	"	AB-7				11. 40		11. 40	"
	"	AB-8			51. 20			51. 20	"
	"	AB-10		31. 80				31. 80	"
	"	AB-12				48. 00		48. 00	"
	"	AB-13					5. 00	5. 00	"
	ATQ WL	V5253	12. 80					12. 80	Resetting
	"	U13957	25. 10					25. 10	"
	"	U13961	27. 40					27. 40	"
	"	CNC1581	11. 00					11. 00	"
	"	MCAT140-1	19. 00					19. 00	"
	"	U13959	8. 30					8. 30	Abandonment
	"	U13956	10. 00					10. 00	"
	Total		238. 50	239. 60	241. 50	243. 70	235. 70	1, 199. 00	
Reaming shell	NTQ WL	V3298		90. 00		95. 60		185. 60	Resetting
	"	VG5331			94. 20			94. 20	"
	"	SCTNR-5	78. 50				71. 70	150. 20	"
	BTQ WL	700475		149. 60				149. 60	"
	"	SCR-2			147. 30			147. 30	"
	"	SCR-12				148. 10		148. 10	"
	"	SCTBR-4	46. 40				164. 00	210. 40	"
	ATQ WL	SCTAR-2	68. 50					68. 50	"
	"	SCTAR-3	45. 10					45. 10	"
	Total		238. 50	239. 60	241. 50	243. 70	235. 70	1, 199. 00	
Casing shoe bit	N X	SCNCP-2	0					1	Resetting
	"	SCNCP-5					0	1	Abandanment
	B X	SCBCP-4	0					1	Resetting
	A X	SCACP-4	0					1	"
	Total		3				1	4	

Table III-3. Drilling progress of DDH–No. 1

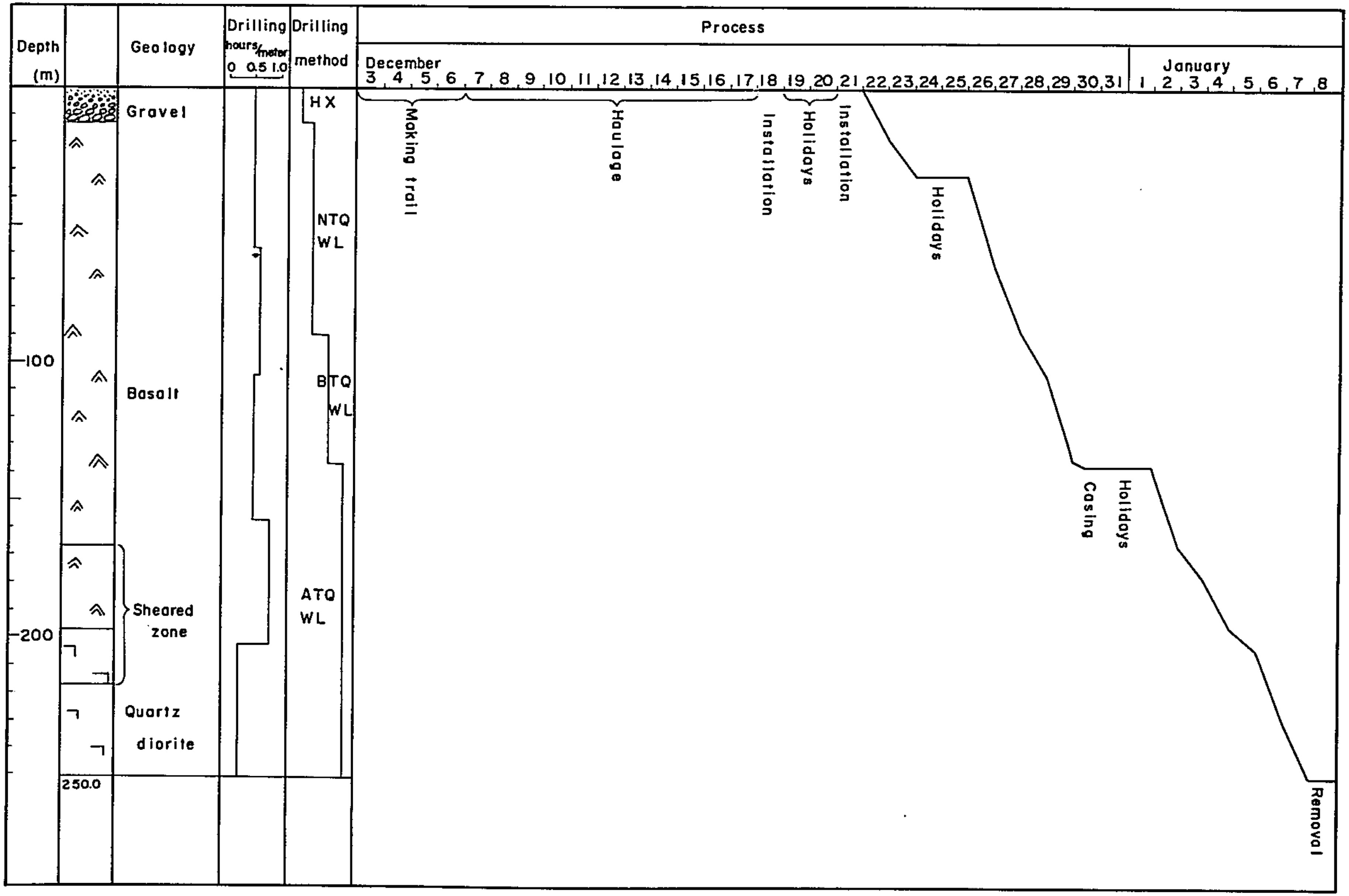


Table III-4. Drilling progress of DDH–No. 2

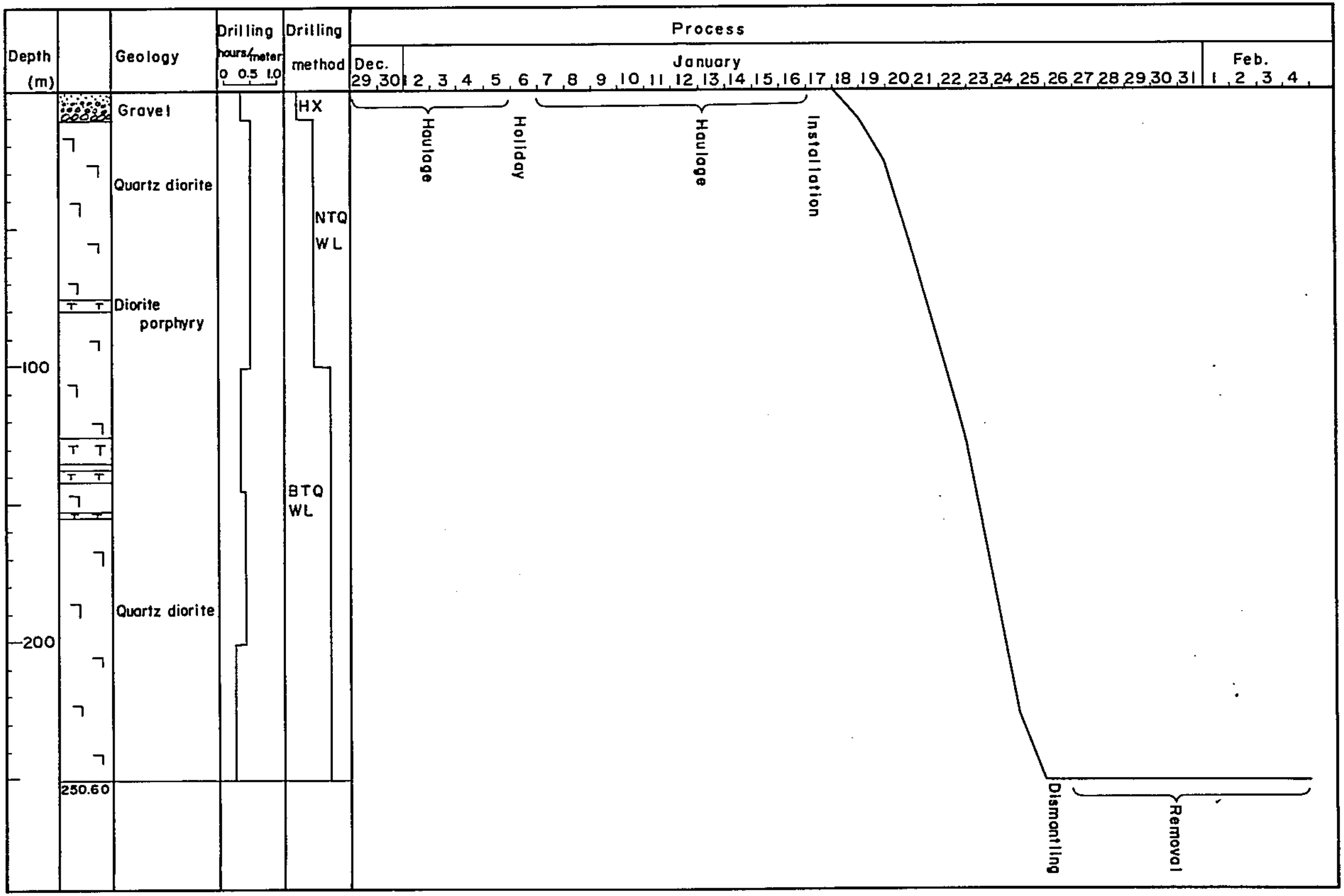


Table III-5. Drilling progress of DDH–No. 3

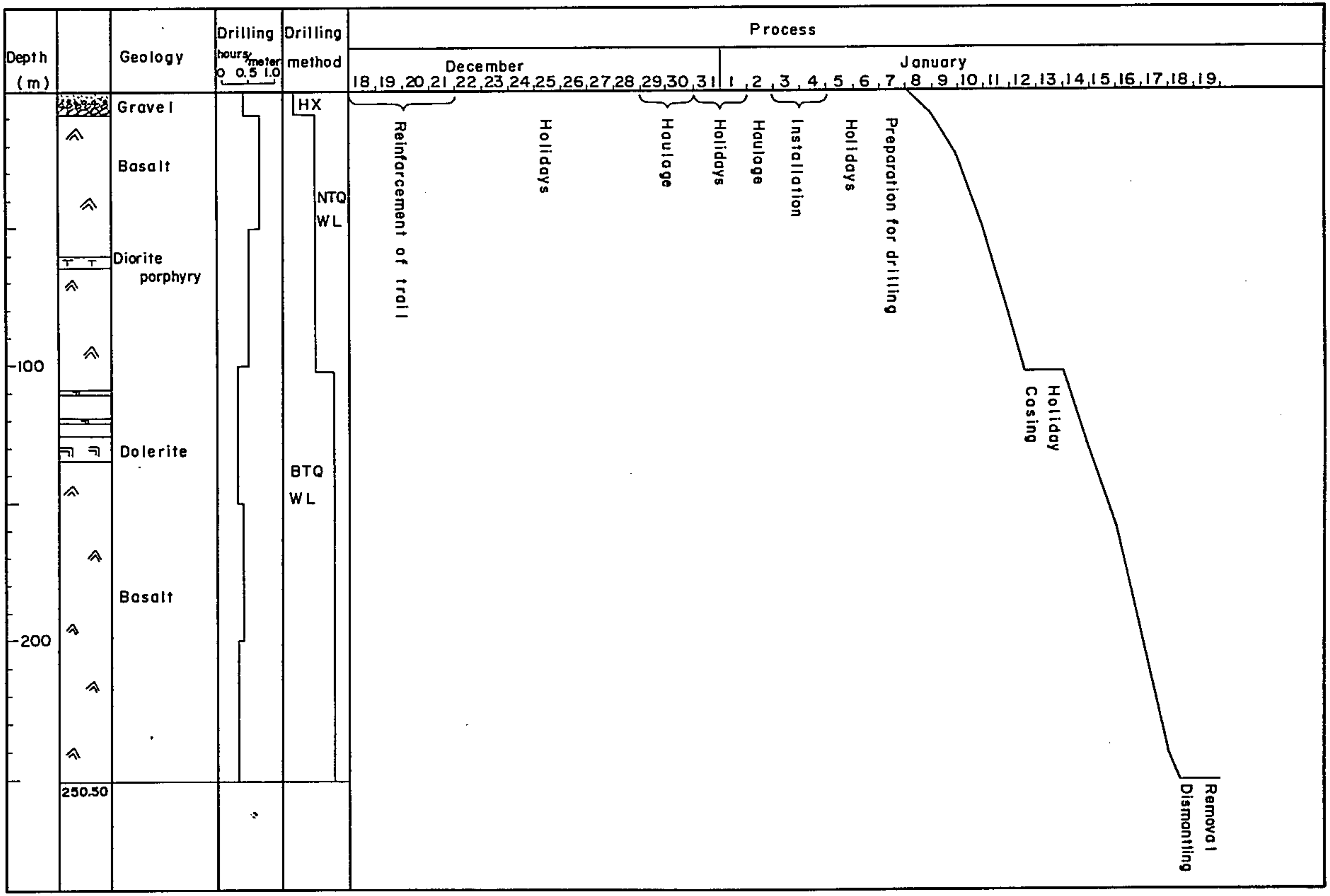


Table III-6. Drilling progress of DDH–No. 4

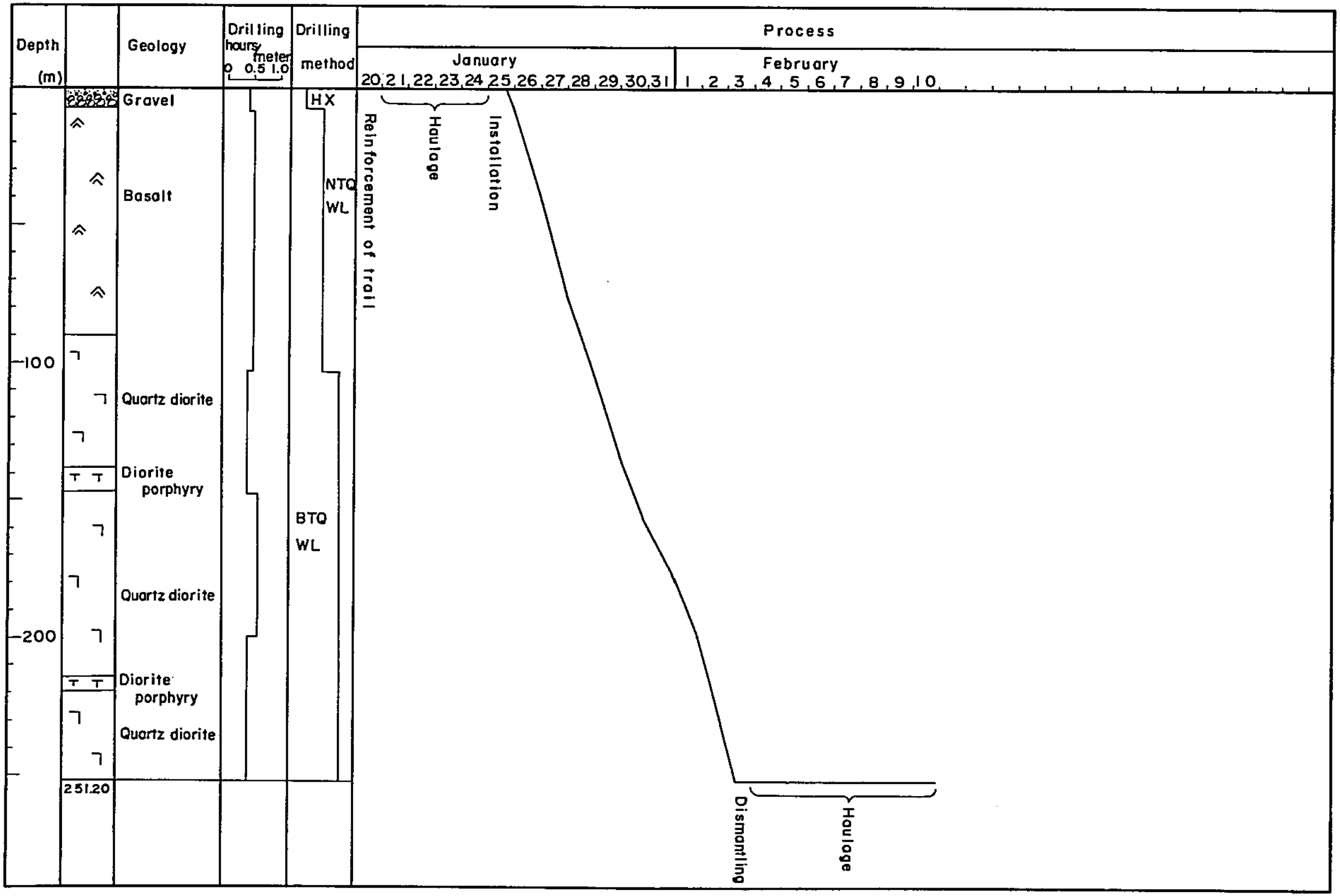


Table III-7. Drilling progress of DDH–No. 5