REPUBLIC OF THE PHILIPPINES

DEPARTMENT OF NATURAL RESOURCES

BUREAU OF MINES

REPORT ON GEOLOGICAL SURVEY OF NORTHEASTERN LUZON

(CONSOLIDATED REPORT)

DEC. 1977

METAL MINING AGENCY

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

The Government of Japan, in response to the request of the Government of the Republic of the Philippines decided to conduct a geological survey for mineral exploration in Northeastern Luzon of the Philippines, and commissioned its implementation to the Japan International Cooperation Agency.

The Agency, considering its technical characteristics, sought collaboration of the Metal Mining Agency of Japan to accomplish the task within a period of three years, 1974 - 1976.

'The survey has been accomplished under close collaboration between Japanese survey team and the Government of the Republic of the Philippines.

This report submitted hereby summarizes the generalization of the results obtained through the period of three years.

We wish to express our heartfelt gratitude to the Government of the Republic of the Philippines and other authorities concerned for their kind cooperation and support extended to the Japanese survey team.

December 1977

Shinsaku Hogen
President
Japan International Cooperation Agency

Yasuaki Hiratsuka
President
Metal Mining Agency of Japan

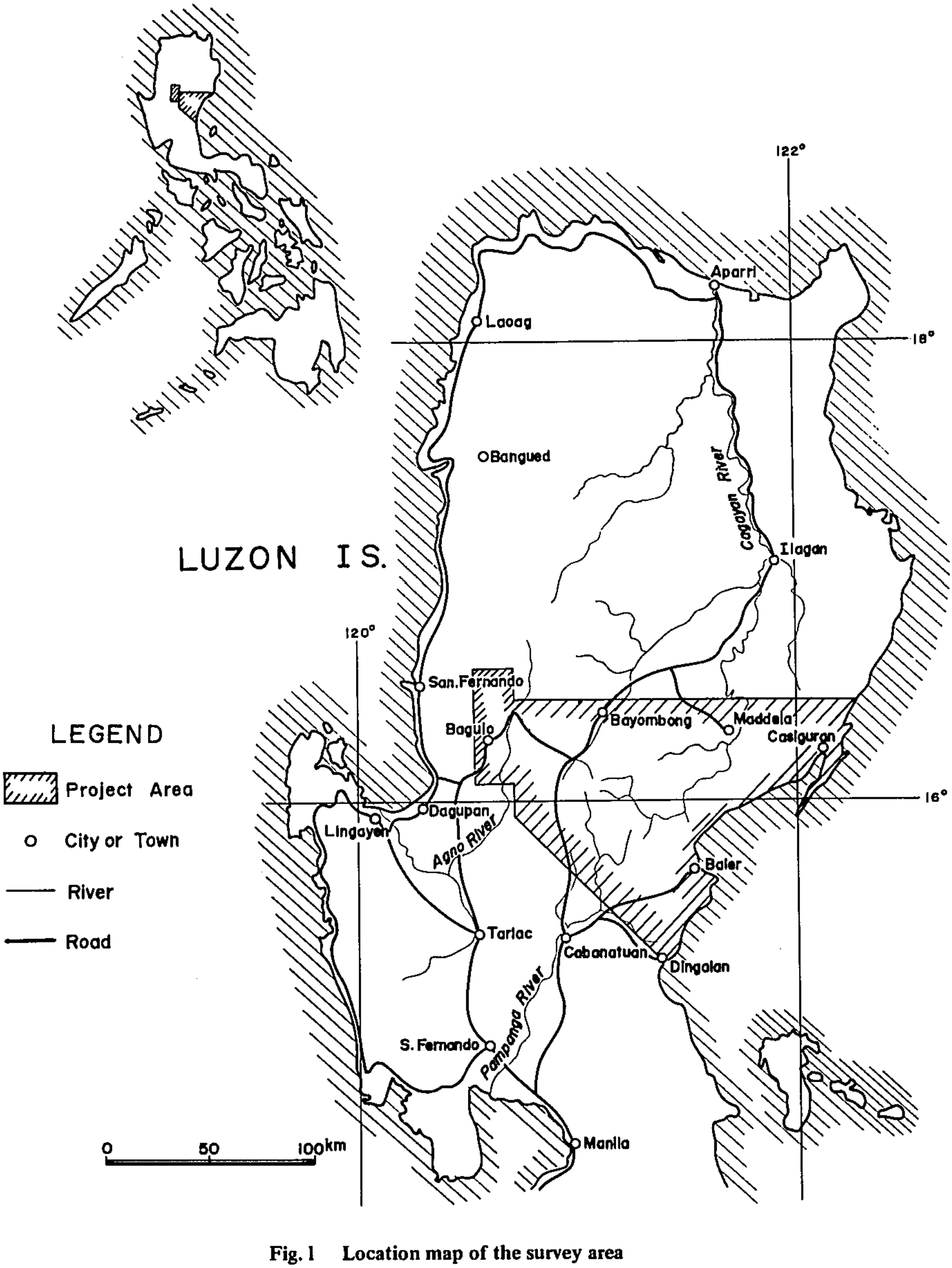

Fig. 1 Location map of the survey area

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ABSTRACT

The purpose of the Northeastern Luzon survey was to make clear the nature of the ore deposits by establishing the stratigraphy and studying the relations between geological structures, igneous activities and mineralization. For this purpose, airborne magnetic, geological and geochemical surveys were carried out in 1974 (fiscal year), followed by semi-detailed and/or detailed geological and geochemical surveys and reanalysis of airborne magnetic survey results in 1975, and semi-detailed and/or detailed geological, geochemical and geophysical (IP and magnetic methods) surveys and drilling exploration in 1976.

The geological survey clarified the sequence of the rocks (which had been lumped together as undifferentiated volcanic rocks or undifferentiated sedimentary rocks) and the sedimentary environments. The ages and the features of acidic igneous rocks were also elucidated by dating and chemical analysis, and were discussed with relation to the mineralizations. Moreover, in Phase III, some conclusions on the mechanism of formation of the ore deposits in the Cordillera Central were obtained from the reconnaissance survey in the Baguio Mineral District. All data thus collected were compared with each other and discussed.

Based on the survey results, the whole surveyed area can be divided into three (3) geological units;

(1) Sierra Madre and Caraballo Mountains, (2) Mamparang Mountains, and (3) Cordillera Central.

It became clear that the Sierra Madre and the Caraballo Mountains are characterized by the Coastal batholith (27-49 m.y.) and the Dupax batholith (26-33 m.y.) of granitic rock, intruded during upper Eocene-Oligocene; the Mamparang Mountains, by the Palali batholith (17-25 m.y.) of alkali plutonic rock intruded in Oligocene-lower Miocene; and the Cordillera Central, by the Agno batholith (18 m.y.) of quartz diorite intruded in lower-middle Miocene. Such regional and periodic differences of the plutonism were possibly caused by the subsiding plates which are considered to exist at both sides of the Luzon Island.

It was also made clear that the ore deposits in the Cordillera Central were accompanied by the diorite porphyry which were derived from the Agno batholith as the latest products of magmatic differentiation, and these deposits are genetically and structurally in close relation with the Agno batholith.

Geochemical drainage surveys for Cu, Zn and Mo were carried out in Phase I and Phase II and soil survey for Cu and Zn, in Phase III. It was proved that drainage survey for Cu was useful for selecting the promising area from the wide area, and soil survey, for delineating the mineralized zone. As a result, some large scale geochemical anomalies were obtained around the mineralized zones.

Geophysical survey was conducted in the Bokod area, which was selected from the geological and geochemical survey results as the most promising area, and some strong IP anomalies were detected. Later on the anomalous zones were tested by drilling exploration, and geophysical IP survey was useful to delineate the sulfide mineralized zones, though it was impossible to distinguish chalcopyrite from pyrite.

A total length of 1,002.55 m three (3) drill holes were sunk mainly for testing the nature of the IP anomalies at depth. Consequently copper mineralized zones were encountered at the shallow part.

PART I INTRODUCTION

1 Purpose of Survey

The purposes of the survey of Northeastern Luzon, Philippines were to select the most promising area for mineral deposits by elucidating the relation among stratigraphy, geological structures and igneous activities, and afterwards, to study the geological situations for mineralizations in the selected area, to clarify their scales and characters, and to investigate the possibility of developing the ore deposits.

2 Outline of Survey

Such basic survey for development of mineral resources was jointly carried out by the Republic of the Philippines and Japanese Governments from 1974 to 1976 to accomplish the above-mentioned purposes.

The promising area was narrowed down by a step by step orthodox procedure, that is, first, by airborne magnetic, then geological and geochemical reconnaissance surveys — detailed geological, geochemical and geophysical surveys — exploratory drilling. Finally, three(3) drill holes were sunk in the selected mineralized zone to test its nature at depth. Thus, the features of porphyry copper deposits in the survey area were clarified. Moreover, the area with working mines of porphyry copper deposit, in the adjacent west of the project area, was (additionally) surveyed in Phase III in order to study the more detailed nature of ore deposits by comparing with those in the adjacent area.

That is, in Phase I, airphotograph interpretation and airborne magnetic survey were carried out on the whole area of about 11,200 km^2

shown in Fig. 1 to get information on the geological structures and the distribution of intrusive rocks. Afterward, the obtained magnetic anomalies scattered at places were checked by geological survey. Geochemical drainage survey was also conducted with geological survey to define the mineralized zones. Based on these results, the north-western part of 3,400 km^2 or nearly 30% of the whole area was selected as having high potential for mineral deposits.

In Phase II, six(6) parties were organized in order to conduct semi-detailed geological and geochemical drainage surveys. The geochemical samples were analyzed semiquantitatively in the field for Cu and Mo. As a result, the Salinas and the Kasibu areas, totaling 300 km^2 were selected as the more promising areas, where detailed geological and geochemical surveys were successively carried out. Before and after the geological survey, reinterpretations of airphotograph were made in Philippines and reanalyses of airborne results, in Japan. All of them were generally discussed with the results of areal surveys. Besides, eastern seaside area where enough geological data could not be collected in Phase I, was resurveyed in Phase II. Based on the results of the Phase I and II surveys, four (4) areas (a total area of 145 km^2), Bokod, Mongia, Salinas and Kasibu, including two of the Phase II detailed survey areas, were selected as having the highest potential for mineral resources. In Phase III, semi-detailed and/or detailed geological and geochemical (for soil) surveys were carried out in the said four areas. Consequently, porphyry copper deposits were revealed in the Bokod and the Salinas areas. As the anomalies in the

Bokod area were large in scale, geophysical surveys (IP and magnetic methods) and drilling exploration were successively conducted.

In order to clarify the nature of these porphyry copper deposits, a geological reconnaissance survey and data collection were made in westerly adjacent to the project area, Baguio area of 980 km^2, where the same type ore deposits are operating and considerations were done from a wide point of view by comparing and discussing the ore deposits, geological structures and igneous activities in both areas.

The outline of the survey carried out over three years is schematically shown below.

Phase I

Airborne magnetic, geological & geochemical (drainage) reconnaissance surveys with airphoto-interpretation
Selection of promising areas (1/3, 3,400 km^2)

↓

Phase II

Semi-detailed geological and geochemical (drainage) surveys, airphoto-reinterpretation and airborne magnetic reanalysis
Selection of { two mineralized zones / more promising areas (300 km^2) }

↓

Detailed geological and geochemical (drainage) surveys
Selection of two mineralized zones / most promising areas (30 km^2)

↓

Phase III

Detailed geological, geochemical (soil) and geophysical (IP and magnetic methods) surveys
Selection of drill sites & drilling exploration
Reconnaissance survey in the adjacent area →
↓
Clarification of the nature of ore deposits

3 List of Members

The list of members engaged in the survey are as follows.

Phase I

(Management)

FEDERICO E. MIRANDA	Bureau of Mines Philippines	HIROSHI FUCHIMOTO	Metal Mining Agency of Japan
		SHINSEI TERASHIMA	do
CONSTANTE B. BELANDRES	do	MASAHARU SAKANO	do
		SATORU KOHIYAMA	Japan International Cooperation Agency

(Geological team)

ARNULFO V. CABANTOG	do	HIROSHI FUCHIMOTO	M. M. A. J.
JOSE N. ALMASCO	do	TAKEOMI MIYOSHI	do
ORLANDO M. PINEDA	do	IKUHIRO HAYASHI	do
ANDRE P. VICTORIANO	do	SADAHARU IWANE	do
BENJAMIN S. CADAWAN	do		

(Geophysical team)

CAROL S. SAMONTE	do	MASAO YOSHIZAWA	do
ROMEO L. ALMEDA	do	IKUO TAKAHASI	do
URBANO PALAGANAS	do	SABURO TACHIKAWA	do
		(Aircraft Crew)	
		MOTOJI ICHIKAWA	do
		MITSURU SAKAZAKI	do
		SHOZO KIMURA	do

		TAMOTSU FUJIKAWA	M. M. A. J.
		TAKASHI YAMANAKA	do

(Photo-interpretation)

PANFILO O. MONTERO	Bureau of Mines Philippines

Phase II

(Management)

CONSTANTE B. BELANDRES	Bureau of Mines Philippines	HIROSHI FUCHIMOTO	Metal Mining Agency of Japan
FEDERICO E. MIRANDA	do	MASAHIRO YAMAMOTO	Japan International Agency of Japan
		SHINSEI TERASHIMA	M. M. A. J.
		KENJI SAWADA	do

(Geological team)

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ROMEO L. ALMEDA	do	YASUKICHI UEKI	do
ANDRE P. VICTORIANO	do	HIROFUMI TANIGUCHI	do
ANGEL A. BRAVO	do	KEIICHI KUMITA	do
JOSE ESPIRIDION	do	IKUHIRO HAYASHI	do
EDWIN G. DOMINGO	do	MASAHIRO HASE	do
PABLITO ESCALADA	do	TSUTOMU ICHINOSE	do
HERMES SERRER	do	KEIGI NAKANO	do
		SADAHARU IWANE	do
		TAKEO KAKIZAKI	do

		MINORU SAITO	M. M. A. J.
		TETSUO SATO	do
		YOSHIAKI SHIBATA	do
(Photo-interpretation)			
PANFILO O. MONTERO	Bureau of Mines Philippines	TOKICHIRO TANI	do
		SADAHARU IWANE	do
		(Aeromagnetic reanalysis)	
		HIDEZO KAKU	do
		ASAHI HATTORI	do
		YOSHIO TAMURA	do
		KENICHI NOMURA	do
		MASAO YOSHIZAWA	do
		SUSUMU SASAKI	do
		YOICHI MATSUDA	do
		MANABU KAKU	do

Phase III

(Management)

CONSTANTE B. BELANDRES	Bureau of Mines Philippines	HIROSHI FUCHIMOTO	Metal Mining Agency of Japan
FEDERICO E. MIRANDA	do	DAI OKUBO	Japan International Cooperation Agency
		MASAHIKO URYU	do
		SHINSEI TERASHIMA	Metal Mining Agency of Japan
		YUTAKA EDA	do

(Geological and geochemical team)

FEDERICO E. MIRANDA	B. O. M.	HIROFUMI TANIGUCHI	M. M. A. J.
ROMEO L. ALMEDA	do	MASAHIRO HASE	do
ANGEL A. BRAVO	do	KEIJI NAKANO	do
EDWIN G. DOMINGO	do	MASATSUGU SAKAI	do
		TETSUO SATO	do
		SHUICHI SATO	do
		TOSHIYUKI GOTO	do

(Geophysical team)

CAROL S. SAMONTE	B. O. M.	ASAHI HATTORI	M. M. A. J.
ORLANDO E. ABARQUEZ	do	AKIO KAKISAKO	do
JOSE N. ALMASCO	do	NORIFU WATANABE	do
ARNULFO V. CABANTOG	do	SHIGEO MATASAKA	do
BENJAMIN S. CADAWAN	do	MASARU HATAKEYAMA	do
		SHINICHI SUGIYAMA	do
		YUTAKA SASAKI	do

		MANABU KAKU	M. M. A. J.
		KAZUTO MATSUKUBO	do

(Drilling team)

CESAR L. LUCERO	B. O. M.	AKIO KATO	M. M. A. J.
		YASUNOBU YOSHIOKA	do
		HIROSHI NIIMURA	do
		MASAO OBARA	do
		ISAMU NAKAYAMA	do
		SOUJI KANNARI	do
		TOMIE TOZAWA	do

4 Location and Accessibility

The survey area is located in the northeastern part of Luzon. It covers an area of about 11,200 km^2 bounded by the following lines:

in the north:	the latitude 16°30' North
in the south:	the foothills, from lower Agno River to Dingalan Bay, bearing S45°E
in the east:	the eastern coast line
in the west:	the longitude 120°45' East

The area covers the provinces of Nueva Vizcaya, Quirino, Isabela, Benguet, Pangasinan, Nueva Ecija and Quezon. The Baguio area including Baguio City, where an additional survey was conducted in the final phase, is enclosed by the latitudes 16°7.5' and 16°37.5' North, and the longitudes 120°35' and 120°45' East.

The national roads in the area are Route No. 5 and No. 11 which pass through the west area or Baguio City. Although there are some branches connecting with the main routes, very few roadways are generally developed owing to rugged topography. Especially, the central part of the area where even trails are not found, has been left behind as an undeveloped area.

Base camps of Bambang in Phase I and Dupax del Sul in Phase II, are very close to Route No. 5 and it takes 5 to 6 hours from Manila by car.

From Baguio City to the Bobok base camp in Phase III it is a 2 hours drive and domestic airline services are available between Manila and Baguio once or twice a day. The flying time is 1 hour.

5 Topography

The topographic features of Northern Luzon can be divided into several subdivisions as shown in Fig. I-1: (1) Sierra Madre, (2) Cagayan Valley, (3) Cordillera Central, and (4) Coastal Folded Belt. Both (1) and (3) are uplift zones, on the contrary, (2) and (4) are subsided zones.

The survey area is just located in the meeting of the above three zones exclusing the Coastal Folded Belt. That is, the Sierra Madre Mountain Range goes down along the coastal line up to Baler where the range is connected with the Caraballo Mountain Range, while the Cordillera Central extends in the south direction as if it followed the southwestern boundary of the project area and also joins with the Caraballo. Therefore, the Cagayan Valley increases its elevation towards the north from near the northern boundary of the area and disappear in the Caraballo Mountain Range.

The two uplift zones show very steep topography. The Sierra Madre Mountain Range has an elevation of 800-1,200 m with some of the peaks reaching over 1,800 m. The V-shape valleys and high walls of cliffs are well developed. The elevation of the Cordillera Central is generally higher than the Sierra Madre, showing 800-1,600 m. Mt. Ugu (2,150 m), the highest peak of the survey area, is in this Central, where many structural line valleys trending NNW-SSE (parallel to the Philippine Fault) are developed. On the contrary, the Cagayan Valley and the Coastal Folded Belt subsided zones show a plain or relatively flat topography.

These mountains with N-S trend are cut by the Philippine Fault (which bounds the survey area) in the south, and are in contact with the Luzon Central Plain.

The drainage systems in the area belong to the Cagayan, the Agno and the Panpanga Rivers. The Cagayan River is the largest in the Philippines and has a large discharge all the year round.

The Kasibu and the Mongia areas of Phase III are located in the uppermost of the Cagayan River and the other 3 areas, in the Cordillera Central, all of which show very steep topography.

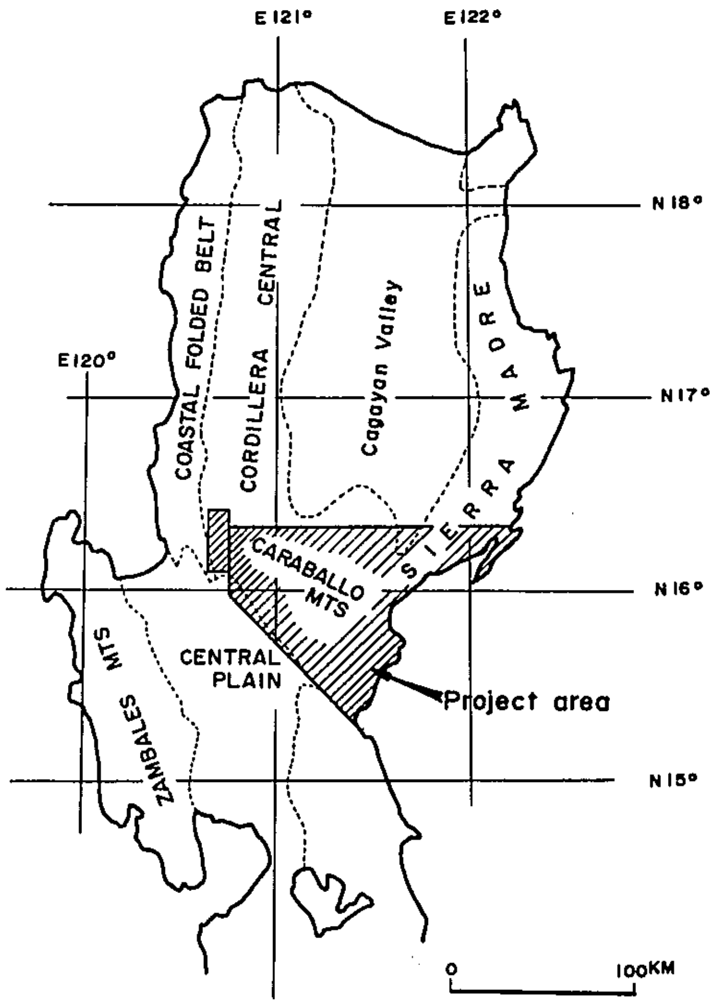


Fig. I-1 Physiographic provinces of Northern Luzon

6 Climate and Vegetation

The climate of the area can be divided into 3 types which correspond roughly to the said physiographic subdivisions.

In the Sierra Madre Mountains in the east, there is no pronounced dry nor rainy season and it rains throughout year. While, in the Cordillera Central Mountains in the west, there are the pronounced dry and rainy seasons. The dry season lasts for 6 months from November to April and the rest is wet season.

In the Cagayan Valley in the central part, the climate is intermediate between the above mentioned areas.

The rainfall is generally heavy so that vegetation is relatively thick in the east side of the Cagayan Valley but some bare mountains can be seen because of few reforestation. Many pine trees grow in the Cordillera Central, the west side of the Cagayan Valley, especially in the Bokod and the Baguio areas covered in Phase III.

PART II GEOLOGICAL SURVEY

1. General Remarks

As previously stated, Northern Luzon is characterized by the topographic features consisting of four belts. The survey area is located in the region of convergence of three belts.

The topographic features are also strongly reflected by the charc-teristics of the geology, and the area can be subdivided geologically into the same belts as the topography.

From the east to the west there are the Sierra Madre uplifted zone, the Cagayan subsided zone and the Cordillera Central uplifted zone.

These three geological zones, which will be individually described in detail are characterized by the rock distribution and the igneous activ-ities.

Both uplifted zones of the Sierra Madre and the Cordillera Central are composed of volcanic rocks and their pyroclastics of Cretaceous to Paleocene-Eocene. In the Sierra Madre no volcanic activities of Oligocene are recognized and the upper Oligocene limestone is locally distributed at places. On the contrary, in the Cordillera Central, the volcanic activities had continued until Miocene time and produced mainly andesitic rocks and their pyroclastics. The Neogene sedimentary rocks are not found in the Sierra Madre. However, the limestone with conglomerate on top are distributed on both wings of the Cordillera Central.

The differences in the rocks distribution clearly indicate that the uplifting movement of the Sierra Madre precedes the Cordillera Central.

On the other hand, in the Cagayan subsided zone between the two uplifted zones, repeated sedimentation went on from south to north in accordance with repeated subsidences and as a whole a semi-circular basin opening toward north was formed during the Crataceous — Eocene to Pliocene.

The igneous activities, especially, the plutonic activities in the three geological zones indicate great differences. From the results of the K-Ar dating and the chemical analysis, obtained from the past 3 year surveys, the plutonic activities of the three zones are summarized in the following paragraphs.

Sierra Madre Area:

The intrusion of the Coastal batholith (27 ~ 49 m.y.) of the granitic rocks in the East Coast Region during upper Eocene ~ Oligocene and the Dupax batholith (26 ~ 33 m.y.) of granitic rocks in the Caraballo Mountains.

Mamparang Area:

The intrusion of the Palali batholith consisted of alkali plutonic rocks (17 - 25 m.y.) in upper Oligocene to lower Miocene.

Cordillera Central Area:

Agno batholith (18 m.y.) consisting of quartz dioritic rocks of lower and middle Miocene.

The differences in lithology and the period of plutonic activities are clearly recognized.

The time lag of the uplifting movements and the lithological differences of the plutonic activities indicate the two uplifted zones on the east and the west sides of the relatively subsiding Cagayan Valley have been formed by different agencies.

These tectonic agencies are, as pointed out in the Phase III report, considered to be caused by the two subduction zones on both sides of the Northern Luzon.

The alkali plutonic activities in the Cagayan subsided zone (including Mamparang Mountains) are somewhat older than the Agno batholith's, which suggests that they are related to the eastern plate subsidence. Although the relation between the alkali rocks and the Coastal or Dupax batholith are not clear, one possibility to explain the both relation is, as RAGLANE et. al. have pointed out, that the alkalinity increases from the trench towards inland.

The distinct differences in the igneous activities have influenced the ore deposition. In the Sierra Madre formed in the older age, no ore deposits have been found. In the Cordillera Central formed by the younger activities, there are many workable ore deposits and form the Baguio Mineral District.

The maldistribution of ore deposits had been considered up to the Phase II Survey to be caused by the granitic rocks contained few alkali and water. But Phase III after studying the Agno batholith, considered to be closely related in forming the Baguio Mineral District, it became clear that there are some differences in lithology such as in granite and quartz diorite, but basically they can be considered to have differentiated from a similar magma, and there is no substantial differences to explain the maldistribution of ore deposits.

According to the survey results of the Baguio area, the ore deposits, especially, the porphyry copper deposits in the Baguio Mineral District, are accompanied by the quartz diorite porphyry stocks, which are the later stage products of the magmatic differentiation (from which the Agno batholith derived) but no porphyry copper deposits are found within the Agno batholith.

In other words, the controlling factors of the ore deposition are shallowly intruded rock bodies which had derived from the calc-alkaline batholith in the later stage of magmatic differentiation.

Considering the Sierra Madre and the Cordillera Central from the same viewpoint, after the intrusion of the batholith, the uplifting movement gradually became stable and the structural movements were weak compared to the western part. Such environment is not suitable to promote the shallow intrusive activities, and few stocks and dykes could be found by the geological survey.

On the other hand, the Cordillera Central, the GERVASIO'S Mobile Belt, had been suffered strong structural movements even after the Agno batholith intrusion. Along these structural lines the later stage intrusives are distributed as stocks and dykes.

The distinct maldistribution of ore deposits observed in the whole survey area can be concluded that it is mainly controlled by the differences in the geological structure, though lithological influence can not be denied.

The genetic relation between the alkali rocks and the ore deposits could not be clarified by the Phase III survey.

The Ronrono gold mine is under prospecting in the alkali rock area. In the northern part of the survey area (Cordon, Isabela), the Cordon porphyry copper deposit is located in the alkali rocks. Therefore, it would be advisable to make a general study on them with the Coastal batholith as soon as possible.

The summary of the geology and the ore deposits of the Sierra Madre, Cagayan and Cordillera Central is shown in the Table II-1.

The details of the geology and the ore deposits will be described in the following chapters.

Table II-1 Summary of geology and ore deposits in 3 geological units

Name of Unit	Formation	Igneous Activity	Ore Deposit
Sierra Madre Eastern Coast	U. Creta Eocene Caraballo Group	Coastal Batholith Granitic rock, 27-49 m.y.	Small Veins and weak disseminated zone
Caraballo Mts	do	Dupax Batholith Granitic rock, 26-33 m.y.	Small Veins San Fabian ore deposit?
South Edge of Cagayan Valley (Mamparang Mts)	Caraballo Group ~ Pliocene Matuno Formation	Palali Batholith Alkaline rock, 17-25 m.y. (Monzonite-Syenite)	Au veinlets network Pyrite weak dissemination (Cordon porphyry copper ore deposit)
Cordillera Central (Baguio Mineral District)	U. Creta Eocene Pugo Formation ~ Pliocene Mirador Formation	Agno Batholith Quartz dioritic rock, 18 m.y.	Porphyry copper deposits Au veins Contact metasomatic ore deposit

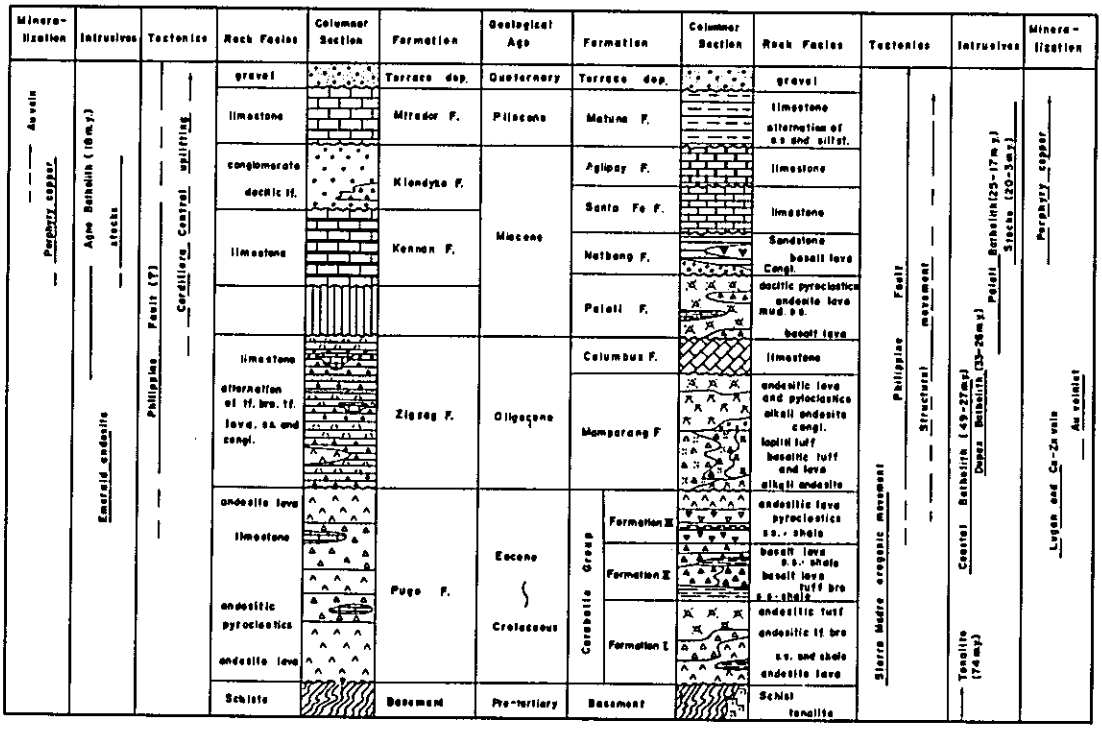
2. Geology

The project area consists of two areas; one is the main survey area which had been surveyed since the Phase I and the other, the Baguio area which was added for survey in Phase III.

The names of the formation in the main survey area had been followed those of the Phase I and in the Baguio area the PEÑA'S names were adopted in the Phase III report.

A generalized stratigraphic section in the whole survey area is shown in Table II-2.

Table II-2 Generalized stratigraphic section of project area



2-1 Stratigraphy

In the main survey area the formations are the Basement Complex, Caraballo Group, Mamparang Formation, Columbus Formation, Palali Formation, Natbang Formation, Santa Fe Formation, Aglipay Formation, Matuno Formation in an ascending order. In the Baguio area the formations are as follows: The Basement Complex, Pugo Formation, Zigzag Formation, Kennon Formation, Klondyke Formation and Mirador Formations in the same order.

2-1-1 Basement Complex

This Complex is widely exposed around Dingalan near the northern end of the survey area and a narrow distribution is recognized along the Agno River from the north of San Nicolas to the central part of the Baguio area.

Other small exposures are also found near Santa Fe, Kayapa and Putlan.

The rock facies are mainly of a weakly metamorphosed schists composed of quartz-plagioclase-augite-hornblende schist, quartz-plagioclase-garnet-hornblende schist, quartz-plagioclase-epidote-chlorite schist, and quartz-plagioclose-two mica schist indicating metamorphosed facies from green schist to the amphibolite.

The schistosity near the Eastern Coast trends NE-SW, but near the Philippine Fault NW-SW direction is prominent. In the Bagiuo area some are striking N10°W, dipping 50° - 60°W and others, N35°E with a dip of 60°W.

Small exposures of the Basement Complex are found at Minuli in the southern part of Santa Fe, and the Complex has been intruded by a fine grained tonalite.

By K-Ar dating, tonalite was determined to be 74 ± 12 m.y. It was, therefore, included in the Basement Complex.

No evidences of unconformity between the schists and the upper Caraballo Group were found. Also no fossils were discovered. Therefore, the formation age of the Complex is not clear. But the schists in the north of Santa Rosa were dated 82.6 ± 20.6 m.y. and 14.2 ± 2.2 m.y. by K-Ar method. The rocks in the northwest of Santa Fe were 31.7 ± 15.3 m.y. The results of the K-Ar dating are so deviated that it is difficult to determine the age of the rocks. Therefore, it was tentatively dated as Pre-Tertiary. The rocks in the Dingalan area are considered to be the Palaeozoic (GERVASIO, 1967)

2-1-2 Caraballo Group

The Caraballo Group is widely distributed in the survey area, mostly in the Caraballo Mountain, the Sierra Madre and the Cordillera Central. It is mainly composed of volcanic and pyroclastic rocks and accompanied by sedimentary rocks. The group can be divided into three formations: Formation I, Formation II and Formation III in an ascending order.

Formation I:

This formation is distributed in the east shoreline, the west of Baler, upstream of the Casignan River, the Bokod area. The rock facies are chiefly composed of dark green andesitic pyroclastic rocks and hyalloclastic andesite lavas with sandstone and shale beds, rarely well-bedded andestic lapilli tuff beds. The sequence of the group from the bottom is andesitic tuff bereccia, a small amount of andesite lava, well-bedded alternated beds of sandstone and shale and andesite lava.

Under the microscope, the andesite lava shows a glomeroporphyritic texture composed of phenocrysts of plagioclase > clinopyroxene > orthopyroxene. The groundmass is composed of plagioclase, opaque minerals and altered minerals such as actinolite, chlorite, epidote, sericete and calcite.

In the Bokod area, the group is distributed showing dome structure with a N-S elongation, as if it surrounded the Bobok body accompanied with the ore deposits. Andesite lava and andesitic lapilli tuff, tuff breccia are developed.

The group is in contact with the Basement Complex by a fault. The relation between the two is not certain, but it is considered to be an unconformity.

<u>Formation II:</u>

It is distributed from place to place, for instance, in the Sierra Madre, Caraballo Mountains and Cordillera Central. In the survey area it exists as a semi-circular basin structure opening toward north and this formation is mainly distributed inside the Formation I.

The rocks are composed mainly of dark green to dark gray basaltic lava, dolerite and basaltic tuff breccia accompanied with comparatively continuous alternative beds of siliceous shale and sandstone. In the basaltic lava a pillow structure and a hyaloclastic texture are recognized. Amygdals are also recognized. These facts indicate that the basalt lava lay in a shollow marine environment. Under the microscope, the basalt has an aphyric texture and a flow structure is highly developed. Chlorite and epidote occur in the groundmass of plagioclase, and clinopyroxene as altered minerals. In the amygdals prehnite, calcite and quartz are recognized.

The alternative beds of the siliseous shale and sandstones in this formation are widely developed in the Cordillera Central. In the Bokod area two alternative beds can be found. As these beds continue consistantly in the area, they are very important as the key bed.

This formation conformably overlies the Formation I.

Formation III:

The Formation III is most widely distributed around the Caraballo Mountains, on the west side of the Sierra Madre and on the southern edge of the Cordillera Central. In this survey area the Formation III occupies the wide area next to the Formation I.

The rocks consist mainly of dark green andesite lava and its tuff breccia including the alternative beds of sandstone, shale and tuff. The andesite lava and its tuff breccia have a strong resemblance to those of Formation I.

This formation shows an intrafolial fold near Santa Fe and composes the maximum submerged part of the anticlinorium in the Sierra Madre and the Caraballo Mountains. The Formation III of Phase I includes a part of the Formation II described above.

The formation, corresponding to the Caraballo Group, in the Baguio area is called the Pugo Formation and it is widely distributed in the northern and the southern parts of the area.

The rocks are mainly composed of greenish andesite lava intercalated with andesitic tuff brecia, siliceous shale, and limestone lenses.

HASHIMOTO (1975) reported fossils of Eocene in the limestone. The thickness of the formation is considered to be approximately 3,000 m.

2-1-3 Mamparang Formation

This formation is mainly distributed in the Mamparang Mountains and in the upper stream of the Cagayan River. Most of the Kasibu area, the area of the Phase III survey, is occupied by this formation.

In the Baguio area, the formation is called the Zigzag Formation occupying the western as well as the northern part of the area.

The formation is composed of greenish gray to dark green andesite lava, andesitic tuff breccia, alkali andesite lava, basalt lava, and basaltic tuff with a small amount of dacitic volcanic rocks, mudstone, tuff and limestone.

In the upper stream of the Cagayan River, this formation conformably overlies the Caraballo Group and its sequence of andesite lava, basaltic tuff, basalt lava, andesite lava and calcareous mudstone with limestone breccia is continuously observed.

In the Kasibu area, white to yellowish white lapilli tuff and tuff are developed and thick alkali andesite lava, andesitic tuff breccia, and tuff are superimposed on the top. The narrow limestone lenses with larger foraminiferas are intercalated in the alkali andesite lava, the age was decided to be Oligocene.

A part of the alkali andesite lava is basaltic and under the microscope phenocrysts of plagioclase occur in a matrix of plagioclase, clinopyroxene, K-feldspar and/or biotite.

The formation in the upper stream of the Cagayan River has generally a strike of NE-SW with a dip of 10° - 20°N. In the Kasibu area the strike is approximately N-S and dips gently (about 20°) forming a folding structure.

The formation overlies unconformably the Caraballo Group. The thickness is about 4,000 m.

The Zigzag Formation in the Baguio area is composed of the light green lapilli tuff, tuff breccia, sandstones and andesite lava with limestone, which is dark gray and looks like a diatreme.

The limestone formation is considered to corresponds to the Sagada Limestone (HASHIMOTO (1975)) and the age is believed to be Oligocene.

2-1-4 Columbus Formation

This formation was included in the uppermost formation of the Mamparang Formation in Phase I, but by the Phase II Survey it has been separated from the Mamparang Formation as the Columbus Formation.

It is distributed in the upper stream of the Columbus River, a branch of the Agno River, and in the upper stream of the Cagayan River, and consists of pure white to bluish white color massive or partly brecciated limestone. From the large foraminifera found in the limestone, this formation is considered to be upper Oligocene. The thickness of the formation is about 300 m.

2-4-5 Palali Formation

In Phase I, the Palali formation was thought as a part of the Santa Fe Formation, but it was separated and named after the type locality, Palali Mountain, by the Phase II survey.

It is distributed in the west of the Palali Mountain, around the Santa Fe and in the southern part of the survey area.

The rocks are mainly composed of greenish dacitic tuff breccia, docite lava accompanied with andesite lava, andesitic tuff breccia, basaltic lava, mudstone, sandstones and welded tuff.

In the tuff breccia distributed around the Mt. Palali the pebbles of syenite and syenite porphyry are included and in the tuff breccia near the Santa Fe, the breccias of the same quartz diorite as the Dupax botholith are also included.

As andesitic to dacitic welded tuff are generally accompanied, the sedimentary environment of this formation is suggested to be marine and terrestrial.

The dacitic welded tuff microscopically shows a eutaxitic texture of glassy tuff. Phenocrysts are composed of plagioclase, quartz and hornblende. A large amount of lithic fragments of pyroxene andesite and quartz porphyry are contained.

The Palali formation, including the lower formation breccias, unconformably overlies the Caraballo Group, the Dupax batholith and the Mamparang Formation in the Palali Mountain and around Santa Fe.

The outcrop of conglomerate including limestone breccia was discovered by the Phase II Survey in the Bolo River, a branch of the

Agno River. As the fossils in the limestone indicate lower Miocene, a part of the Caraballo Group in the Bakod area was considered to correspond to the Mamparang Formation. But the Phase III check survey has concluded that the limstone is possibly a boulder. And the formation was corrected to the Caraballo Group.

The formation age was revealed to be 17 m.y. by K-Ar dating on the dacitic welded tuff distributed near Santa Fe indicating lower to middle Miocene. The thickness of the formation is approx. 300 m.

In the Baguio area the corresponding formation is called the Kennon Formation which is composed of white to whitish gray limestone. From the fossils in the limestone, it is considered to be lower to middle Miocene. The thickness of the formation is about 150 m.

2-1-6 Natbang Formation

The formation is distributed in Natbang, west of Bayombong, and mainly composed of conglamerate with alternative beds of sandstones and mudstones. Thin layers of basaltic lava are partly intercalated.

As the formation is in contact with other formations by a fault, the stratigraphic relation is not certain. But it is covered by the Santa Fe Formation unconformably, so that is is considered to be lower to middle Miocene. Generally the strike trends N-S dipping steeply to the north. The formation was included in the Santa Fe Formation in Phase I.

2-1-7 Santa Fe Formation

The formation is distributed in the east of the Natbang and along the road from Santa Fe to Dalton Pass. The rocks are white to light pinkish gray limeston and its thiskness is about 300 m. The larger foraminifera in this formation was identified as lower to middle Miocene.

The formation unconformably overlies the Natbang Formation (in Natbang) and the Palali Formation (around Santa Fe).

It actually corresponds to the Klondyke Formation of upper Miocene in the Baguio area. The Klondike Formation is mainly composed of conglomerate partly intercalated with sandstones and dacitic tuff breccia. The conglomerate sometimes contains pebbles of the Agno batholith, quartz diorite porphyry, and rarely sulphide. The thickness of the formation is about 800 m.

2-1-8 Aglipay Formation

The formation is a light pink limestone exposed near Aglipay located in the lower stream of the Addalam River. It also covers the Caraballo Group unconformably.

As the formation is found only in Aglipay and two other small areas north of Aglipay. The relation with the other formations are unknown.

From the large foraminifera, the age is middle Miocene.

2-1-9 Matuno Formation

This formation includes the Maddela Formation and Pantabangan Formation of the Phase I. It covers a wide area from Maddela in the mid-stream of the Cagayan River to Tauayan in the upper stream of the same river and the northeast area of San Jose.

The rocks are composed of yellowish brown to gray alternation of sandstone and mudstone.

The formation deposited in the sedimentary basin with a long axis trending NS, covering the lower formations unconformably and formed a synclinal structure dipping 10-20°N. The age is not certain as no fossils are found, but lithologically, it seems to corresponds to the Rosario Formation of CORBY and it is considered to be Pliocene.

In the Baguio area, the Mirador Formation considered to correspond to the formation and it is composed of gray well-bedded limestone, which is Pliocene according to HASHIMOTO (1975).

2-2 Intrusive Rocks

Many kinds of intrusive rocks can be found in the survey area; such as ultrabasic rocks, granitic – dioritic batholith, and alkali batholith. The main intrusive rocks will be described in this section.

2-2-1 Ultrabasic rocks

These rocks are distributed in the mountain region facing the Philippine Sea, south of Baler. Along the eastern shore line in the Northeastern Luzon, exists a large structural line, along which large-scaled ultrabasic rocks have intruded. The rocks near Baler are considered to be the southern extension of the intrusive body.

The rocks are mainly composed of pyroxenite intruded by small dikes of peridotite from place to place. Both of them are greenish gray compact rocks. Under the microscope, the pyroxene has subhedral-granular texture. A large amount of clinopyroxene (diopside) are filled up by interstitial olivine. As the accessary minerals a small amount of serpentine and calcite are recognized.

From the aerial photographs interpretation these rocks are in contact with the Basement Complex by thrust faults.

2-2-2 Plutonic Rocks

The rocks consists of granitic, dioritic and alkaline; rocks and have built large scale frames of geological units, such as, the Caraballo, the Mamparang Mountains and the Cordillera Central, forming large-scale batholiths. Namely, the Coastal batholith distributed from the Sierra Madre to the Caraballo Mountains, the Dupax batholith composing the northern part of the Caraballo Mountains, the Palali batholith forming the Mamparang Mountains and the Agno batholith composing the Cordillera Central.

(1) Coastal Batholith

The batholith is distributed along the eastern coast from northwest of Casiguran to Baler and in the mountains from Baler to Pantabangan forming a part of the Caraballo Mountains.

The rocks are mainly composed of tonalite, quartz diorite and diorite accompanied by gabbro.

The tonalite and dioritic rocks are chiefly distributed in different areas. North of Dinajawan is mainly dioritic rocks and the tonalite are predominant in the southern part.

The tonalite is a biotite-hornblende tonalite. There are two kinds, such as leucocratic, homogeneous, coarse-grained and hypidiomorphic, medium-grained.

Quartz diorite-diorite rocks consist of quartz diorite which is dark greenish gray, coarse-to medium-grained and comparatively equi-granular in size of plagioclose and quartz and diorite which is dark greenish gray, fine-to medium-grained with scattered coarse-grained quartz.

The gabbro is light green to dark greenish gray and fine to medium-grained. It characteristically contains prismatic plagioclase, coarse-grained idiomorphic pyroxene. There are quartz gabbro containing quartz and gabbro without quartz.

The age of the batholith by the K-Ar dating is considered to be 27 - 49 m.y. which is Eocene-Oligocene.

(2) Dupax Batholith

It is distributed from near Burgos to Aritao, northwest of Dupax. It is composed of tonalite, diorite and quarz diorite with/without gabbro like the Coastal batholith.

There are no district differences between the Dupax and the Coastal batholiths except the former is somewhat fine-grained.

The igneous activities of the batholith took place approx. 26 - 33 m.y. ago or in the Oligocene age. It is somewhat later than, but from the lithology, both batholiths are considered to be formed by the same plutonism.

(3) Palali Batholith

It has intruded up to the Palali Formation, forming a trapezoidal topography in the west of Bayombong.

The rocks are composed of syenite, monzonite with a small amount of alkali feldspar syenite.

The syenite are gray — light pinkish gray, medium- to coarse-grained and uniform. Microscopically, a poikilitic texture with idiomorphic K-feldspar is observed.

Most part of the plagioclases are altered to zeolite, sericite, calcite and chlorite.

Small rock bodies of alkali plutonics with similar facies occur around the Palali batholith and some of them have intruded into the Dupax batholith.

Some K-Ar datings indicate 17-25 m.y. The period of the intrusion is, therefore, considered to be later than that of the Dupax batholith, that is, upper Oligocene to lower Miocene.

(4) Agno Batholith

This is a large body intruded along the Agno River in the middle to the southern part of the Baguio area, extending towrards to the North. It consists of quartz diorite and quartz gabbro.

The quartz diorite is biotite-pyroxene quartz diorite and some have chemical compositions to be classified into tonalite group.

Under the microscope, abundant medium to fine grained idiomorphic plagioclase and pyroxene phenocrysts occur in a holocrystalline matrix.

The quartz gabbro is classified into two types, namely, pyroxene-quartz gabbro and biotite-pyroxene-quartz gabbro, but gabbro with biotite is very limited. These rocks are distributed in the northern part of the batholith.

The intrusion period of the quartz diorite indicated 18 m.y. by K-Ar dating. Among the batholiths distributed in the survey area, this batholith is the youngest and shows lower to middle Miocene age.

This batholith has a very close relation to the ore deposits in the Baguio area.

2-2-3 Plutonic-Hypabyssal Rocks in a Stock Form

The rocks of this group are composed of tonalite, quartz diorite, diorite, gabbro, quartz diorite porphyry, diorite porphyry and alkali plutonic to hypabyssal rocks.

The group is distributed along the Santa Fe Fault trending NNW-SSE and passing through near Santa Fe, in the northern part of the Dupax batholith, in the Mamparang Mountains, in the Bokod area and also around the Agno batholith.

(1) Vicinity of Santa Fe Fault

The stocks intruded along the Santa Fe Fault in an elongated shape are composed of tonalite, basic diorite and gabbro.

The tonalite is greenish gray, medium grained and chloritized hornblende and plagioclase are remarkable.

Under the microscope the altered minerals of sericite, epidote and calcite are recognized. The small amount of biotite included are completely chloritized.

The diorite is dark greenish gray and fine-to medium-grained and shows a porphyritic texture of plagioclase and hornblende.

Under the microscope, a large amount of idiomorphic plagioclase and hornblende are observed. They are intensely chloritized and sericitized.

As to the age the intruded stocks located along the Santa Fe Fault, more reasonable to consider to occur in Oligocene when the fault movement of this system took place.

(2) Northern Part of Dupax

The stocks are diorite, diorite porphyry and monzonite found near the Mapayao Creek, branch of the Santa Cruz River and the southern part of Pingkian. They are also exposed in the Salinas area of the Phase III.

The diorite is composed of hornblende diorite porphyry and diorite. Both of them have two types each, fine- or coarse-grained.

The diorite porphyry is hornblende diorite porphyry with few quartz and under the microscope, a large amount of idiomorphic plagioclase and hornblende can be recognized, and some crystals of K-feldspar are also found in the groundmass.

The altered minerals are chlorite, sericite and epidote. This diorite porphyry is accompanied by the San Fabian ore deposition.

The monzonite consists of monzonite and monzonite porphyry.

Even with the naked eye K-feldspar, hornblend and biotite are recognizable. Under the microscope, the idiomorphic plagioclase, hornblende and pyroxene and hypidiomorphic K-feldspar are found.

The period of the intrusion is dated by K-Ar as 20.6 ± 1.1 m.y. on diorite porphyry and 23.2 ± 1.2 m.y. on monzonite, both of which correspond to lower Miocene.

(3) Bokod Area

The stocks are quartz diorite porphyry found near Bobok south of the Bokod. The largest stock in Phase III was called the Bobok body, which extends 7 km in N-S direction and 2.5 km in E-W direction.

The stock is composed of quartz diorite porphyry type I with a large amount of quartz phenocrysts, quartz diorite porphyry type II with few or no quartz phenocrysts and dacite dykes.

It is accompanied with the porphyry copper deposit, which is under exploration by BCI.

The period of the intrusion is estimated at 3 - 6 m.y. or upper Miocene, but it may be indicating a younger period of rejuvenation caused by alteration accompanied with the mineralization.

(4) Surroundings of the Agno Batholith

Many stocks of quartz diorite porphyry with various sizes are found in the surrounding area of the Agno batholith.

They are mostly composed of biotite-horblende diorite porphyry with distinct chloritization and sericitization.

Lithologically, the rock is very similar to the quartz diorite porphyry type II. Some of the stocks have accompanied a porphyry copper deposits which are mining now. They have also formed the metasomatic ore deposits by their intrusion into the limestone. Moreover, they are closely related with the formation of many gold-silver vein deposits.

The period of intrusion is not certain as no dating information is available, but it is lithologically estimated the same age as the Bobok body which is in upper Miocene.

2-2-4 Volcanic Rocks

The intrusive volcanic rocks of andesite, dacite and dolerite are found at various places as dykes, but the scale of the dykes is very small.

2-3 Chemical Composition of the Plutonic Rocks

Many samples were taken from the batholiths and plutonic to hypabyssal stocks distributed in the survey areas. 5 samples in Phase I. 40 samples in Phase II and 9 samples in Phase III with a total of 54 samples were collected in order to study the chemical conpositions of the plutonic rocks. The results of the analysis are shown in the Table A-2.

The analytical results on the whole rock samples are plotted in SiO_2 - (K_2O + Na_2O) diagram as shown in the Fig. II-1. It is clear from the diagram that the Palali batholith and the plutonic rocks in its surrounding area (includes the Kasibu area of the Phase III survey) belong to the alkali rock series.

The Agno batholith as well as the Coastal and the Dupax batholiths.

The analytical results excluding alkali rocks' data plotted in the AFM diagram are shown in Fig. II-2. It is evident from this figure that the Agno batholith is more alkalic than the Coastal or the Dupax batholith and that the Bobok body is much alkalic, suggesting it is produced in a later stage of magmatic differentiation.

Fig. II-3 is an Or-Ab-An diagram on all samples, indicating that the Agno batholith has the same feature as other acidic batholiths. What is obvious on comparing this figure with the Or-Ab-An diagram Fig. II-4 on the plutonics in each petrographic province in Japan, is that all batholiths in the survey area are of few Or type and the stocks in the Cordillera Central have similar compositions to those of granitic rocks in Green tuff region in Japan.

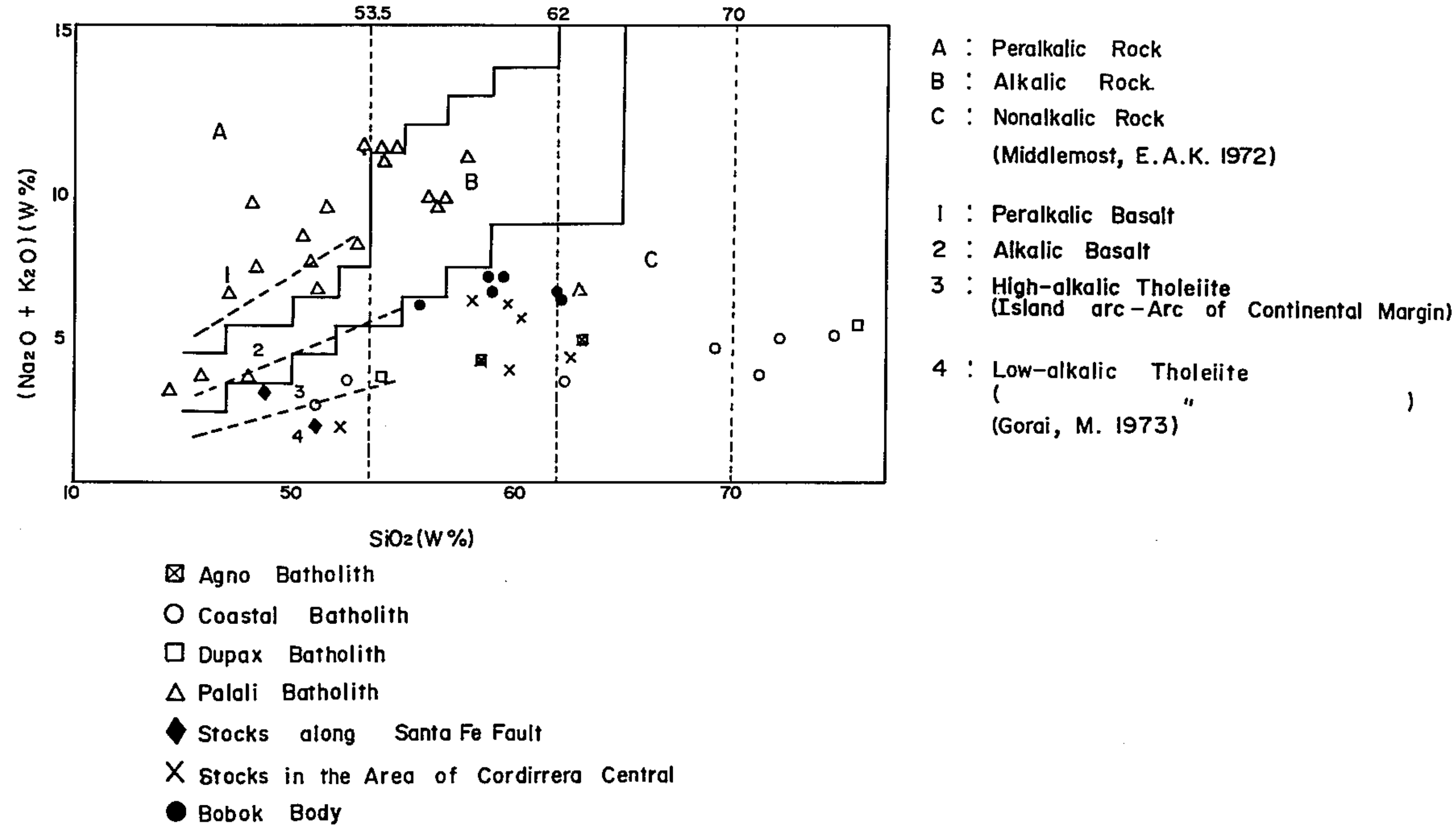


Fig. II-1 SiO2 - (K2O + Na2O) diagram

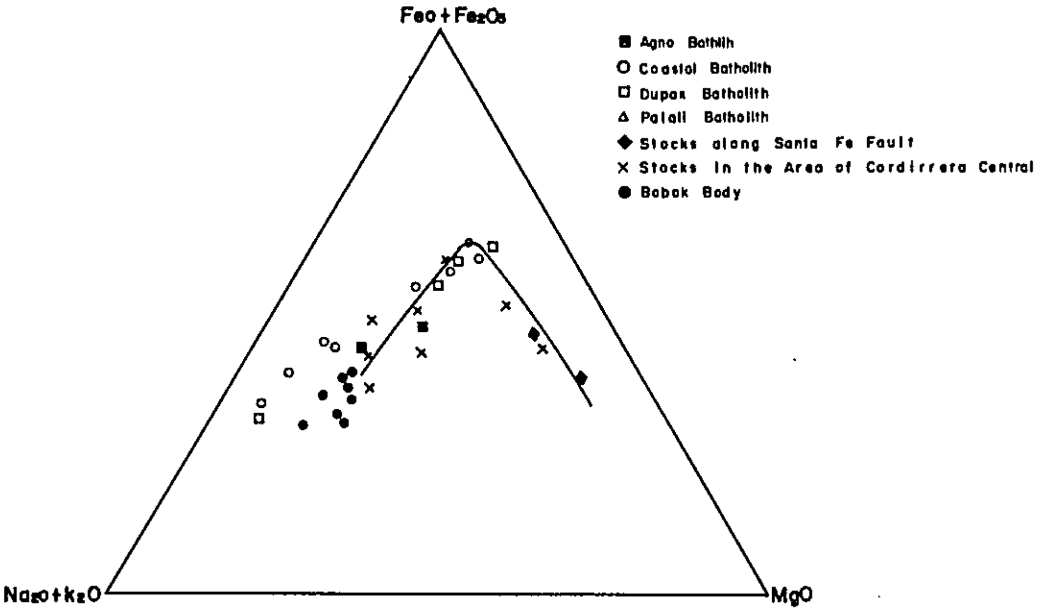


Fig. II-2 A.F.M. diagram of granitic rocks

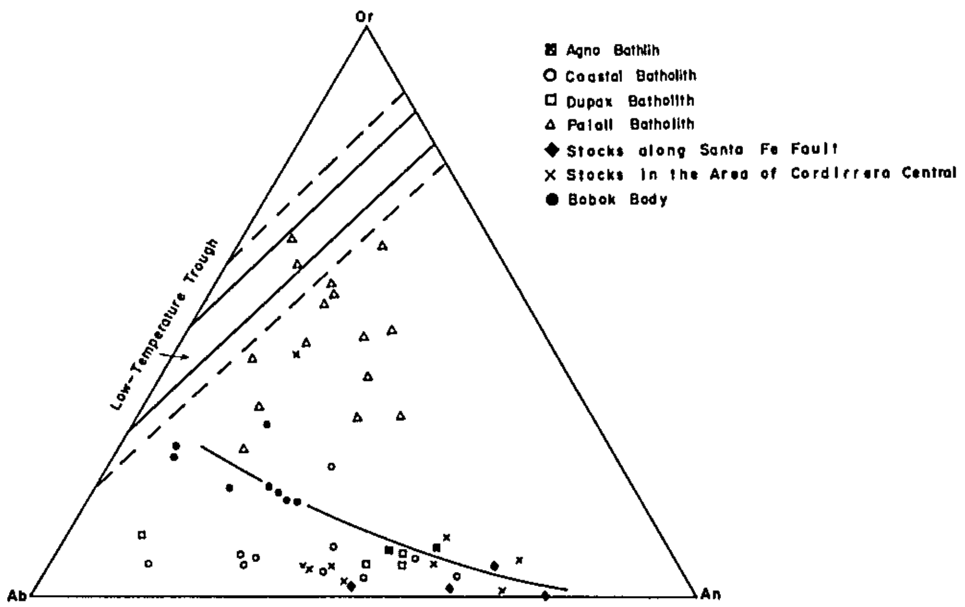


Fig. II-3 Or-Ab-An diagram of granitic rocks

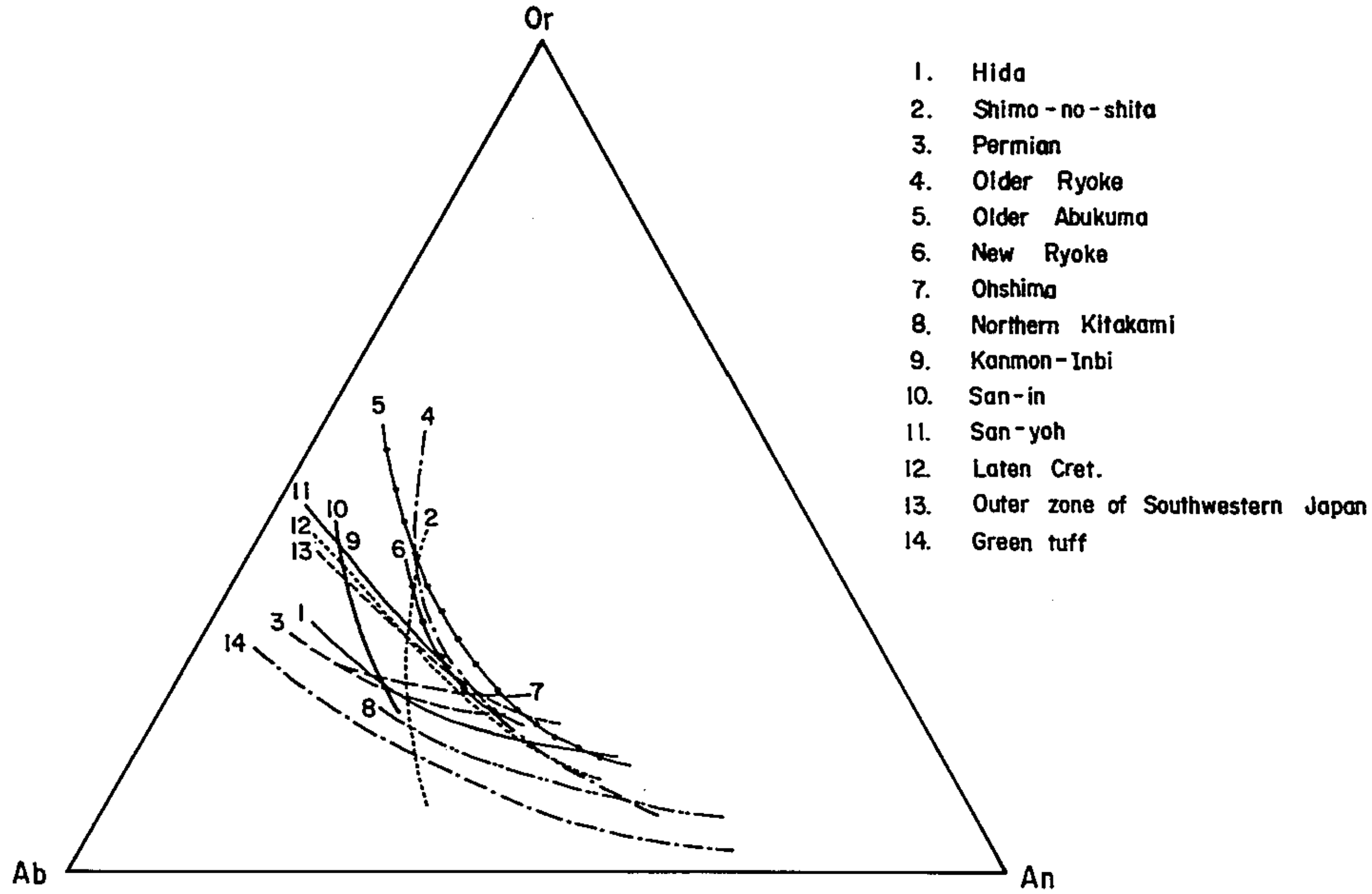


Fig. II–4 Or–Ab–An diagram for each Japanese plutonic province (SHIBATA, 1961)

2-4 Geological Structure

The geological structure of the survey area may be classified into three zones; (1) Sierra Madre-Caraballo Mountain uplifted zone (old uplifted zone) of older age represented by intrusion of the Coastal and the Dupax batholiths, (2) the Cagayan subsided zone where the thick sedimentary formations are distributed in the north central part of the survey area, and (3) the Cordillera Central uplifted zone of newer age (new uplifted zone) represented by the Agno batholith intrusion.

The above structural subdivisions have been formed by subsidence of the two plates located on the east and west sides of the Northern Luzon. It is considered that the east plate subsidence began ahead of the west.

The structural line in the survey area are the Philippine Fault running near the southern boundary of the area in the NW-SE direction and its large branch-off faults (considered to be a part of the Philippine Fault) running in the NNW-SSE $\sim$ N-S direction and the NE-SW fault.

The Philippine Fault borders the Central Plain from the Caraballo Mountains. But no exposures could be found by the geological survey, so that the visible observation was not possible, but it is recognized by the interpretations of aerial photographs and of the ARTS image. This fault has been moving continuously until the Recent.

The faults of NNW-SSW system are most prominent in the west of the main survey area and in the Baguio area, They are also found in the central part of the area.

The main faults in this system are the Agno River, Santa Rosa, Santa Fe and the Palali Faults. Each fault is a gravity fault with a displacement of 1000 - 2000 m down eastward. The plutonic stocks are intruded along Santa Fe Fault.

The faults of NE-SW system are distributed widely in the survey area, especially, in the southern part of the Baguio area, the Bokod area, the Mamparang Mountains, and in the East Coast.

Some older faults of this system have stimulated the Coastal batholith to intrude, but other faults near the Agno batholith and its surroundings have cut accross the Agno batholith and the Bobok body is also cut by the same system. Therefore, the fault movements are considered to have been for a long time:

The EW fault system and the NNE-SSW fault system are found locally, but the scales are not large. The folding structures having axes of NE-SW, NNN-SSE and NNE-SSW (or N-S) directions are most prominent.

The NE-SW folding structure is developed in the Caraballo Group with an axis length of 20 - 40 km and a wave length of 15 - 20 km. In the Sierra Madre the axes gradually plunge northeastward forming an anticlinorium. In the Cordillera Central the folding axes plunge towards the southwest.

The NNW-SSW system folding structures are found in and around the Mamparang Mountains with an axis length of less than 10 km and a wave length of about 5 km. The NNE-SSW (N-S) system structures are generally found in limited areas, such as the Bokod, the Salinas, the northern part of the survey area where the Palali Formation is distributed, and the Baguio areas.

The geological structure in the Bokod area shows an anticlinal form and the Bobok body has been intruded along the axis. The structure in the Salinas area is a small scale anticline with a N-S axis.

The one in the Baguio area is a large scale anticlinal structure with an axis of close to NNW-SSW direction and the Agno batholith has intruded along the axis.

The anticlinal structures in the Baguio-Bokod-Salinas area are as a whole composing a large scale anticlinorium.

2-5 Geotectonic History (cf. Fig. II-5)

In the Stage I, the metamorphic rocks and the tonalite of the upper Cretaceous, which are considered to be the present basement complex, are distributed in the whole survey area.

On the basement complex, the volcanic and pyroclastic rocks of the Caraballo Group were deposited under marine environment in the last stage of Cretaceous to Eocene time (Stage II-IV).

The Caraballo Group has been affected by a regional metamorphism of low temperature which was accompanied by the tectonic movement of forming the anticlinorium in the Sierra Madre.

The Coastal batholith intruded into the anticline in the synclinorium and later on followed by the Dupax batholith intrusion.

The sedimentation of the Caraballo Group over 5000 m thick, the formation of synclinorium and the intrusion of batholiths can be considered to be part of the orogenic movement, which is tentatively named the Sierra Madre Orogenesis (Stage V).

After the Sierra Madre Orogenesis, a large scale fault movement trending NNW-SSE, considered to be the branch-off of the Philippine Fault, took place and a collapse zone was produced in the Mamparang area. Afterward, the Mamparang Formation was accumulated and the Palali batholith composed of alkali plutonics, intruded. (Stage VI)

After the Palali batholith intrusion, the Agno batholith intruded into the anticlinal structure, which had been formed in the Baguio area and followed by the later stage magmatic differentiation which formed stocks of the Bobok body and other porphyries (State VII).

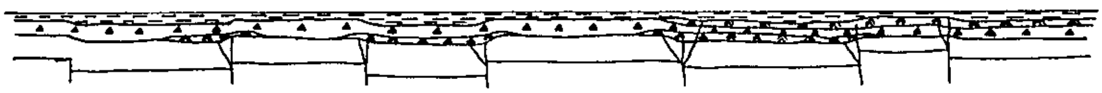
After the upper Miocene, sedimentary basins were formed for normal sediments. Especially, the sedimentary basin of the Matsuno Formation extended to the Cagayan Valley which is parallel to the Luzon Island Arc.

Stage VII Intrusion of Agno Batholith

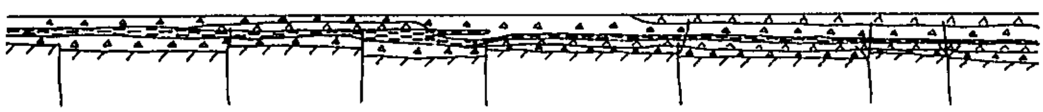
Stage VI Deeper fracturing and Alkalic plutonism

Stage V Final stage of Sierra Modre movement
(Emplacement of Coastal and Dupax Batholith)

Stage IV Caraballo G. III.F.



Stage III Caraballo G. II.F.



Stage II Outbreagking stage of Sierra Madre movement
(Caraballo G. I.F.)

Stage I After Older tectonic movement of Pretertiary

Fig. II-5 Geotectonic history

Table II-3 Summary of Bobok mineralized zones

	Bolo	North Oding (Que Sera)	South Oding	Remarks
Horizontal scale of mineralized zone	E-W N-S 2 km x 1.7 km	E-W N-S 2.5 km x 1.6 km	1 km in diameter	
Host rock	q-dio-porp II > q-dio-porp I	q-dio-porp II > q-dio-porp I	q-dio-porp I	
Occurrence of primary minerals	diss, stockwork mainly stockwork	mainly diss. partially stockwork	diss, stockwork	
Primary ore mineral	Py, Mag, Mgh, Cp, Hem, Bor, Moly	Py, Cp, Mag, Hem, Bor, Moly	Py, Mag, Cp, Hem	
Secondary mineral Gangue mineral	Mal, (Azu), (Cov) Q, Cal, (clay), (Gy)	Mal, (Azu), (Cov) Q, Cal	Mal, (Azu) Q, Cal, (clay), (Gy)	only on outcrop
Mineral sequence	(1) Py·Mag (Mgh) → (2) Py·(Cp) → (3) Cp·Moly·Bor·Q	(1) Py·Mag → (2) (Py) Cp → (3) (Cp)·Moly·Bor	(1) Py·Mag → (2) Py·(Cp)·(Mo) → (3) (Cp)·(Moly)·(Bor)	sometimes overlapping
Zoning of ore mineral (From center)	invisible	(Bor)·(Mo)·Cpy → Cp·Py → Py·Mag (?)	invisible	
Controlling of mineralization lithologic structural	 edge of host rock NE-SW > N-S fracture	 E-W > NE-SW fracture?	 NW-SE > NE-SW > E-W fracture	
Zoning of alteration mineral (From center)	(1) Sil·Ser·Chl → (2) Ser·Chl·(Agl) → (3) Chl·Cal·Agl → Chl·Epi	(1) Sil,Ser·(Bio)·Chl → (2) Ser·Chl·(Agl) → (3) Chl·Cal·Agl → (4) Chl·Epi	(1) (Sil·Ser·Chl) → (2) Ser·Chl·(Agl) → (3) Chl·Cal·Agl → (4) Chl·Epi	
Expansion of mineralized zone for depth	Shallow in Cp and Py Gy predominant in deeper part	very deep in Cp and Py	shallow in Cp deep in Py	based on the result of drilling exploration of phase III and BCI

Abbreviation :

q-dio-porp I : quartz diorite porphyry type I
q-dio-porp II : quartz diorite porphyry type II
diss : dissemination
Py : pyrite
Mag : Magnetite
Mgh : maghemite
Moly: molybdenite
Cp : chalcopyrite
Hem : hematite
Bor : bornite
Mal : malachite
Azu : azurite
Cov : covellite
Sil : silicification
Ser : sericitization
Bio : secondary biotite
Chl : chloritization
Agl : argillization
Cal : calcite
Epi : epidotization

3. Ore Deposit

The survey conducted for the last three years recognized many ore deposits and mineral showings in the project are including the porphyry copper deposits under prospects by the private companies.

In the Baguio area, where the additional survey was conducted in Phase III, many porphyry copper deposits, including vein type gold deposits, contact metasomatic deposit and others are distributed composing a large metallogenic province.

The outline and discussion on the main mineralized zones of the main survey area and the Baguio area will be given below separately.

3-1 Main Survey Area

3-1-1 Bobok Mineralized Zone

The mineralized zone is located in the south of Bokod, 25 km east of Baguio City. This zone corresponds to the Bolo River mineralized zone of the Phase I and also to the mineralized zones along the Bolo River and the Bobok of the Phase II.

The mineralized zone is a porphyry copper type occurring in the Bobok body which has intruded into the Caraballo Groups Formation I and II. It can be divided into the Bolo, the North Oding and the South Oding mineralized zones. But both the North and South Oding mineralized zones have been clarified to join together at depth by the geophysical survey.

The summary of these three mineralized zones are shown in Table II-3.

The Bolo mineralized zone is mainly distributed along the Bolo River and its southern branches. Pyrite is predominant at the outcrop and accompanied secondary malachite, covellite and azurite, but chalcopyrite is few.

Samples taken from many outcrop have low copper content and there were only 3 samples out of 19 exceeding 0.4% Cu.

The occurrence of primary minerals in the mineralized zone is mainly dissemination. But veinlets of quartz, and calcite accompanied chalcopyrite, molybdenite and bornite can also be seen. They are strongly controlled by the main structure. Strong IP and Cu anomalies have been detected in this zone by the geophysical and the geochemical soil surveys. And a diamond core drilling exploration of 350 m (PJ-1) was conducted at the mid-stream of the Maidit Creek. A mineralized zone containing chalcopyrite was recognized in the shallow zone. But after 56 m the veinlets of gypsum developed and the mineralization becomes weak toward depth.

The North Oding mineralized zone is distributed widely along the North Oding Creek and the Que Sera ore body (ore reserve 178 million t, Cu: 0.393%) is located in the central part of the zone where BCI is conducting a drifting exploration.

The occurrence of outcrops is the same as that of the Bolo and only 1 sample out of 6 collected at the outcrops indicates over 0.4% Cu. Four samples out of 6 collected from the ore stockpiles at the Que Sera adit give over 0.4% Cu. The better part of fine-grained chalcopyrite and pyrite dissemination shows 1.58% Cu.

In the Bolo mineralized zone quartz and calcite veinlets developed, but only minute veins of quartz are found in the outcrop and the underground in this zone and copper minerals are concentrated in the disseminated zone. In this mineralized zone BCI has completed the drilling exploration over 40 holes in a grid system, and it has been proven that the high grade copper zone continues down to 1000 m below the surface.

The South Oding mineralized zone is distributed along the middle to upper stream of the South Oding Creek. The mineralizations observed in the outcrops and other showings are very similar to the Bolo mineralized zone. Regarding the copper values of the outcrop, only one sample out of the 14 collected from the outcrops show 1.02% Cu and the rests are less than 0.2% Cu.

The veinlets of quartz and calcite are developed like those of the Bolo mineralized zone and are strongly controlled by the surrounding structures.

In this mineralization zone a hole of 350 m (PJ-2) was drilled on the ridge near the boundary of the North Oding mineralized zone and another drill hole with 350 m depth (PJ-3), at the South Oding Creek.

In PJ-2 drill hole, the mineralization of mainly pyrite continues to the bottom of the hole. The copper value above 0.4% can be seen only between 86.90 - 88.70 m. In the PJ-3 drill hole no parts of the hole indicate over 0.4% Cu. Gypsum veinlets developed below 187 m depth. And the mineralization is clearly weakening towards depth.

As described above, the Bobok mineralized zone may be summarized as follows, based on the results of geological, geochemical and geophysical surveys and drilling exploration.

The Bobok porphyry copper depost is a disseminated - network ore deposit in the quartz diorite porphyry intruded in the upper Miocene time. It can be divided into two mineralized zone, namely. the Bolo and the Oding. Between the two, the Oding mineralized zone is better and contains the Que Sera ore body with high grade Cu.

The Que Sera ore body is mainly composed of disseminated chalcopyrite and pyrite accompanied partly with minute veins of quartz. The main primary minerals are chalcopyrite, pyrite and magnetite with minor amounts of molybdenite, bornite and hematite. These primary minerals can be traced down to the depth in the Que Sera ore body. Whereas, they are limited in comparatively shallow depth in the Bolo mineralized zone. These differences on the mineralization between the Bolo and the Que Sera may be regarded that the Bolo mineralized zone is located on the outer rims of the Bobok body, and among the quartz diorite porphyry as host rock, the type II (which is more closely related to the mineralization) is in a smaller scale than in the Oding and that the gypsum zone is well developed.

Regarding the mineralization, the structural control is clear and agree with the prominent structure developed around the mineralized area. The control of outer fringes of the body is also clearly seen and the mineralization in the rocks intruded deteriorates rapidly, which is evident from the geophysical survey results.

The alterations accompanied by the mineralization including the hypogene alteration are basically, divided into four types. But the main alterations are silicification, sericitization and chloritization. The first two are closely related to the mineralization. The secondary biotite tends to occur more abundantly in the strongly mineralized area, but closer relations can not be recognized.

The porphyry copper deposit is accompanied by the Bobok body, which, will be described later, is the product of a later stage magmatic differentiation of the Agno batholith. From this reason it has very close genetic relationship with the Agno batholith.

3-1-2 Benneng Mineralized Zone

This zone is located in the upper stream of the Benneng River, a branch of the Agno, south of the Bobok mineralized zone. It extends along the main stream of the Benneng River and its branch stream covering an area of approx. 1.5 km in the E-W and about 1.0 km in the N-S direction. It consists of dotted pyrite disseminations. The host rocks are basaltic rocks of the Caraballo Group Formation II and dacite dykes. Many dacite dykes are recognized in the Bobok body, and they are observed as post-mineralization dykes. Therefore, the Benneng was formed after the Bobok mineralization.

The pyrite is the only ore mineral and no other copper minerals are found except a very small amount of malachite. The host rock alteration is so weak that the mineralization seems to be locally limited.

3-1-3 Benneng River Mineralized Zone

This mineralized zone was discovered by the Phase I survey and is located in the lower stream of the Benning River. This area is composed of basaltic pyroclastics and lavas of the Caraballo Group and intruded micro-diorite stocks. Quartz veinlets (about 5 cm in width) containing fine grains of chalcopyrite, sphalerite and pyrite are observed at the contact between the stocks and the Group. This area is intensively silicified with a width of approximately 700 m accompanied by pyrite dissemination. In the lower stream of the zone, quartz veins with epidote and clay are found and chalcopyrite disseminations with 0.10% Cu and 5.20% S are also observed at places but generally, the host rock is fresh and the mineralization is weak.

3-1-4 San Fabian Ore Deposit

The ore deposit is situated at approximatly 15 km west of Bambang along the National Road No. 5, and also at the mouth of the Mapayao Creek, a branch of the Santa Cruz River. The ore deposit is a porphyry copper deposit formed in the diorite porphyry stocks intruding the basaltic rocks of the Caraballo Group Formation II.

The Philex Mining Corp. has prospected the property, and it is said that the ore reserves amount to 8 million tons of 0.4% Cu, though an oral communication. All exploration instruments have been removed and only the portal and waste materials are found.

The topography around the ore deposit is a gently sloping hill, therefore, the outcrop exposures are poor, but along the prospecting roads mineralized outcrops are found from place to place. Judging from these occurrences, the mineralized area seems to be limited within 400 m diameter circle.

The ore minerals in the outcrops are mainly malachite with very small amount of pyrite and chalcopyrite. The ore stockpile, which seems to come from the underground, contain considerable amount of sulphide minerals, which are mainly the primary minerals.

The occurrence of the minerals is mainly in a disseminated form. But the micro-fractures and joints are developed in the NE-SW to E-W directions filled mainly with filmy veins.

The remarkable alterations accompaning the mineralization are silicification and argillization, and sometimes it is very difficult to recognize the orginal rock.

The samples collected at the outcrops contain malachite and covellite. The average values of five samples give 0.73% Cu and 0.1% S, indicating that the copper minerals are mainly oxides with few, sulfide minerals.

The geochemical survey in Phase III detected many intensive anomalies extending in the NE-SW direction with an area of approximately 1300 x 1300 m near the ore deposit as well as along the north side of the Mapayao Creek. No diorite porphyry distribution is recognized on the north side but quartz and calcite veinlets are found in the basaltic rocks. The veinlets may have caused the anomalies.

The age of diorite porphyry, accompanying the ore deposit is indicated to be 20.6 ± 1.1 m.y. by K-Ar dating conducted in Phase II, indicating lower Miocene.

3-1-5 Salinas Area No. I Disseminated Zone

The zone is located in the upper stream of the above-mentioned Mapayao Creek, corresponding to the Mapayao River mineralized zone of the Phase I survey. This zone consists of many disseminated areas distributed in an area of approximately 600 m x 300 m located along the Mapayao Creek and its branches.

The rocks in the area is composed of the sedimentary rocks of the Caraballo Group Formation II, diorite porphyry stocks, altered andesite dykes and diorite stocks. The mineralization occurs mainly in the diorite porphyry.

The ore minerals consist of pyrite, malachite, bornite and magnetite. The better portion gives 0.6 g/t Au, 0.64% Cu and 0.5% S, indicating that the copper comes from copper oxide minerals. A copper geochemical anomaly the same as the San Fabian is obtained near the mineralized zone.

Other mineralized zones, No. II - No. IV, are located, in the Salinas area, all of which contain mainly pyrite and the values of mineralizations are very weak compared to No. I.

3-1-6 Lugan Ore Deposit

The ore deposit is situated in the Lugan Creek, a tributary of the Kion Creek branching off from the Betmong River, 11 km southeast of Dupax.

The ore deposit was once prospected by Lepanto Consolidated Mining Co., but the development was suspended due to its small scale deposit.

The ore deposit has been formed metasomatically in the tuff breccia in fine grain sedimentary rocks intercalated in pyroclastics and basalt lavas of the Caraballo Group Formation II. It is a massive copper-zinc deposit striking N70°W and dipping 70°N. The scale of the high grade portion is approx. 6 - 7 m in length with a thickness of about 2 - 3 m.

The ore minerals are chalcopyrite, sphalerite, galena, pyrite and tennantite with a small amount of quartz. The surface of the mineralized zone is covered with bushes so that it is impossible to find any outcrops. Only a small amount of ore left in the old ore chute can be seen at present. The ore is megascopically of a very compact massive type like "Kuroko" in Japan. The assays of the high grade massive samples are shown as follows:

	Au g/t	Ag g/t	Cu %	Pb %	Zn %	S %	Mo %	As %	Sb %
f-317 (1)	0.35	50.5	0.05	0.01	0.07	5.0	—	—	—
(2)	7.80	10.7	18.49	8.54	11.51	9.0	—	0.130	0.011
(3)	4.50	0.2	4.33	0.06	27.86	33.5	—	0.042	0.010
(4)	0.20	511.5	5.10	0.05	34.52	23.8	0.000	0.209	0.053
(5)	0.04	2.9	11.00	0.00	33.26	31.1	0.000	—	—

(-: No-analysis)

As indicated in the table, some samples contained a large amount of silver. As no silver minerals are recognized under the microscope, the silver may be included in the tennantite.

The ore deposit has been formed metasomatically in a highly permeable tuff breccia in the fine-grained sedimentary rocks; which is a very unique occurrence that a large scale ore deposit can not be expected. There is also a mineralized zone with about 1.0% Zn nearby the ore deposit and it is also considered to be formed by the same mineralization.

3-1-7 Maasin River Mineralized Zone

The monzonite is widely distributed along the Sulong River, a branch of the Magat. In the upper reaches of the Maasin River at the western edge of the rock body, the andesitic rocks are distributed with alteration due to mineralization. The mineral compositions are very fine grain disseminated pyrite with a few chalcopyrite, partly being a network. The result of the analysis is Au < 0.2 g/t, 0.13% Cu and 2.01% S.

3-1-8 Balite River Mineralized Zone

Accompanying a small amount of bornite, malachite and epidote, many quartz veins are developed along the mid-stream of the Balite River, which is located at the western fringe of the Dupax batholith distributed around SE of the Santa Fe River. The strike and dip of the veins are N40°N and 75°SE, respectively. The average width is 1 - 2 cm, occasionally 20 cm. The host rock is biotite-hornblende quartz diorite.

3-1-9 Other Mineralized Zones

Other mineralized zones are: (1) pyrite disseminations in the upper reaches of the Baan River, a branch of the Santa Cruz, (2) the pyrite disseminated zone (Cu < 0.01%, S: 3.12%) distributed between the mid-stream of the Mapalyao, a branch of the Magat River and Campote Creek, a branch of the Diduyon River, (3) the pyrite diseminations (Au: 0.3 g/t, Cu: 0.01%, S: 6.49%) in the porphyritic andesite in the lower stream of the Sulong River, (4) the pyrite dissemination in the mid-stream of the Cabalisian River, (5) the pyrite (rarely chalcopyrite) disseminated zone in the mid-stream of the Dumalalto River and (6) the pyrite disseminations along the Denip, a branch of the Cagayan River. All of them are very low in copper contents.

3-2 Baguio Area

The reconnaissance survey and data collection were made in the Baguio area to compare data on ore deposits of the both areas.

In this area the porphyry copper mines are, (1) Santo Niño, (2) Kennon, (3) Santo Tomas, and the vein type gold ore deposits are (4) Antamok, (5) Acupan, (6) Balatoc, (7) Itogon, (8) Atok Big Wedge, and a metasomatic type mine, (9) Thanksgiving. In addition, (10) Boneng mine is operating at the point, 2 km north of the northern boundary of the area. The localities of these mines are shown in Fig. II-6.

Excluding Balatoc, Atok Big Wedge and Itogon, the ore deposits of the seven mines surveyed are listed in Table II-4 with their general information.

The general information on the ore deposits of each types is described as follows:

3-2-1 Porphyry Copper Ore Deposit

The porphyry copper type ore deposits are four mines, namely, Santo Tomas, Sañto Nino, Boneng and Kennon. Every ore deposit occurs

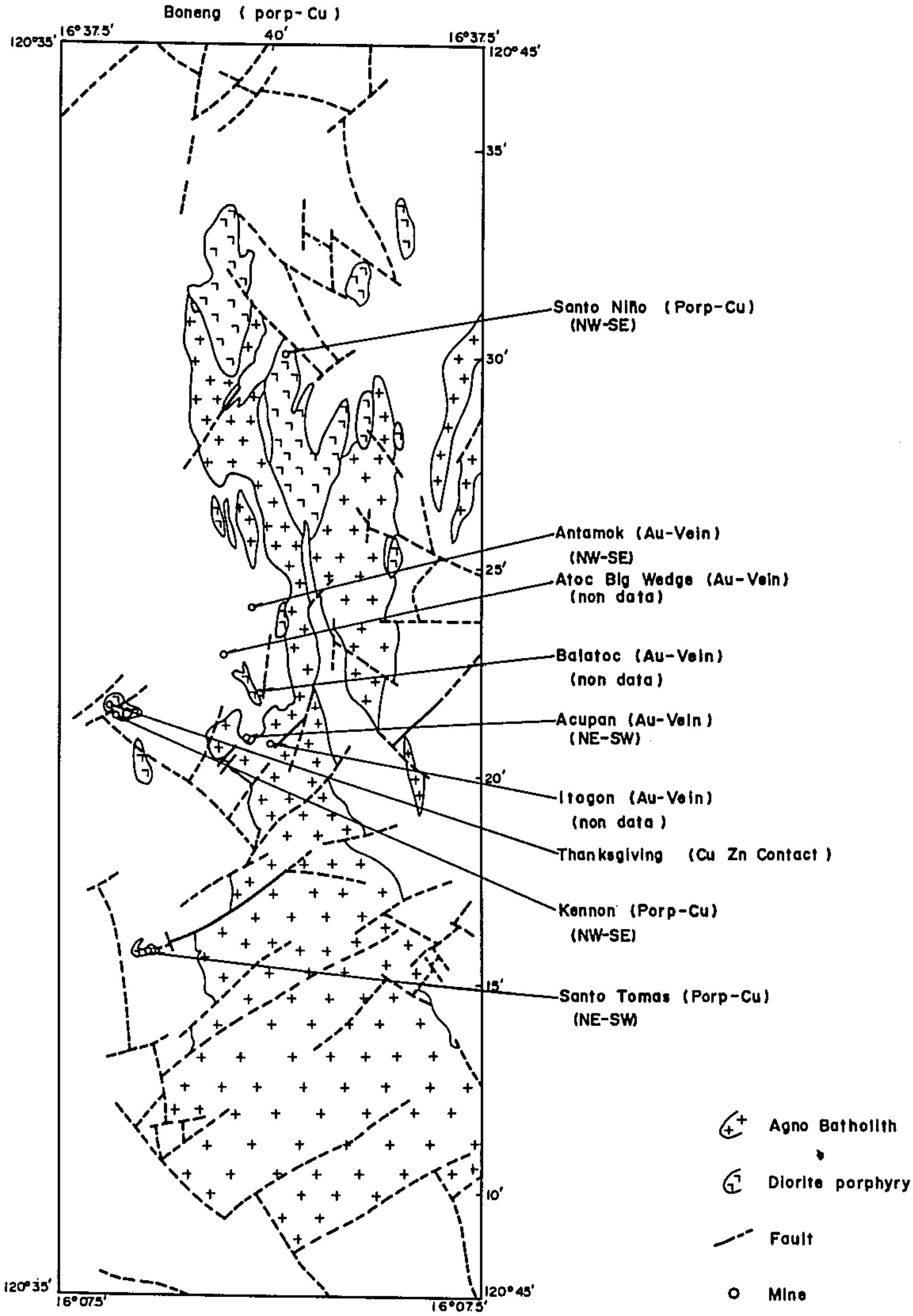


Fig. II-6 Distribution map of Agno batholith, diorite porphyry and mines in Baguio area

Table II-4 Summary of ore deposits in Baguio area

	Santo Tomas	Santo Niño	Boneng	Kennon	Acupan	Antamok	Thanksgiving	Remarks
Location	120°-37', 16°-16'	120°-40', 16°-29'	120°-41', 16°-38'	120°-37', 16°-21'	120°-39', 16°-21'	120°-39', 16°-24'	120°-36', 16°-22'	
Production	27,000 t/day	4,000 t/day	13,000 t/day	3,300 t/day				
Ore reserve (grade)	140 m.t (Cu 0.44%)	52 m.t (Cu 0.38%)	203 m.t (Cu 0.35%)	25 m.t (Cu 0.45%)				ALMOGELA (1977)
Number of ore body	1	2 (Santo Nino, Ulman)	2 (Boneng, Lobo)	1				
Occurrence	diss ~ stockwork high grade in stockwork	diss ~ stockwork	diss ~ stockwork high grade in diss	diss ~ stockwork high grade in stockwork	vein	vein	contact metasomatic massive (~ vein)	
Scale of ore body	E-W N-S depth 500 m x 400 m x 600 m	E-W N-S depth 330 m x 200 m x 300 m	Boneng: 150 m x 200 m (?)	E-W N-S depth 230 m x 450 m x 150 m	mineralized area E-W 2 km x N-S 3 km			
Pre-ore host rock	Pugo F.	Pugo F., ZigZag F.	ZigZag F.	Pugo F., ZigZag F.	} Q-dio (Aqno), andesite,	} ZigZag F., dio (Agno)	} limestone of ZigZag F.	
Host rock (Wall rock)	Small dio-porp stock	big dio-porp stock	dio-porp stock	small dio-porp stock	Balotoc plug		dio-porp	
Structural control								
lithologic	shattered zone along cont.	edge of host rock	edge of host rock					
structural	NE-SE fracture	NW-SE fracture	NW-SE, N-S fracture	NW-SE fracture	NE-SW > E-W	NW-SE > NE-SW, E-W	limestone	
Primary ore mineral	Py, Cp, Mag, Bor (Moly), (Ga)	Py, Cp, Mag, (Bor), (Sph), (Moly), (Hem)	Py, Cp, Bor, (Mag), (Moly), (Hem)	Py, Cp, Mag	Gold, Silver, Tell. base metal sulfides	Gold, Silver, Tell, base metal sulfide	Sph, Py, Cp, Mag, Ga, Tell.	
Ore mineral zoning (From center)	Cp-Bor → Py-Mag							
Secondary mineral	Mal, Cc, Azu, Cov	Mal						MOTEGI (1977)
Gangue mineral	Q, Cal, Ser, Chl, Gy (deeper part)	Q, Cal, Chl, Clay	Q, Cal	Q, Cal	Q, Cal, Rd, Rdch, Gy	Q, Cal, Rd, Rdch, Gy	Skarn mineral, Q, Cal Chl	
Mineral sequence	(1) Mag-(Cp)-Sph-(Py) → (2) Cp-Sph-Bor-Q → (3) Cp-Bor → (4) Moly	(1) Py-Mag → (2) Py-Cp Sph → (3) (Cp)-Bor-Moly				(1) Q Rd-Py (2) Au-Ag-Sulf (3) (Q)-Cal-Rdch (4) Gy	(1) Skarn mineral (2) Py-Sph (3) Cp-Ga (4) Tell	
Hypogene enrichment	shattered zone of andesitic rock (Pugo)	contact between Q-dio and dio-porp (especially dio-porp)	intersection of faults and shattered zone	central portion of dio-porp				
Alteration	inner zone: Sil, Ser, Bio, Chl outer zone: Chl, Epi, Carb, Pyri	inner zone: Sil, Chl, Ser, Bio, Agl, Carb outer zone: Epi, Chl, Carb, Agl	Sil, Pyri, Agl, Bio Bio: intensely mineralized zone.	inner zone Sil dominant outer zone: Chl dominant				
Breccia pipe	Cu-bearing (Cu 3.0%)	barren breccia pipe						

Abbreviation :

m.t : million tons,
diss : dissemination
Q dio-porp : quartz diorite porphyry
dio-porp : diorite porphyry
Q : quartz
Cal : calcite

Sil : silicification
Ser : sericite and/or sericitization
Bio : biotite
Chl : chlorite and/or chloritization
Pyri : pyritization
Gy : gypsum

Carb : carbonitization
Epi : epidotization
Agl : argillization
Rd : rhodonite
Rdch : rhodochrosite

Py : pyrite
Cp : chalcopyrite
Sph : sphalerite
Ga : galena
Bor : bornite
Mal : malachite

Moly : molybdenite
Tell : telluride minerals
Mag : magnetite
Hem : hematite
Azu : azurite
Cov : covellite

in stocks of diorite porphyry (including quartz diorite porphyry) as disseminations or stockworks. The main primary minerals are cholcopyrite, pyrite and magnetite accompanied by minor amounts of bornite, molybdenite and hematite. They are mostly disseminated in the host rock, but sometimes in a stockwork of quartz and calcite veinlets. The copper minerals are found in dissemination in the Boneng mine but are concentrated in the stock work in others.

As the mineralization control, the outer fringe control of the rock body and the structural control are found. The elements of the structural control are the concordant structures with the fault system well developed at the margin of the intrusive rock, like in the Bobok mineralized zone. The bonanzas of the mines are found either at the places where the fault fractures are concentrated or at the intersection of the faults.

The outstanding characteristics of the occurrences of the porphyry copper deposits are that the deposits have not been accompanied by a large scale intrusive rock body like the Agno batholith, but accompanied by the stocks of the later stage. These stocks are lithographically very similar to the quartz diorite porphyries type I and II of the Bobok body.

3-2-2 Vein Type Gold Ore Deposit

This type of deposit is composed of gold and silver minerals as the main ore minerals. There are five deposits belonging to this type. As shown in the Fig. II-6, their localities are concentrated at the point where the NE-SW fault systems and NNW-SSE fault systems intersect and the batholith is narrowest here.

This fact indicates that the numerous small faults and fissures created by the fault movements have given places for the ore deposition.

The ore deposits of this type are represented by the Antamok and Acupan deposits containing mainly native gold, and the tellurides of gold and silver in quartz and calcite veins.

The Antamok veins mainly run in the NW-SE direction and the Acupan veins are mostly trending NE-SW. These trends agree with the prominent structural direction in this area.

From the characteristics of the veins, they are considered to be epithermal deposit, and have possibly be deposited showing one kind of the zonal distribution near the porphyry copper deposits. A direct genetic relation with the igneous rock is not clear, but the Acupan deposit is formed within the Agno batholith, and the nearby porphyry copper deposits are accompanied by diorite porphyry stocks so that they are most likely to be related to the stocks.

3-2-3 Metasomatic Ore Deposit

The Thanksgiving ore deposit is formed at the contact where the lens-shaped limestone of the Zigzag formation is intruded by the diorite porphyry accompanying garnet skarn.

The characteristics of this ore deposit are that the ore usually contains high contents of gold-silver (Au: 33 g/t, Ag: 156 g/t) compared to other contact metasomatic deposits and that the tellurides of gold and silver can be found. Therefore, a part of the deposit is considered to have been formed by the low temperature hydrothermal solution.

3-3 Discussion

The ore deposits in the Baguio area are distributed on the western fringes of the Agno batholith, and genetically they are accompanied by the diorite porphyry intruded in the later stage than the Agno batholith and have a very close relation with them.

According to the K-Ar dating, the Agno batholith intruded in the lower to middle Miocene (18 m.y.), and it becomes clear from the results of chemical analysis that it belongs to the typical calc-alkali rock series. From genetic standpoint, the host rocks of the Bobok ore deposit could be stated to be of the same origin as the Agno batholith.

There is no analytical data on the diorite porphyry accompanying the ore deposits in the Baguio area, but it is clear that the porphyry have microscopically the same properties as the Bobok body. From this reasoning, the ore deposits in the Baguio area including the Bobok ore deposit have genetically originated from same magma. As the batholith was still in a undifferentiated stage, it was not accompanied with ore depositions, but the porphyries were in the later stage of differentiation and had enough concentration of the metal elements to compose the ore deposits.

The reason for the concentration of ore deposits around the batholith in the Baguio area is due to the fact that the diorite porphyry intruded along the structural lines formed or reactivated by the intrusion of the Agno batholith, which had a great influence on the localization of the ore deposits.

Regarding the San Fabian ore deposit, there is a question whether the diorite porphyry accompanying the deposit is genetically related to the Agno or the Dupax batholith. According to the results of chemical analysis, both batholiths have similar characteristics and are exactly the same in the respect of being in the undifferentiated stage. The characteristics of the host rock of diorite porphyry, is also very similar to the Bobok's. Therefore, it is appropriate to consider that the San Fabian ore deposit is related to the Dupax batholith.

It is difficult to discuss the Lugan ore deposit genetically as it was impossible to clarify the relationship with the igneous rocks. In the Phase III report, the dolerite closest to the deposit was considered, as one possibility, to be related to the ore deposit, but diorite porphyries might be exist.

3-4 Period of Ore Deposition

The age of ore deposits in the Bobok and the Baguio areas is considered of uppermost Miocene (3 - 6 m.y. by the K-Ar dating on the Bobok body). While, the K-Ar age of the San Fabian ore deposit is 20.6 ± 1.2 m.y. which is older than the ore deposits in the Baguio area this may be because the Dupax batholith of 26 - 33 m.y. is older than the Agno batholith.

The ages of the other mineralized zones are not clear as no information is available. But considering the batholith near the mineralized zone, the age may be considered to be middle to upper Miocene.

PART III GEOCHEMICAL SURVEY

1. General Remarks

In Phase I and Phase II, the geochemical survey for stream sediments was conducted with the geological survey for the most effective methods to select the ore-bearing area from the wide unsurveyed area is to conduct geochemical survey for stream sediments. In the Phase III survey, in order to delineate the mineralized zone from the promising area previously selected, the geochemical survey for soil was conducted.

Consequently, in the Phase I survey in order to cover the whole survey area, the stream sediments were sampled and in the area where the samples were insufficient and 1168 supplementary samples were collected by the Philippine geologists.

As porphyry copper type deposits were expected in this survey area, the quantitative analysis for three elements, namely, Cu, Zn and Mo, was conducted for all the samples collected. As a result, eight anomalous zones with potential for porphyry copper type deposits including the Bolo River and the Mapayao Creek were detected.

Like in Phase I, semi-detailed and detailed geochemical drainage surveys were carried out on the northwestern part of the project area covering 3,400 km^2 in Phase II. The semi-quantitative analyses for Cu and Mo were conducted in the field camp and the complete quantitative analyses were performed in Japan. The results of analyses indicated a similar distribution of anomalous zones as that of the Phase I survey.

It became clear from the results of the geological survey that most of these anomalous zones were accompanied by stocks of diorite porphyry and the rest was related to alkali rocks.

The Phase III geochemical survey being carried out only in ore-bearing area and the detected anomalous zones, soil sampling was applied. For indicator elements Cu and Zn were chosen. As a result, intensive copper anomalous zones surrounded by Zn anomalous zones were obtained in the Bokod and the Salinas areas, where porphyry copper deposits were recognized by the Phase I and II surveys. Among the detected anomalous zones, intensive Zn anomalies accompanied by a replacement deposit were obtained in the Mongia area. But in the Kasibu area no anomalies for Cu nor Zn were recognized and the relatively higher Cu zones detected by the stream sediment survey depend on the lithology distributed in this area.

2. Survey Method and Compilation of Results

The geochemical surveys were conducted on stream sediments in Phase I and Phase II, but the soil sampling was applied in Phase III. The methods of survey and analysis and compilation of the data are as follows:

2-1 Method of Survey

Generally silty sediments (under 80-mesh fraction) deposited on the river-bed were collected. Tributaries were mainly chosen as the sample sites instead of main rivers from where effective information is hardly obtained.

The average sampling densities in Phase I, semi-detailed and detailed in Phase II were 0.10, 1.0 and 4 per km^2 (including 1.0 of the semi-detailed survey), respectively. The samples were mainly collected along the geological surveys route.

In case of soil sampling, the accumulated layer (B horizon) below the humic soil were chosen and the average sampling density was 5 samples/km^2 for the semi-detailed and 15 to 25 samples/km^2 for the detailed surveys. The samples were collected mainly along the drainage system but when the route spacings were too wide, the samples were further collected along the ridges to equalize the density.

The collected samples were sent to the base camp to be naturally dried and screened to 80 mesh for analysis. The numbers of samples collected are 1,168 stream sediments in Phase I and 4,544 stream sediments for the semi-detailed survey and 1,251 stream sediments for the detailed in

Phase II. Soil samples of 514 for the semi-detailed and 844 for the detailed survey were collected in Phase III.

2-2 Method of Analysis

In Phase I and Phase II, all samples collected were quantitatively analyzed for Cu, Zn and Mo in Japan, and also in Phase II, semi-quantitatively for Cu and Mo in the field camp. In Phase III, the analyses were conducted semi-quantitatively for Cu in the field camp and quantitatively for Cu and Zn in Japan and the same analytical methods were applied. The analytical methods are briefly explained as follows:

2-2-1 Semi-Quantitative Analysis

1) Copper

To a 0.2 g sample a 0.6 g pyrosulphate fused. After fusion, 4 ml of dilute HCl (1%) is added and heated to be dissolved. Then 10 ml of keno buffer solution is added. After confirming a PH 5.0, add 2 ml of biquinoline solution and shake strongly. The reddish reaction color is compared with colours of standard solutions.

2) Molybdenum

To a 0.2 g sample add 4 ml of agua regia, 1 ml of $HClO_4$ and 2 ml of H_2SO_4 (1+1) and heat until white vapor appears. After cooling, add 7 ml of NaOH (40%) and a 1 ml Na_2CO_3 (10%) and the total volume is diluted to 20 ml. Then the iron hydroxide formed is filtered and removed. 5 ml of filtrate is taken and 5 ml of 2.5% hydroxylamine hydrochloride solution is added and gently shaken. Next, a 1 ml of 1% zinc dithiol solution is added and after through shaking, the color is compared with the naked eye with the standard solutions.

2-2-2 Quantitative Analysis

1) Copper and Zinc

Add 5 ml of concentrated HNO_3 and 3 ml of $HClO_4$ to a 1 g sample, and heat on the sand both until white vapor appears. After cooling, 5 ml of dilute HNO_3 (1:2) is added to dissolve. Then distilled water to adjust the volume to 20 ml. The filtrate is analyzed by the atomic-absorption spectrophotometry using wave lenghs of 3,247 A° for Cu and 2,139 A° for Zn.

2) Molybdenum

The analysis is the same method as the semi-quantitative method except in the colour measurement. A photo-electron colorimeter is used in order to measure with higher accuracy.

2-3 Compilation of Results

The analytical data were subjected to the graphical method (LEPELTIER-1969) to determine the mean background and the threashold values.

The data obtained in Phase I and Phase II were subdivided into groups such as reconnaissance semi-detailed and detailed samples, but no classification was made from stratigraphical point. In Phase III the data were subdivided into each survey area.

The mean background and threshold values in each phase are shown in Table III-1. To show the trend of anomalies clearly, the value (t') corresponding to 10% of the total observations from the highest and 2t and 3t were supplementary used on the anomaly map.

Table III-1 Mean background and threshold values

(ppm)

Phase	Accuracy of Survey	Kind of Sample	Area	Element	Background Value (b)	Threshold Value (t)	Coefficient of Correlation between Cu and Zn ( )	Number of Samples
I	Reconnaissance Survey	Stream Sediment	Whole area	Cu Zn Mo	50 97 <2	175 450 5	0.449	1.168 pcs
II	Semi-detailed Survey	do	Semi-detailed Survey area	Cu Zm Mo	54 87 <2	215 375 7	0.568	4.544
	Detailed Survey	do	Detailed Survey area	Cu Zm Mo	97 118 <2	280 320 9	0.359	1.251
III	Semi-detailed and detailed Survey	Soil	Bokod area	Cu Zm	95 90	155 170	0.370	737
			Mongia area	Cu Zm	40 75	240 96	0.544	430
			Salinas area	Cu Zm	100 75	155 115	0.273	253
			Kasibu area	Cu Zm	200 75	380 122	0.493	238

3. Outline of Survey Results

3-1 Results of Phase I Survey

As a result of the geochemical survey of the whole area, 8 anomalous zones were detected. Among these anomalies, some seems to be related to the known ore body and others may be only local.

The main anomalies are as follows:

Anomaly-1 (Cu, Zn, Mo)

It is a Cu, Zn and Mo anomalous zone extending widely around the quartz diorite porphyry (reported as diorite in Phase I) which occurs on the south side of the Bolo River, a branch of the Agno River. This anomaly is the most intensive one detected by the Phase I survey, and was called the Bolo mineralized zone in the Bokod area by the Phase III survey.

Anomaly-2 (Cu)

It is distributed in the upper reaches of Mapayao Creek branching off from the Santa Cruz River, and it is considered to be related to the diorite porphyry stocks. This anomaly is called the No.1 disseminated zone in the Salinas area by the Phase III survey.

Anomaly-3 (Cu, Zn)

This anomaly is considered to be only local or caused by the lithology.

Anomaly-4 (Cu)

This is a small anomalous zone with an area of less than 0.3 km^2 distributed in the mid-stream of the creeks of the Marang River near San Francisco village. But according to an information obtain, between Dupax and San Francisco, a pyrite dissemination zone accompanied by copper and a network of pyrite veinlets is recognized near the contact between altered basalt and diorite.

Anomaly-5 (Cu)

A wide area of approx. 30 km^2 with Cu anomalies is recognized all all around Kongkong Valley in the upper stream of the Kasibu River and copper contents are 175-245 ppm. This anomalous zone have no Mo nor Zn anomalies and no distinct mineralization is recognized.

Anomaly-6 (Mo)

The anomaly occurs in the eastern part of monzonite stock in the upper reaches of the Sulong River, which is flowing on the eastern side of the Kongkong Valley. In the pyroclastics around the monzonite stock, a gold deposit is known and veinlets of molybdenite-pyrite are recognized in the diorite near Dupax. This Mo anomaly is, therefore, considered to be related to a porphyry type mineralization.

Anomaly-7 (Cu, Zn)

This is considered to be only local and not important.

Anomaly-8 (Cu, Zn, Mo)

The anomalous zone of Cu, Zn and Mo is found in the upper stream of the Diarabasin River on the East Coast, but in the adjacent creek, only Zn anomaly is detected and Cu and Mo values are lower than the background value that the scale of anomaly is considered to be very small.

3-2 Results of Phase II Survey

A semi-detailed survey was conducted all over the anomalies excluding the above mentioned anomalies 1 and 8. Furthermore, a detailed survey was carried out, in the most promising area of 300 km^2 selected by the semi-detail survey.

3-2-1 Semi-Detailed Surveys

Seven anomalies were recognized by this surveys. The four out of seven anomalies were found by the Phase I survey. Anomalies 3 and 4 found in Phase I were not detected by the Phase II survey.

1) Bokod Anomalous Zone

The Cu, Zn and Mo anomalous zone corresponding to Anomaly 1 of the Phase I, was confirmed to be the most intensive anomalous zone in this survey. This zone includes the porphyry copper deposit, which is being prospected by BCI at present.

2) Mapayao Anomalous Zone

This is the copper anomaly found at the junctions of the Santa Cruz River and the Mapayao Creek, and it was newly recognized by this survey. The porphyry copper deposit which was prospected before, occurs in this zone. In the upper stream of the Mapayao Creek, Cu anomaly was detected. This part corresponds to the Anomaly 2 of the Phase II.

3) Kongkong Valley Anomalous Zone

This zone corresponds to the Anomaly 5 of the Phase I, extending 15 km in the N-S direction and 8 km in the E-W direction with Kongkong Valley as the center. The highest copper value is 1,188 ppm and Zn anomalies were also recognized. But no mineralization was found around here like in Phase II.

4) Manga River Anomalous Zone

By the Phase I survey, weak Zn anomalies were recognized but there are no anomalous zones to speak of because of limited distribution of anomalies. The maximum Zn content of 3,888 ppm was locally recognized at the same point by the following survey. In this neighborhood, the basalt lavas of the Caraballo Group Formation II are developed.

5) Diduyon River Anomalous Zone

In the upper reaches of the Diduyon River south of the Kongkong Valley Anomaly Zone, Zn anomalies was found with the maximum Zn value of 467 ppm, which is not so high. This area is covered by andesitic rocks of the Caraballo Goup. It is considered to be due to lithology.

6) Sulong River Anomalous Zone

This corresponds to the Anomaly 6 with Mo anomaly detected by the Phase I survey. However, no mineralization was found by the Phase II survey. No conclusion has been reached whether Mo anomaly is related to the Au deposit, or to the porphyry copper deposit as pointed out by the Phase I survey.

7) Dabibi River Anomalous Zone

A Cu anomalous zone was found in the upper reaches of the Dabibi River with a maximum value of 258 ppm (not so high) and no mineralization was recognized.

3-2-2 Detailed Survey

Among the anomalies mentioned in the previsou paragraphs, the Bokod Anomalous Zone is the largest in scale and in metal content. As the porphyry copper deposit, under prospecting, exists in this zone, the Bokod area was excluded for the detailed survey as the known ore deposit. The Mapayao and Kongkong Valley Anomalous zones, the next promising areas, were selected for the detailed surveys.

1) Mapayao Area

This area including the Anomaly 2 detected by the Phase I survey is located at the confluence of the Santa Cruz River and the Mapayao Creek. This anomaly extends in NE-SW direction covering an area of 4 km x 1 km, with copper values ranging 284-776 ppm. The area consists of basaltic rocks and intruded stocks of diorite porphyry, which is accompanied by pyrite dissemination and malachite. The anomalous zone in the upper stream revealed by the detailed survey extends only 1 km x 1 km with Cu values of 160-180 ppm. On the west side of the anomaly at the junction, the porphyry copper deposit is known to have been prospected by a private company as the San Fabian ore deposit in the Salinas area referred by the Phase III survey.

2) Kasibu Area

This semi-detailed area includes the Kongkong Valley Anomaly as the center. Anomalies of Cu, Zn and Mo were recognized in this area, but there is no superimposition. The copper anomaly in the upper reaches of the Kasibu River covers an area of 10 km x 5 km but the values is not so high.

Its distribution coincides well with syenite. Therefore, it is very likely that the anomaly is caused by the lithology as pointed out in Phase I.

The Zn anomaly is found on the south side of Cu anomaly with no Cu nor Mo anomalies and besides the Zn values are not so high. Mo anomaly is recognized widely on the west side of the copper, but no indications of mineralization were found. It is not clear whether they are caused by lithology or not.

3-3 Survey Results of Phase III Survey

In Phase III, semi-detailed and a detailed soil surveys were carried out in the four areas; namely, the (1) Bokod and the (2) Salinas (Mapayao area in the Phase II detailed survey) areas, both include the known ore deposits, the (3) Kasibu area, where the nature of the anomaly had not been clear ever since the Phase I survey, and the (4) Mongia area including the Zn anomaly recognized by the Phase II semi-detailed survey.

The result of each area is summarized as follows:

1) Bokod Area

In tensive Cu anomalies were recognized in three places. They are along the main and southern branches of the Bolo River, around the mid-stream of the North Oding Creek and around the mid-upper stream of the South Oding Creek. The anomalies are mainly in the Bobok body consisting of quartz diorite porphyry and intruded dacite dykes. The distribution of anomalies coincides well with each mineralized zone of the Bolo, North Oding and South Oding.

The Bolo anomaly covers an area of about 2.5 km in the E-W direction and of about 1.5 km in N-S direction with the maximum Cu value is 7,455 ppm and shows over 4t (620 ppm) at 15 sites. This is the largest anomalous zone detected. The Cu anomaly in the North Oding Creek includes the Que Sera ore body, which is under prospecting, and covers an area of 2.3 km in E-W direction and 0.8 km in N-S direction with 6 sites over 4t. But 3 out of 6 sites are isolated from each other and this anomalous zone is not as large as the Bolo. The maximum Cu value is 1,790 ppm. The Cu anomaly at the South Oding originally belongs to the same anomalous zone as the North Oding, but they are apparently divided by the ridge located between the two creeks. The area of anomaly is about 2 km in the E-W direction and 1 km in the N-S direction, but it consists of three small scale discontinuous anomalous zones. The Zn anomalous zones are distributed as if many large and small "islands" were located in the Bobok body and in the intruded rocks. Among the anomalous zone, the Bolo has the largest area of 2 km x 1 km with the highest value of 920 ppm. The anomalous zone located in the upper most stream of the North Oding has over 1,000 ppm at 5 sites and, it is the strongest with the respect to intensity.

The Cu, Zn anomaly distribution is shown in Fig. III-1. The characteristic of the Zn anomaly is surrounding the copper anomaly. This is also clear from low coefficient of correlation as 0.370 and is considered to show a zonal distribution of Cu→Zn.

2) Mongia Area

The strong Zn anomaly was detected again by the Phase III survey. That is, in the western part, an intensive anomalous zone covers an area of about 1.5 km in the N-S direction and about 0.6 km in the E-W direction including ten sites with over 3 t (384 ppm). The maximum value is 4,995 ppm. And no copper anomalies were recognized, except for some local anomalies overlapping the Zn anomalies. According to the geological survey results, the Lugan ore deposit has a large amount of sphalarite and was reportedly prospected by a private company. The strong Zn anomaly is brought about by this ore deposit. The distribution of anomalies are shown in the Fig. III-2.

3) Salinas Area

In this area, an intensive Cu anomalous zone was located at the mouth of the Mapayao Creek and also the Cu-Zn anomalous zone was recognized in the upper stream of the same creek. The former zone extends in NNE-SSW direction in an oval shape with a long axis of 2 km and a short axis of 0.7 km. There are three sites each on the both sides of the Mapayao Creek

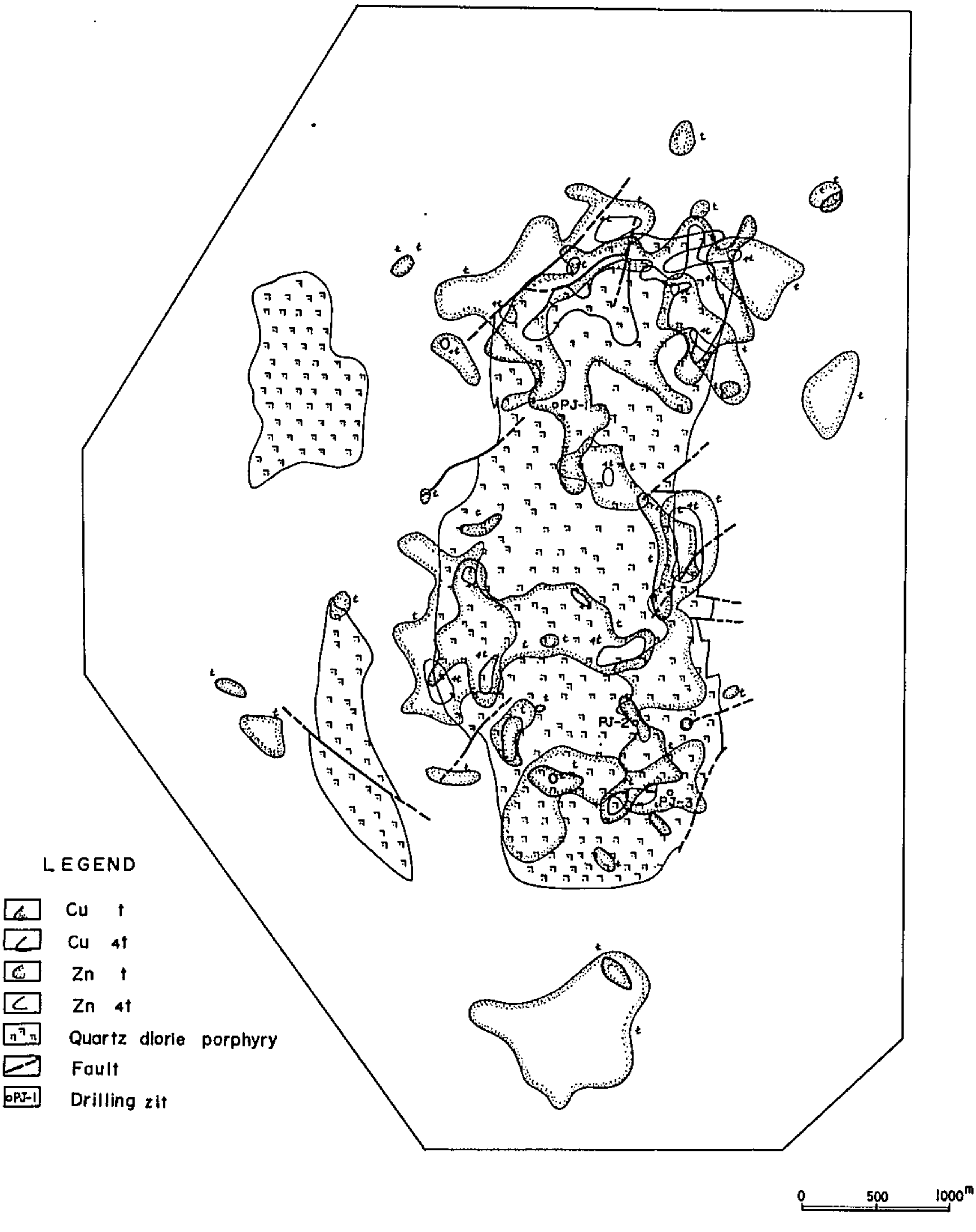


Fig. III-1 Geochemical anomalies map of Bokod area

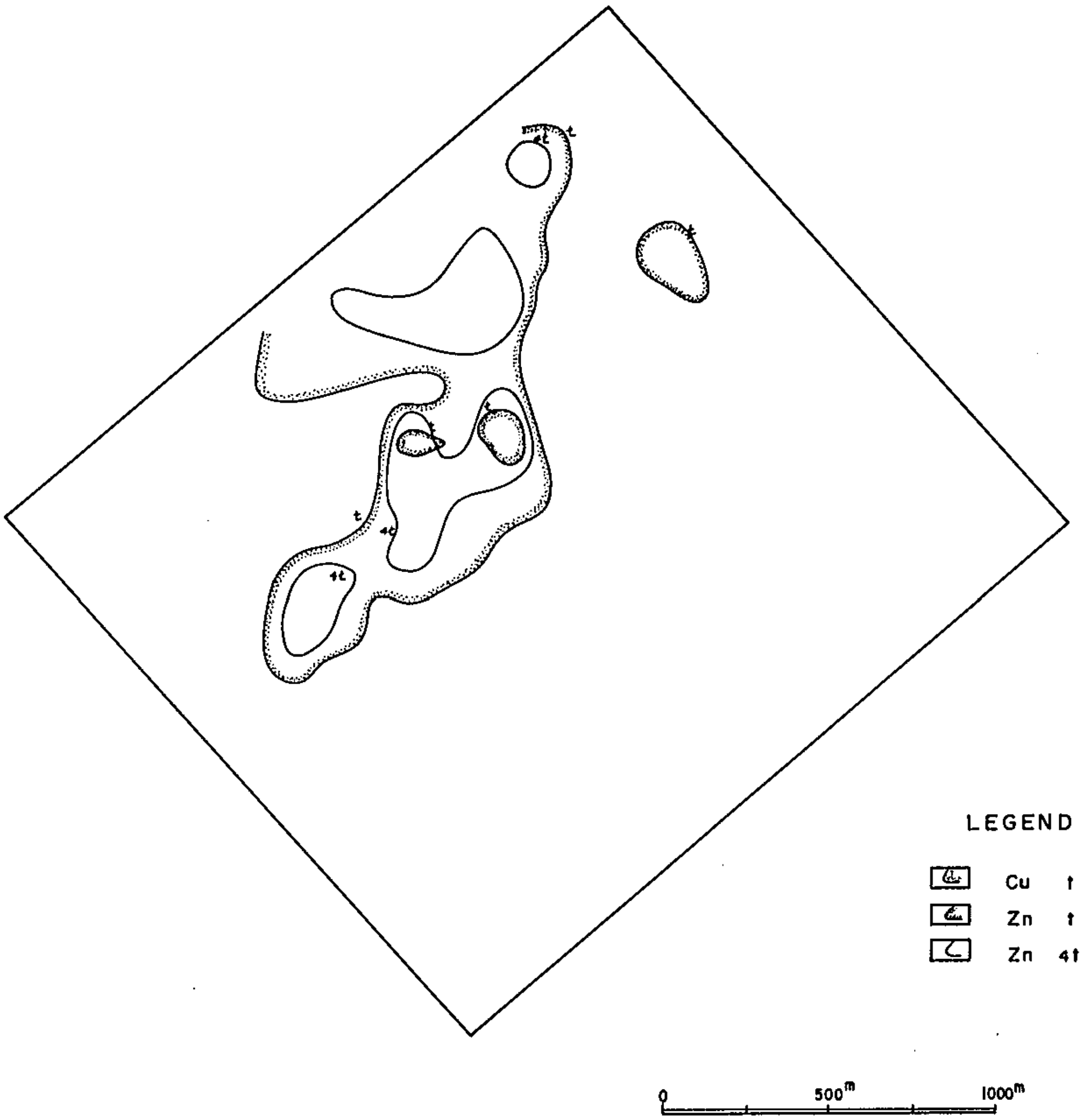


Fig. III-2 Geochemical anomalies map of Mongia area

with values exceeding 1,000 ppm. The highest value of 9,510 ppm is found on the south side.

The south side is, as stated before, indication of the San Fabian porphyry copper deposit, whereas, on the north side, many quartz and calcite veinlets are found in the basaltic rocks by the geological survey.

The anomalous zone in the upper stream is due to No.1 disseminated zone and extends outside of the survey area, so that the limit of the zone is unknown. The maximum value exceeds 2,024 ppm. This zone is equivalent to the Mapayao Creek anomaly in Phase I.

On the south side of the Cu anomaly, a Zn anomaly extends 1.5 km southward. The distributions of Cu and Zn anomalies are shown in Fig. III-3. The Zn anomalies are distributed surrounding the Cu anomalies, like in the Bokod area, and they are considered to manifest the typical distribution pattern of a porphyry copper deposit.

4) Kasibu Area

By the Phase III survey, no anomalous zones were detected in this area. That is, the unusually high copper background value of 200 ppm, as indicated in the Table II-1, is exceedingly high as compared to other areas.

For this reason there were only 3 samples exceeding the threshold value (t=380 ppm). As for Zn, only 2 samples were above the threshold value (t=122 ppm). Based on the

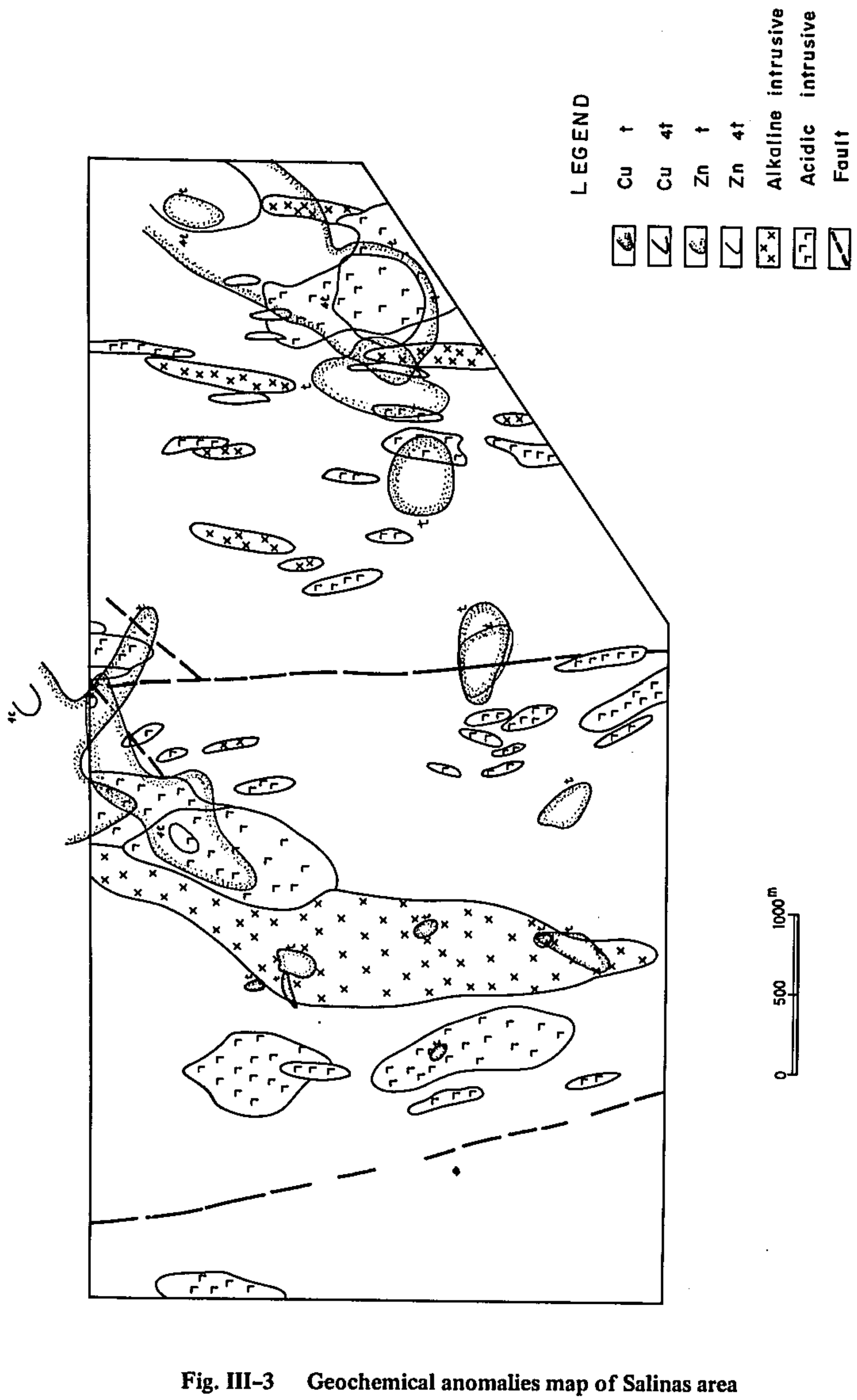


Fig. III-3 Geochemical anomalies map of Salinas area

above results, the anomalous zone detected by the Phase I and Phase II surveys in the Kongkong Valley was concluded that it caused by alkali rocks distributed in the area.

PART IV GEOPHYSICAL SURVEY

1. General Remarks

In Phase I, the airborne magnetic survey was conducted in order to know the geological structures and to discriminate the area where the existence of the ore deposits are expected.

The results of the airborne survey of Phase I were re-analyzed in Phase II.

During Phase III the ground geophysical surveys (IP method electrical survey and the ground magnetic survey) were conducted at the Bokod area, where the geochemical anomaly was the most intensive among the promising areas.

A total survey line of 11,244 km covering an area of 14,500 km^2 was performed by the airborne magnetic survey as the Phase I geophysical survey in the Northeastern Luzon in order to select approx. 30% of the total area as the most promising area for the ore bearing zones.

The main geological structures controlling the survey area and the distribution of the lineaments were clarified from the survey. By comparing the results of the magnetic susceptibility measurements of rock samples with the results of the quantitative analysis, the diorite distribution areas were selected, where the ore deposit may be most likely correlated. The promising areas as concluded are mainly in the northern part of the airborne survey area.

The major geological structures in the area were determined by the re-analysis of the survey results. Thirty-five NS profiles at 5 km intervals apart were chosen. By performing the quantitative analysis using the computer, the depth distribution of the basement complex was obtained.

The Bokod area surveyed by the Phase III Survey is a part of the prospecting area of the Benguet Consolidated Inc. (BCI), and a small scale IP method has been conducted by BCI since 1968. According to the IP electrical survey conducted on top of the known ore body (Que Sera) by BCI, an intensive FE anomaly of 15% has been detected, but no report is found. Intensive IP anomalies and also the existence of three mineralized zones including the Que Sera ore body are expected in this survey area. And from the distribution of the intrusive rocks, one mineralized zone is considered to be located in the Bolo area and the other one in the Oding area. The IP method was conducted in the Bolo area (10 survey lines, 23.2 km) and also in the Oding area (12 survey lines, 20.8 km). And the results of the data conducted previously by BCI were compiled together. According to the result of the BCI's ground magnetic survey, a very strong anomaly has been confirmed at the top of the known ore body, and it is considered to be caused by the quartz diorite porphyry with rich magnetite. The IP traverse lines were utilized in order to measure the magnetic force distribution surrounding the magentic anomaly and the data were analyzed in conjunction with the BCI data. The object of this Phase III geophysical survey was to select the most effective drilling site after the integrated interpretation of the distribution of the ore body, using the results of the IP method to delineate the area of the mineralized zones, and the ground magnetic survey to determine the distribution of the intrusive rocks and also the sulphide minerals. Although the mineralization found in the upper stream of the Copper Creek was comparatively shallow, very intensive deep IP anomalies were detected in the other creeks. The spread of the mineralized zone in the Bolo area practically coincide with the distribution of the quartz diorite porphyry extending approx. 2 km in the E-W direction with its northern limits at the Bolo River, but no deep anomaly was found in the upper streams of the Polanos and Copper Creeks, except for a strong E-W directional mineralization on the east side of the Maidit Creek. In the Oding area the southern extension of the Que Sera ore body was deteced and also a wide IP anomaly was also confirmed at the South Oding Creek. There is a strong magnetic anomaly at the Que Sera ore body, whereas a wide low magnetic anomaly is found at the South Oding Creek, so that it has become clear that an intensive IP anomaly at the South Oding Creek was caused mainly by pyrite. As mentioned above, as the sulphides cause the intensive IP anomalies in this survey area, it was possible to delineate the outline of the mineralized zone. But as the resistivities in these IP anomalies are comparatively high and the magnetic low was confirmed, it is assumed that these IP anomalies are caused mainly by the pyritization in the silicified zone of the upper part of the porphyry copper type deposit.

2. Method of Survey

2-1 Phase I Survey

The airborne magnetic survey was conducted as the Phase I Geophysical Survey. The specifications at the site were as follows:

Air Base: Nichols Airbase (Manila International Airport)

Diurnal Observation Station: Bayombong, Nueva Vizcaya

Flight Elevation: 2,000 m A.S.L. (horizontal navigation)

	Traverse Lines	Tie Lines
Separation of Flight Lines	1.5 km	10 km
Flight Direction	S-N	E-W
Effective Lengths	9,717.25 km	1,526.75 km
Total	11,244 km	

Inclination: 20°

Geomagnetic Declination: 0°

Total Geomagnetic Intensity: 40,000 gammas

The instrumentation and navigation system used for the survey were as follows:

a. Airplane

YS-11, Registration JA8612, manufactured by the Nihon Aeroplane Manufacturing Co., Ltd.

b. High sensitivity airborne proton magnetometer

Model G804, made by Geometrics Co. (USA)

c. High sensitivity optical pumping magnetometer

Cesium Magnetometer Model MDA-7101A,

made by Marubun (Japan)

d. High Sensitivity digital clock

Model M-733 Digital Clock, made by Marubun (Japan)

e. Radar altimeter

Model YG-90000,

made by Nippon Koku Denshi Co. (Japan)

f. Barometric altimeter

g. 35 m/m Tracking camera

35 m/m Strip Camera ST-102, made by NAC (Japan)

h. Two-channel analog recorder

7128A Analog Recorder, made by Howlet Packard Co. (USA)

i. Doppler radar navigation equipment

GPK-1000 and GPQ-601 Doppler Radar System,

made by Singer (USA)

j. Digital data acquisition system

Model 70, made by Cipher Co. (USA)

2-2 Phase III Survey

By the Phase III Survey, the IP method, electrical survey and the ground magnetic survey were conducted. The IP method was conducted by dipole-dipole electrode configuration. The electrode distance, a was 100 m and n was 1, 2, 3 and 4. The penetration depth was 250 m. For the Phase III Survey, ten survey lines were used with 200 m distance apart totaling 23, 200 m in length in the Bolo area, and in the Oding area twelve survey lines were used with the same 200 m distance apart totaling 20,800 m in length.

The survey instruments used for the Phase III are as mentioned below:

IP Transmitter:	Model CH-505, CH-509, made by Chiba Electronics Lab. (Japan) Maximum output 2.5A, 800V
Electric Generator:	Model 421, made by Geotronics Co. (USA) Maximum output 2.0 kW, 400 Hz, 115V
IP Receiver:	Model YDC 434B, YDC 441 and 7505-B, made by Yokohama Electronics Lab. (Japan) Model R401, made by Geotronics Co. (USA)
IP Checker:	Made by Yokohama Electronics Lab.
Transceiver:	Hitach & Co. CH-1330, 500mV Sony Corp. ICB-350, 500mW
Magnetometer:	Model G-186, made by Geometrics Co. (USA) Accuracy: $\pm 1 \gamma$

In the survey area the topography are so steep and rugged, that the traverse survey method was adopted. The instruments used were the Ushikata pocket compass S-25 and an Eslon tape, and the accuracy was more than 1/50.

3. Outline of Survey Results

3-1 Survey Results of Phase I

Magnetic anomalies in the survey area are classified into four classes, namely A, B, C and D in proportion to the magnetic intensities of the corresponding courses. In other words, the magnetic anomalies are caused by the magnetic sources of Rank A (strongly magnetic), Rank B (intermediately magnetic), Rank C (weakly magnetic) and Rank D (slightly magnetic). According to the susceptibility measurements of rock samples, andesitic and basaltic rocks belong to Rank A, dioritic rock and sandstone to Rank B, tuffaceous rock and mudstone to Rank C, and green-schist and limestone to Rank D.

The geological lineation runs in a NW-SE direction inthe western part of the survey area and in a NE-SW direction in the eastern part. This tendency is well consistent with the magnetic lineaments. Many lineaments in the northwestern area are oriented obliquely to some of the N-S lineaments. The distribution of diorite limited along these lineaments. Porphyry copper type deposits are known to be associated with the dioritic intrusions. Therefore, we can conclude that the area limited to Rank B magnetic zones in the northwestern part of the survey area is more promising for the ore bodies.

Furthermore, it is suggested that detailed survey including airborne or ground electromagnetic exploration and/or Induced Polarization prospecting will be conducted over the Rank B magnetic zones that have been recognized by the present airborne magnetic survey.

3-2 Survey Results of Phase II

The results of the interpretation can be summarized as geotectonic lines as given below.

(A) A geotectonic line running in a NW-SE direction from Dingalan to the south of Baguio City.

(B) A geotectonic line trending in a N-S direction to the north of Banak after branching off from geotectonic line (A) about 5 km northeast of San Jose.

(C) The other geotectonic line trending in a NW-SE direction extends to the south of Baguio City running 20 km northwards after branching off from geotectonic line (A) 10 km northeast of San Quintin.

(D) A geotectonic line running north 10 km from Aritao.

(E) A geotectonic line running northeastwards from Bambang through Bayombong.

(F) A geotectonic line running in a NW-SE direction from Bambang to about 15 km west of Dipaculao.

The main structures were clearly divided by the above-mentioned main geotectonic lines. The structures showing the depth to the basement-complex and the top of Caraballo Group were surrounded by each geotectonic lines.

This analysis has been made only for the underground structure, but the change of physical property, i.e., the distribution of mineralized alteration might be analyzed by way of geological, electrical, gravity and aeromagnetic surveys.

3-3 Survey Results of Phase III

3-3-1 Bolo Area

In addition to the expected anomaly of the Copper Creek, intensive IP anomalies were newly detected in two areas. The FE anomaly between 6E and 12E on Line 2 coincides with the geochemical anomaly, and the anomaly was confirmed to continue to the depth. An anomaly on the adjoining line is found, but this area has low magnetic anomaly zone caused by demagnetization due to pyrite.

The intensive anomaly extending in the NS direction in the east side of the Maidit Creek is near the western limits of the mineralized zone in this area and it seems to be distributed along the N-S trending boundary of rock faces. As the IP anomaly has the possibility to extend further to the south and no demagnetization effects were found, the area was chosen as a core drilling site for the survey area.

The drilling site (PJ-1) conducted near 10S on the Line 8 revealed pyrite dissemination continuing from the shallow down to the bottom of the hole. From the results, the IP anomaly mentioned above was caused by sulphides, and chalcopyrite were only found from 50 m depth up to the shallow.

As the low resistivity (100 Ωm or less) zone found in the other porphyry copper type deposits was not found here, it has been discovered that argillization is weak, and the silicification causing the high resistivity is strong.

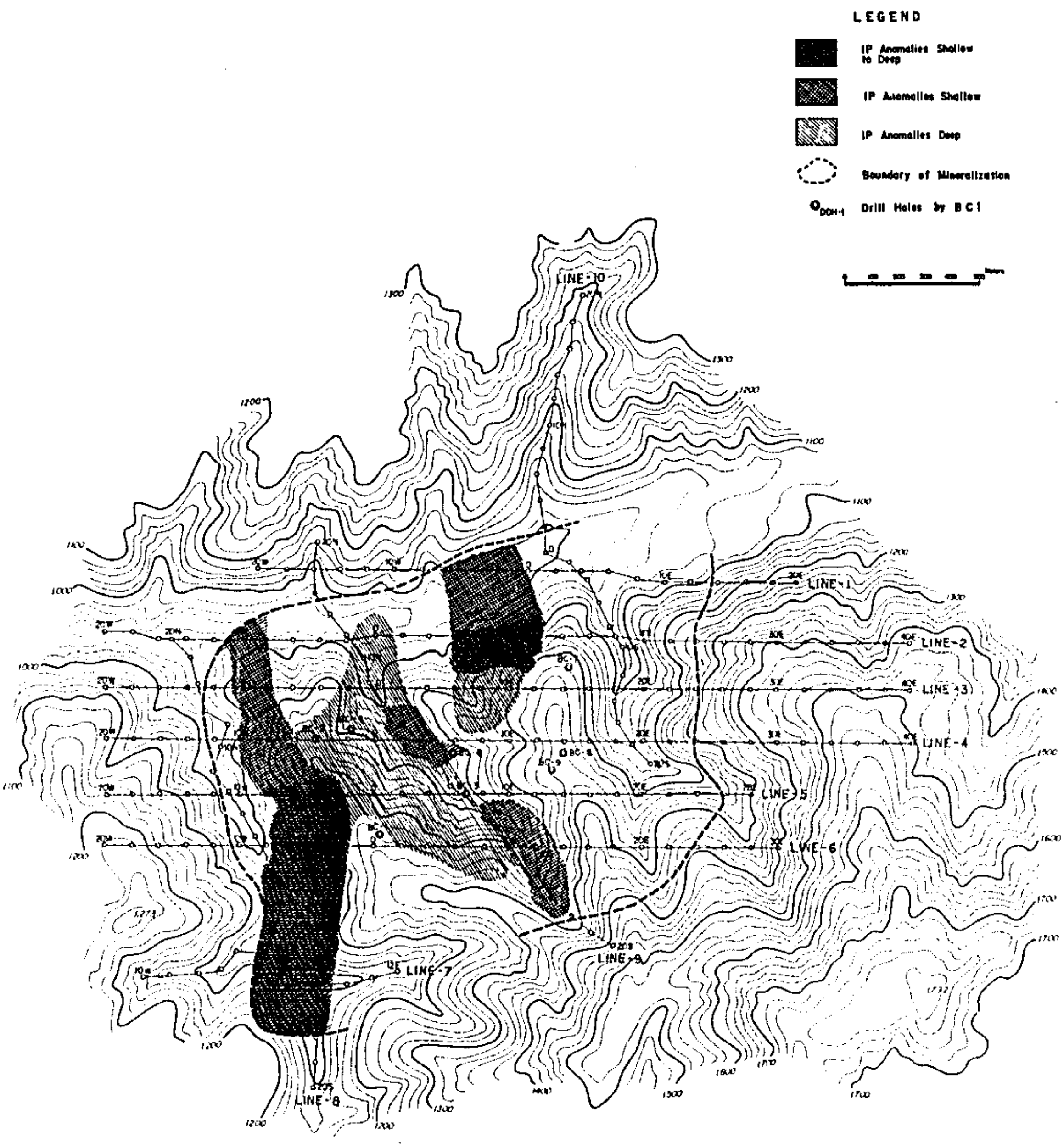


Fig. IV-1 Interpretation map of Bolo area

The outline of the sulphide dissemination in the Bolo area has a width of about 2 km in the E-W direction with the Bolo River as the northern limits, where was discovered to correspond practically with the quartz diorite porphyry distribution. The IP anomalies found in the upper stremas of the Polanos and the Copper Creeks was a shallow anomaly and it is not expected to be intensive dissemination at depth.

3-3-2 Oding Area

The southern extension of the Que Sera ore body has been confirmed. It is intruded by several intrusive rocks of the post-mineralization age that very complicated anomalies were confirmed and it has been discovered that at depth, it is connected to the mineralized zone found widely in the South Oding Creek. The widely intensive anomaly in the South Oding Creek accompanying a low magnetic anomaly is considered to be caused by the pyrite dissemination. In order to confirm the IP anomaly connecting the North Oding and the South Oding Creeks core drilling (PJ-2), and to find out the minerals in the South Oding Creek core drilling (PJ-3), were planned. The results of both core drillings revealed rather low copper content, and the intensive sulphide dissemination coincides very closely with the IP anomaly. As the ground magnetic survey conducted on the Que Sera ore body by BCI have detected a typical magnetic anomaly, IP survey lines utilized the same IP survey line.

The magnetic variations of the surrounding area of the Que Sera ore body were surveyed. The magnetic body containing several percent magnetite has been confirmed to have magnetic susceptibility of 4×10^{-3} emu from both the results of the magnetic susceptibility measurement of rock samples as

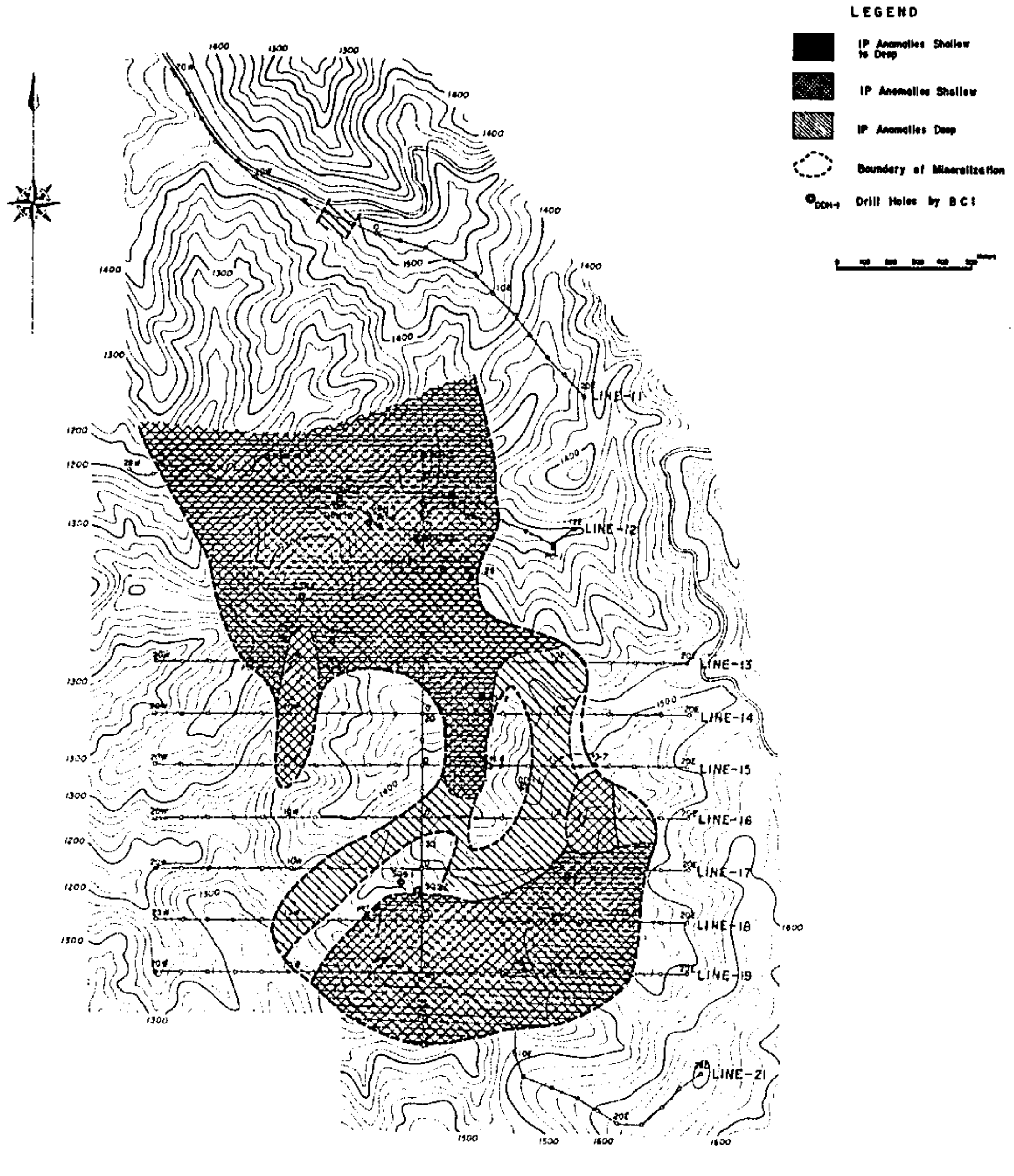


Fig. IV-2 Interpretation map of Oding area

well as the theoretical calculation. There were no other typical magnetic anomalies. Several small scale magnetic anomalies caused by low magnetite contained rock bodies are recognized. The low magnetic anomalies were overlapping in the IP anomalies that there were no other effective information to determine the types of minerals near the surface except to interpret the anomaly as pyrite ore.

4. Future Problems

In the Phase III Survey, Line 11 was surveyed in order to confirm the northern extentions of the Que Sera ore body, but no wide anomaly was found. Consequently, the Que Sera ore body may plunge deeply to the north or it may pinch out. The northern limits of the Que Sera ore body was not defined by this survey, that it would be advisable to plan several parallel survey lines north of the BCI survey line 2,700S in the future.

Although the topography is steep and rugged in the Bolo area, it was possible to confirm the outline of the mineralized zone. If possible it would be desirable to establish several parallel survey lines south of Line 6 in order to confirm the southern extention of the mineralized zone. The interrelation of the Bolo area and the Oding area will be possibly clarified by these survey lines.

The electrode distance in the previous survey was 200 feet (about 66 m) and the deviations of the FE values were recognized due to short electrode distances in the case of this area where there are many intrusive rocks. In the future as the promising mineralization is expected in the deeper zones, it is recommended to conduct the deep penetration survey with the electrode distance at 100 m or 200 m.

The distribution of the rocks with high magnetic susceptibility was detected and the pyrite related to the mineralization was confirmed by utilizing the ground magnetic survey in this survey.

It was possible to estimate the demagnetization effect due to pyrite by detecting the intensive FE anomaly with the widely low magnetic anomaly. For the future in order to confirm the distribution of the igneous rocks and the mineralization, the electrical survey, the ground magnetic survey and other geophysical methods would be desirable to be conducted jointly at the same time.

As the magnetic survey was conducted by utilizing the IP survey lines, the magnetic variations were observed mainly in the E-W direction and the magnetic variations were unknown between the survey lines, that it would be desirable to establish additional survey lines in the N-S direction.

PART V DRILLING EXPLORATION

1. General Remarks

It has been clarified by the geological, geochemical and geophysical surveys in Phase I, II and III that porphyry copper deposits occur in the Bokod and Salinas areas, and that the quartz diorite porphyry stock with the Que Sera ore deposits entirely suffered mineralization where the Phase III geophysical survey found IP anomalies extention towards depth. A drilling exploration was carried out to test the anomalies detected by the Phase III geochemical and geophysical surveys. Three (3) holes totaling 1,002.55 m in length were set up in the Bolo (PJ-1), the North Oding (PJ-2) and the South Oding (PJ-3) areas. The drilling operations were carried out in three shifts with wireline method using two sets of drilling machines. Partial collaps due to argillization were encountered in each hole, but the operation went on smoothly. Average drilling length per shift is 5.86 m with 96.3% core recovery.

The outline of each hole is as follows.

No.	JP-1	JP-2	PJ-3
Location	Bolo mineralized zone, Midit Creek	North Oding m. zone, Divide	South Oding m. zone, South Oding Creek
Drilled length	301.45 m	350.10 m	351.00 m
Core recovery	97.3%	95.5%	96.2%
Lithology	Quartz diorite porphyry type II Dacite dyke	Quartz diorite porphyry type II Dacite dyke	Quartz diorite porphyry type I & II Dacite dyke
Result	21.30-27.20m Cu: 0.26% 50m ~ py only gyp stringers occur below 64m, afterwards getting poor mineralization	86.90-88.70m Cu: 0.70% better grade (Cu 0.1-0.2%) in the depth than PJ-1 and PJ-3. gy stringers, recognizable	140.80-149.10m Cu: 0.1-0.2% gyp stringers developed below 187m, afterwards getting poor mineralization rapidly like PJ-1

Remarks m. zone : mineralized zone

gyp : gypsum

py : pyrite

2. Details on Each Hole

2-1 PJ-1 (Depth 301.45 m)

The PJ-1 hole is located in the midstream of the Maidit Creek, a branch of the Bolo River. Pyrite disseminations can be seen around this place, where copper anomalies overlapped by IP anomalies with N-S trend, were detected. The drill hole with the scheduled depth of 300 m was sunk to test the nature of mineralization at depth.

The core consists of quartz diorite porphyry type II and dacite dykes which have cut the former. Although mineralization can be recognized from the surface up to 235 m depth, copper grades exceed 0.3% only from 24.80 m to 27.20 m in depth where pyrite and chalcopyrite are disseminated. Chalcopyrite grains in quartz or calcite stringers are also seen. From 57.50 to 58.00 m in depth is a network of quartz stringers with galena and sphalerite disseminations, which is considered to be formed in the later stage of the mineralization. Gypsum stringers occur below 64 m depth and tend to increase toward depth unlike sulphide mineralization. And below 235 m depth, only gypsum stringers are recognized.

Assays of the main mineralized parts are as follow:

Sample No.	Depth m	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Mo %	S %
PJ-1-1	21.30-24.80	0.02	0.05	0.14	N.A	N.A	0.001	2.0
4	24.80-27.20	N.A	N.A	0.44	N.A	N.A	N.A	1.8
6	57.50-58.00	0.83	14.9	0.07	1.37	1.08	0.001	6.3
14	97.30-97.70	N.A	N.A	0.04	N.A	N.A	N.A	5.0

(N.A : No-analysis)

2-2 PJ-2 (Depth 350.10m)

The hole is on the divide between the North Oding and the South Oding Creeks, where strong IP anomalies were detected. As these anomalies are included in the extention of IP anomalous zone where BCI exploration works are undertaking. The scheduled depth was 350 m which is equivalent to the maximum capacity of the machine.

After reaching the bed rock at 26.00 m depth, quartz diorite porphyry type II and intruded dacite dykes continue to the bottom like the PJ-1 hole but the occurrence of dacite is much less than the PJ-1.

Pyrite disseminations or pyrite-quartz networks are recognized in the all cores. An average copper grade in a 1.80 m length between 86.90 m and 88.70 m is comparatively high (0.70%). Quart-calcite networks with pyrite is well-developed in this part. After 88.70 m depth, the dissemination is getting poor showing 0.13-0.22% of Cu. A few amount of chalcopyrite can be recognized in the sections of 275.70-281.20 m and 331.70 m-333.45 m having 0.11-0.16% of Cu. But they continue spottedly. Afterwards pyrite dissemination is predominant. Gypsum stringers can not be observed, which may suggest that the mineralization is still continuing towards depth.

Assays of the main mineralized sections are as follows:

Sample No.	Depth m	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Mo %	S %
PJ-2-4	86.90 ~ 88.40	N.A	N.A	0.65	N.A	N.A	N.A	3.6
5	88.40 ~ 88.70	0.34	7.3	0.98	0.04	0.70	0.000	5.2
6	88.70 ~ 90.35	N.A	N.A	0.18	N.A	N.A	N.A	3.3
7	90.35 ~ 91.50	0.02	0.9	0.13	N.A	N.A	N.A	2.7
9	91.50 ~ 92.30	N.A	N.A	0.22	0.02	0.11	N.A	4.1
10	146.60~149.10	N.A	N.A	0.04	N.A	N.A	N.A	2.8
15	182.40~184.60	N.A	N.A	0.05	N.A	N.A	N.A	3.3
19	275.70~279.00	0.09	1.8	0.11	N.A	N.A	N.A	3.1
20	279.00~281.20	N.A	N.A	0.12	N.A	N.A	N.A	2.8
24	331.70~333.45	N.A	N.A	0.16	N.A	N.A	N.A	3.8
25	341.65~344.30	N.A	N.A	0.04	N.A	N.A	N.A	2.4

(N.A : No-analysis)

2-3 PJ-3 (Depth 351.00 m)

This hole is located in the upper reaches of the South Oding Creek where geochemical Cu anomalies overlap wide IP anomalies extending from the surface towards depth. The drilling operation was carried out with 350 m scheduled depth to secure information on mineralization.

As the site was in the creek, the overburden was very thin. After reaching the bed rock at 4.80 m depth, quartz diorite porphyry type I continues up to 64.00 m, and is followed alternatively by dacite dyke and quartz diorite porphyry type II. Pyrite dissemination and network of quartz and/or calcite stringers with chalcopyrite and pyrite are developed up to about 160 m depth, but afterwards gradually weaken. Gypsum stringers increase after 187 m depth like the PJ-1 hole.

On the contrary, mineralization becomes poor.

The core section between 140.80 m and 149 m depth shows the highest Cu content in this hole. It is a mineralized part of quartz-calcite stringers where a small amount of chalcopyrite are recognizable in pyrite dissemination. In the section between 144.00 m and 147.00 m, sphalerite and galena are spottedly observed in quartz stringers.

Chemical assays of the main mineralized parts are as follows:

Sample No.	Depth m	Au g/t	Ag g/t	Cu %	Pb %	Zn %	Mo %	S %
PJ-3-1	12.60 ~ 14.40	0.02	0.6	0.02	0.01	0.01	N.A	2.8
2	19.45 ~ 22.10	N.A	N.A	0.00	N.A	N.A	N.A	4.1
3	22.10 ~ 25.30	N.A	N.A	0.04	N.A	N.A	N.A	3.8
8	99.20 ~ 103.00	N.A	N.A	0.02	0.00	0.00	N.A	6.0
12	140.80 ~ 142.25	1.04	18.1	0.16	0.37	1.67	0.001	3.4
14	142.25 ~ 143.95	N.A	N.A	0.10	N.A	N.A	N.A	3.6
15	143.95 ~ 145.15	2.02	43.2	0.11	0.36	1.13	0.001	3.7
16	145.15 ~ 147.05	N.A	N.A	0.11	0.43	1.20	N.A	3.4
19	147.05 ~ 149.10	N.A	N.A	0.12	N.A	N.A	N.A	3.0

(N.A : No-analysis)

The result of each hole is as stated above and can be summarized as follows:

Cu mineralizations with 1 ~ 2 m width are recognized in the relatively shallow zone. In the North Oding hole (PJ-2) the mineralization may be expected to extend towards depth but in the Bolo and the South Oding drill holes (PJ-3) they are mostly composed of pyrite. So the IP anomalies extending towards depth are considered to be caused by pyrite disseminations. It can be concluded that the IP anomalies coincide well with the drilling results when pyrite and chalcopyrite are lumped together as sulphide without discrimination.

The result on each hole is shown in Fig. V-1.

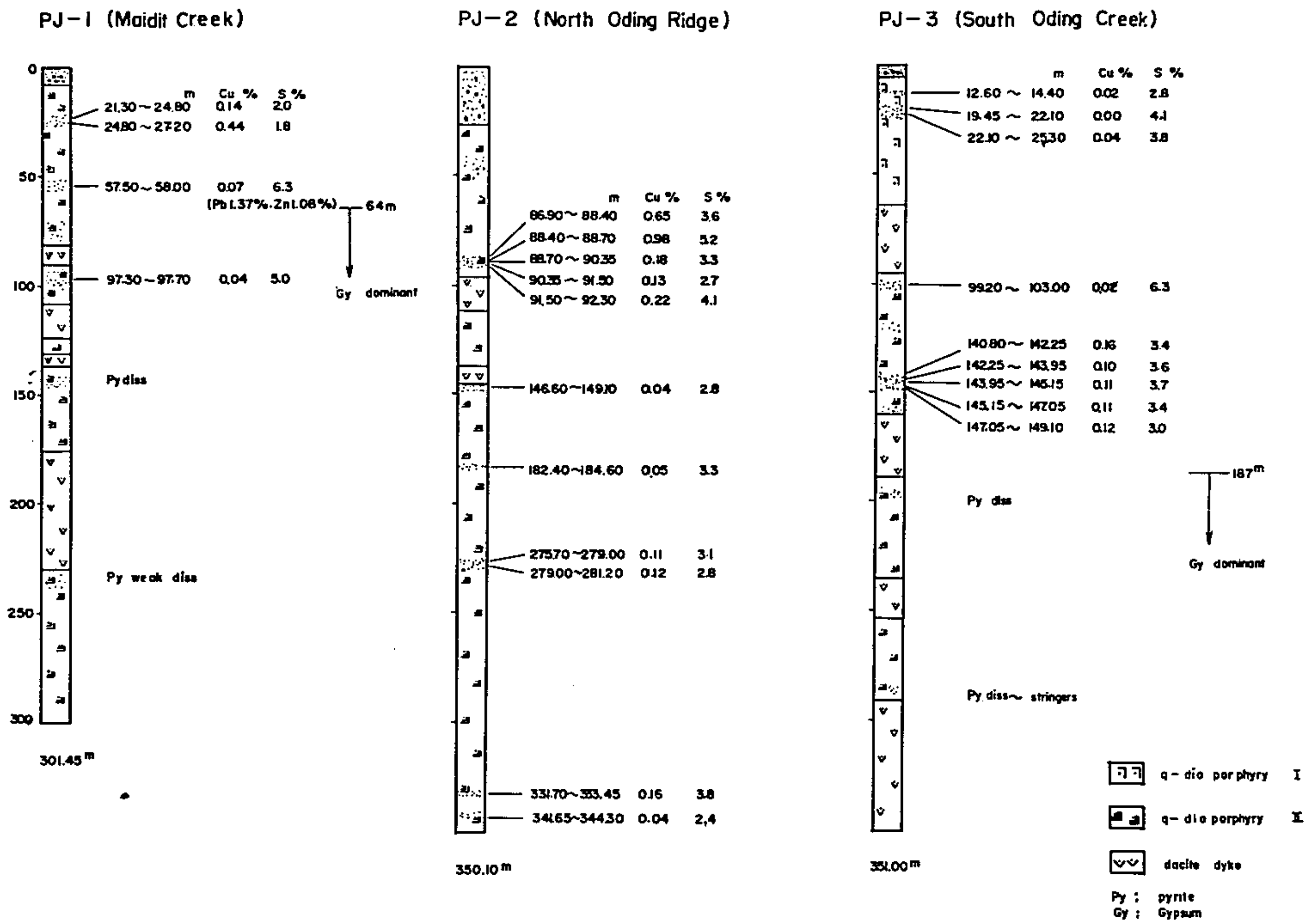


Fig. V-1 Compilation of core-logs

PART VI CONCLUSION

The systematic surveys were carried out in Northeastern Luzon over three years from 1974 to 1976 (fiscal year).

The conclusions obtained by the surveys are as follows:

1. Expecting the known ore deposits, new explorable mineralized zones could not be found in this project area. However, much informations on porphyry copper deposits, vein type deposits and contact metasomatic ore deposits in the area were obtained. Especially, the relation between the igneous activities and the mineralizations in the Cordillera Central and the Sierra Madre became clear, so that some considerations were made on maldistribution of ore deposits in both areas.

2. The geological surveys classified the so-called "Metavolcanics" and "Metasediments" of Cretaceous to Paleogene, distributed widely in the survey area and clarified the ages and environments of their sedimentation. The characters and the ages of the igneous activities were also elucidated from the results of K-Ar dating and rock chemical analysis. These data will play on important role in geological survey or mineral exploration on the surrounding area.

3. It was proved that geochemical drainage survey was very useful for selecting the promising area from the unsurveyed wide are and geochemical soil survey and geophysical ground survey were most effective and efficient for defining the mineralized zone.

4. Based on the survey results of this project, the north extension of the Cordillera Central is believed to have the highest potential for mineral resources. According to the report on the

recconaissance geology of the northwestern Luzon (FERNANDEZ J.C. et. al. 1967), the same igneous rock bodies as the Agno batholith extend intermittently toward north up to the end of Luzon Island and some ore deposits are known on both side of the bodies. The results of this project also suggest the highest potential for mineral resources in the vicinity of the igneous bodies. Therefore, systematic explorations will be desirable in those area.

5. As the relation between alkali rocks and mineralization could not be clarified by the project, further study is needed on the Cordon ore deposits (under exploration) to solve this problem.

APPENDICES

Table A-1 Ages of K-Ar dating

No.	Sample No	Rock Name	Location E Long.	Location N Lat.	Age m.y.	Remarks
			Phase I			
1	A- 22	Gabbro	121°28'	15°53'	19	
2	A- 31	Granite	121°24'	15°50'	45	
3	A-182	Microgabbro	121°40'	16°01'	30	
4	A-200	Granite	121°36'	16°56'	43	
5	A-201	Gabbro	121°35'	16°56'	47	
6	A-283	Granite	121°23'	15°45'	45	
7	B- 35	Gabbro	120°58'	16°08'	25	
8	B- 41	Granodiorite	121°04'	16°09'	27	
9	B- 93	Monzonite	121°19'	16°26'	26	
10	B-314	Granodiorite	121°07'	16°15'	29	
11	B-330	Granite	121°13'	16°22'	25	
12	B-340	Diorite	121°00'	16°13'	29	
13	B-379	Porphyrite	121°07'	16°26'	33	
14	C- 1D	Dacite	120°53'	16°49'	7	
15	C- 3D	Aplite	120°44'	16°27'	9	
16	C- 4D	Quartz dolerite	120°45'	16°27'	27	
17	C- 6D	Andesite	120°47'	16°23'	7	
18	C- 7D	Dacite	120°48'	16°23'	6	
19	D-R7D	Andesite	121°00'	15°54'	10	
20	PA-14	Quartz diorite	121°23'	15°48'	49	
			Phase II			
21	A- 44	Tonalite	121°58'	16°11'	32.5± 3.8	
22	A- 64	Hornblende gabbro	121°13'	16°00'	31.2± 4.2	
23	A-216	Tonalite	120°54'	16°00'	31.7± 2.8	
24	B-118	Hornblende diorite	121°28'	16°22'	20.4± 3.9	
25	B-335	Syenite	121°19'	16°21'	20.3± 2.0	
26	C- 26	Quartz diorite	121°00'	16°12'	30.3± 3.4	
27	C- 35	Schistose amphibolite	120°58'	16°10'	31.7±15.3	
28	C- 98	Quartz gabbro	120°57'	16°03'	74 ±12	
29	H-353	Dacite	120°52'	16°10'	17.6± 1.0	
30	H-380	Amphibole schist	120°43'	16°19'	14.2± 2.2	
31	L- 33	Quartz diorite	121°51'	16°07'	27.4±11	
32	L- 38	Amphibole gabbro	121°20'	15°50'	30.0± 2.9	
33	L- 74	Andesite	120°51'	16°27'	6.1± 0.7	
34	L- 76	Quartz diorite	120°51'	16°26'	3.5± 0.7	mineralized
35	L-115	Syenite	121°13'	16°23'	17.2± 1.0	
36	A- 22	Tonalite	121°43'	16°05'	43.9± 4.2	
37	C-181	Monzonite	121°12'	16°22'	24.9± 4.2	
38	D- 18	Diorite porphyry	120°59'	16°21'	20.6± 1.1	
39	K-576	Andesite	121°19'	16°25'	10.4± 1.3	
40	N-181	Amphibole schist	120°44'	16°22'	82.6±20.6	
			Phase III			
41	k-108	Quartz diorite porphyry	120°52'	16°28'	5.6± 0.3	weakly mineralized
42	k-149	Quartz diorite porphyry	120°51'	16°26'	3.6± 0.6	weakly mineralized
43	k-152	Quartz diorite porphyry	120°51'	16°26'	3.6± 0.2	weakly mineralized
44	j-595	Alkaline gabbro	120°57'	16°21'	23.2± 1.2	
45	g-711	Syenite porphyry	121°15'	16°22'	20.8± 1.2	
46	N- 76	Quartz diorite	120°42'	16°23'	17.9± 0.9	

Table A-2 Chemical composition of the granitic rocks

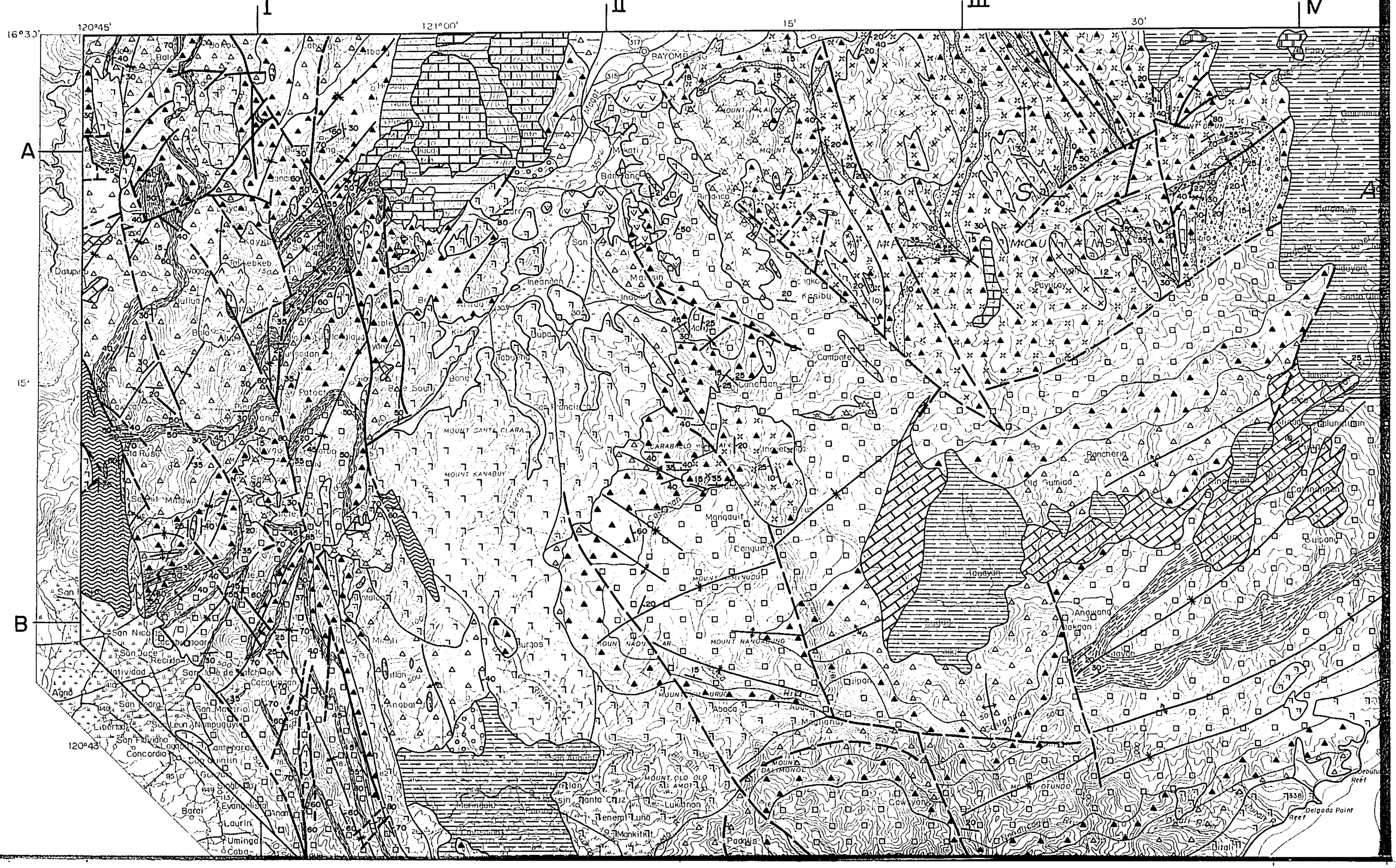
Phase		Sample Number	E Long.	N Lat.	Rock Name	SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	Fe	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5	S	SO_3	CO_2	H_2O (+)	H_2O (-)	Total
I	1	A-200	121°36'	16°56'	Granite	75.15	0.58	11.72	1.68	1.12	-	0.02	1.00	4.30	3.51	0.50	0.02	-	-	-	0.60	0.27	100.47
	2	B- 34	121°00'	16°09'	Gabbro	51.46	0.85	18.72	3.87	5.83	-	0.18	5.67	11.11	1.98	0.53	0.07	-	-	-	0.23	0.11	100.61
	3	B- 93	121°19'	16°26'	Monzonite	51.64	0.92	19.10	2.04	2.70	-	0.03	3.85	7.93	3.40	3.97	0.03	-	-	-	2.92	0.80	99.33
	4	C- 5	120°46'	16°23'	Microdiorite	49.03	0.55	19.56	1.94	4.44	-	0.15	5.64	11.62	3.23	1.09	0.07	-	-	-	2.25	0.34	99.92
	5	PA-14	121°23'	15°40'	Q-diorite	54.98	0.71	16.89	5.07	2.06	-	0.01	5.26	9.23	3.86	0.94	0.05	-	-	-	0.69	0.20	100.55
II	6	A- 20	121°44'	16°08'	Q-diorite	72.16	0.34	13.67	1.08	2.66	-	0.12	0.77	3.21	4.34	0.70	0.06	-	-	-	0.52	0.24	99.87
	7	A- 44	121°58'	16°11'	Quartz gabbro	71.19	0.33	14.23	1.20	2.59	-	0.08	0.88	4.50	3.41	0.40	0.06	-	-	-	0.79	0.18	99.81
	8	A- 64	121°13'	16°00'	Gabbro	52.50	0.74	18.05	3.58	6.72	-	0.16	4.16	8.73	2.91	0.61	0.13	-	-	-	1.21	0.26	99.76
	9	A-216	120°54'	16°00'	Tonalite	69.30	0.47	14.07	0.96	3.84	-	0.11	1.34	3.45	4.30	0.46	0.08	-	0.21	-	1.02	0.30	99.70
	10	B- 18	121°10'	16°28'	Diorite	48.15	0.58	18.76	4.03	4.67	-	0.21	3.21	9.07	3.17	3.57	0.12	-	-	-	2.52	0.48	99.34
	11	B-214	121°18'	16°25'	Syenite	54.27	0.41	20.29	1.71	2.30	-	0.33	1.47	3.11	4.26	7.00	0.19	-	-	-	2.80	0.82	98.96
	12	B-225	121°19'	16°24'	Syenite	52.88	0.63	16.75	5.49	1.78	-	0.13	4.16	5.71	5.27	3.03	0.21	-	-	-	3.09	0.52	99.65
	13	B-251	120°52'	16°25'	Dio-porphyry	63.11	0.44	16.83	2.43	2.55	-	0.09	2.01	2.89	4.67	2.10	0.19	-	-	-	2.20	0.16	99.64
	14	B-335	121°19'	16°21'	Syenite	54.17	0.49	20.06	1.87	2.52	-	0.26	1.38	3.94	4.62	6.94	0.23	-	-	-	2.68	0.42	99.58
	15	B-337	121°19'	16°27'	Syenite	56.59	0.53	19.58	3.08	1.19	-	0.12	1.73	3.14	4.82	4.70	0.13	-	-	-	3.35	0.54	99.50
	16	B-339	121°19'	16°29'	Syenite	57.95	0.42	19.95	2.86	0.79	-	0.06	2.55	1.17	2.78	8.55	0.05	-	-	-	1.95	0.32	99.40
	17	B-342	121°19'	16°25'	Syenite	56.98	0.32	19.98	2.33	1.28	-	0.07	1.81	3.11	3.61	6.32	0.07	-	-	-	3.27	0.67	99.82
	18	C- 7	121°08'	16°15'	Tonalite	60.38	1.04	15.80	4.23	3.63	-	0.23	2.45	3.91	5.08	0.65	0.19	-	-	-	1.48	0.38	99.45
	19	C- 21	121°03'	16°08'	Q-diorite	54.01	0.85	17.96	3.15	5.78	-	0.19	3.66	8.29	3.10	0.58	0.15	-	-	-	1.28	0.36	99.36
	20	C- 26	121°00'	16°12'	Q-diorite	49.09	0.97	18.85	3.56	7.47	-	0.23	4.28	10.16	3.16	0.08	0.33	-	-	-	1.01	0.18	99.37
	21	C- 98	120°57'	16°03'	Quartz gabbro	45.73	1.95	16.08	5.43	9.92	-	0.20	5.73	8.93	3.53	0.13	0.08	-	-	-	1.96	0.18	99.85
	22	C-102	121°19'	16°29'	Monz-porphyry	55.20	0.51	20.24	1.83	2.05	-	0.23	1.38	1.84	4.64	7.82	0.15	-	-	-	2.63	0.46	98.98
	23	C-109	121°18'	16°29'	Monz-porphyry	56.31	0.52	19.88	2.87	2.55	-	0.27	2.19	2.22	4.30	5.55	0.30	-	-	-	2.08	0.30	99.58
	24	C-125	121°17'	16°27'	Syenite	53.24	0.43	20.83	1.55	1.72	-	0.31	1.16	3.84	3.54	8.14	0.13	-	-	-	4.03	0.72	99.64
	25	C-144	120°47'	16°24'	Dio-porphyry	47.98	1.33	19.77	4.37	6.86	-	0.14	4.14	9.62	2.94	0.70	0.11	-	-	-	1.41	0.11	99.59
	26	C-181	121°12'	16°22'	Monzonite	51.55	0.44	19.83	2.26	2.87	-	0.23	1.97	5.25	3.80	5.84	0.30	-	-	-	3.99	0.84	98.97
	27	D- 18	120°59'	16°21'	Diorite	44.71	1.22	16.88	6.05	5.71	-	0.17	7.74	12.24	2.75	0.44	0.64	-	-	-	1.42	0.08	99.75
	28	F-102	121°03'	16°24'	Dio-porphyry	59.96	0.63	16.42	2.90	4.28	-	0.09	2.96	6.47	3.65	0.29	0.10	-	-	-	1.68	0.10	99.61
	29	H- 20	121°07'	16°12'	Granophyer	75.60	0.35	12.49	0.43	2.34	-	0.05	0.64	1.13	4.56	0.84	0.06	-	-	-	1.17	0.04	99.70
	30	H- 32	121°06'	16°13'	Monzonite	50.72	0.37	18.39	7.61	1.18	-	0.08	2.30	8.03	3.14	4.65	0.07	-	-	-	3.36	0.43	100.33
	31	H- 53	121°04'	16°16'	Q-diorite	49.09	0.31	15.94	15.14	2.86	-	0.18	7.85	4.71	2.73	0.51	0.04	-	-	-	0.85	0.13	100.34
	32	H-125	120°58'	16°19'	Q-diorite	48.62	0.27	14.58	5.08	6.49	-	0.09	10.49	11.54	1.17	0.00	0.01	-	-	-	1.88	0.20	100.42
	33	H-192	120°56'	16°10'	Tonalite	51.09	0.45	13.54	1.70	6.14	-	0.13	10.71	12.67	1.85	0.08	0.04	-	-	-	1.34	0.02	99.76
	34	H-210	121°06'	16°03'	Porphyrite	50.45	0.74	15.56	6.20	3.13	-	0.13	3.95	7.98	4.56	3.98	0.12	-	-	-	2.58	0.44	99.82
	35	H-360	120°43'	16°19'	Dacite	62.73	0.20	19.81	2.92	0.94	-	0.06	2.20	4.99	3.93	0.45	0.10	-	-	-	0.89	0.18	99.40
	36	H-372	120°46'	16°19'	Dio-porphyry	53.66	0.98	17.84	0.97	5.46	1.30	0.18	3.84	5.00	4.10	0.53	0.33	1.49	0.16	-	3.35	0.08	99.27
	37	K-576	121°19'	16°23'	Andesite	48.32	0.88	15.78	5.25	2.76	-	0.13	6.98	9.05	3.59	3.99	0.12	-	-	-	2.71	0.35	99.91
	38	K-578	121°19'	16°25'	Monzonite	48.11	0.87	19.73	3.43	2.98	-	0.28	1.87	6.90	4.57	5.33	0.29	-	-	-	4.25	0.54	99.15
	39	L- 22	122°04'	16°20'	Quartz gabbro	74.59	0.28	13.07	0.79	2.08	-	0.07	0.54	2.21	4.62	0.43	0.05	-	-	-	0.79	0.08	99.60
	40	L- 33	121°51'	16°07'	Q-diorite	62.49	0.56	15.74	2.10	5.21	-	0.14	2.67	6.45	3.23	0.30	0.06	-	-	-	0.79	0.02	99.76
	41	L- 38	121°20'	15°50'	Amp-gabbro	51.22	0.79	17.02	3.82	7.40	-	0.27	4.88	9.89	2.32	0.32	0.05	-	-	-	1.30	0.02	99.30
	42	L- 74	120°51'	16°27'	Andesite	59.83	0.46	17.24	2.02	1.98	-	0.11	2.60	5.52	4.24	1.96	0.15	-	-	-	2.80	0.40	99.31
	43	L- 76	120°51'	16°26'	Q-diorite	58.21	0.61	18.13	1.12	3.84	0.72	0.08	2.74	3.65	4.37	2.02	0.28	0.83	0.49	-	2.28	0.14	99.51
	44	L-115	121°13'	16°23'	Syenite	54.66	0.41	20.97	1.75	2.23	-	0.19	0.91	3.24	4.10	7.31	0.15	-	-	-	2.90	0.90	99.72
	45	N-181	120°44'	16°22'	Amp-schist	52.21	0.45	17.99	1.11	6.14	-	0.17	6.81	11.15	0.03	1.94	0.10	-	-	-	1.61	0.04	99.75
III	46	k-108	120°52'	16°28'	Q-dio-porp	55.71	0.56	17.22	1.44	3.59	-	0.25	2.35	5.55	3.85	2.17	0.26	-	-	3.63	2.91	0.14	99.63
	47	k-140	120°50'	16°27'	Q-dio-porp	61.54	0.40	16.90	1.19	2.37	0.44	0.23	1.65	3.72	4.14	2.14	0.21	0.51	0.08	1.74	2.23	0.14	99.63
	48	k-149	120°51'	16°26'	Q-dio-porp	59.29	0.52	17.79	2.11	3.77	-	0.14	2.52	4.56	4.70	2.17	0.26	-	-	-	1.35	0.06	99.24
	49	k-152	120°51'	16°26'	Q-dio-porp	58.66	0.59	17.79	2.39	3.81	-	0.13	2.66	5.37	4.61	2.26	0.26	-	-	-	0.70	0.04	99.27
	50	k-193	120°51'	16°26'	Q-dio-porp	61.73	0.53	16.25	1.04	3.13	0.69	0.10	2.34	3.33	3.37	2.74	0.24	0.79	0.23	0.77	1.99	0.12	99.39
	51	g-711	121°15'	16°22'	Sye-porphyry	45.30	0.78	19.93	4.26	3.84	-	0.28	3.22	9.37	2.52	3.62	0.86	-	-	-	4.99	0.82	99.79
	52	J-595	120°57'	16°21'	Alkali gabbro	56.79	0.55	17.64	3.00	3.70	-	0.17	3.06	6.98	3.66	2.64	0.25	-	-	-	0.82	0.14	99.40
	53	N- 16	120°41'	16°23'	Q-diorite	58.29	0.55	17.61	2.75	3.99	-	0.16	3.27	6.04	3.22	0.92	0.18	-	-	0.35	1.88	0.14	99.35
	54	N- 76	120°42'	16°23'	Q-diorite	62.50	0.35	17.48	2.47	2.73	-	0.10	1.80	6.01	3.88	0.90	0.17	-	-	-	0.80	0.10	99.29

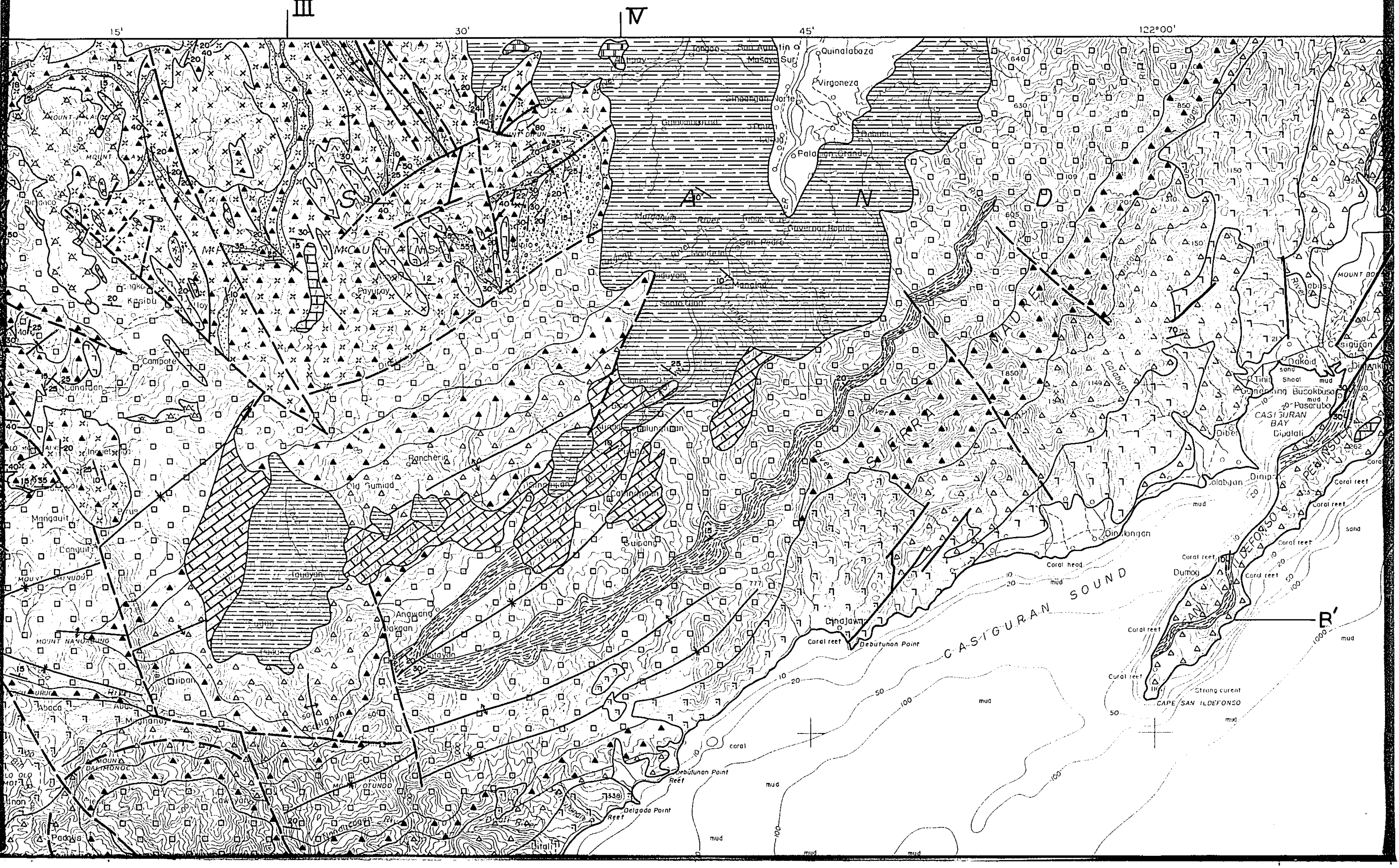
Abbreviation:

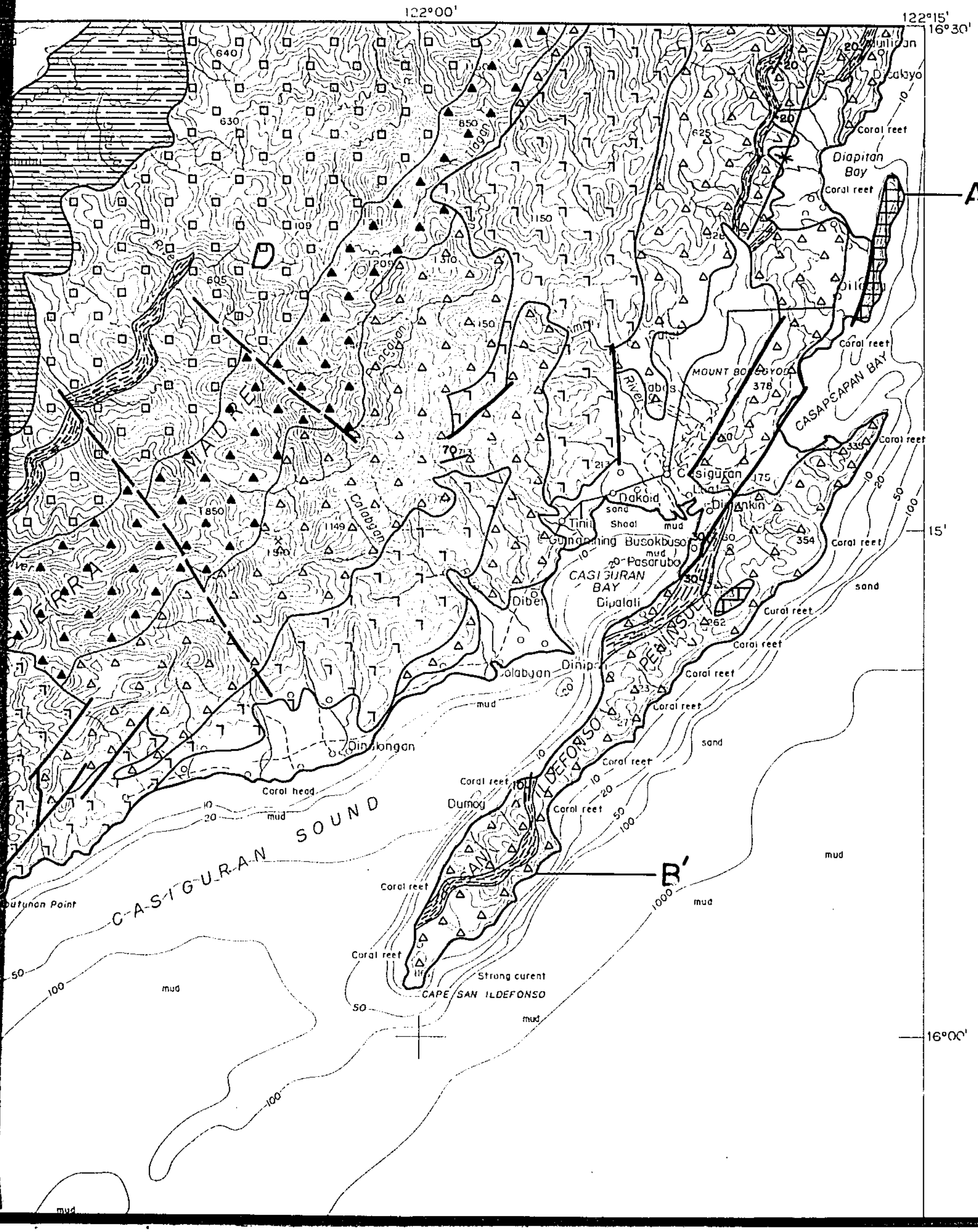
Q-diorite: Quartz diorite
Q-dio-porp: Quartz diorite porphyry
Dio-porphyry: Diorite porphyry
Monz-porphyry: Monzonite porphyry
Sye-porphyry: Syenite porphyry
Amp-gabbro: Amphibole gabbro
Amp-schist: Amphibole schist

Table A-3 List of fossil

Phase	No.	Sample Number	Location E Long.	Location N Lat.	Operculina complanata	O. venosa	O. sp.	Heterostegina borneensis	H. sp.	Spiroclypeus leupoldi	S. higinsi	S. sp.	Sporadotrema cylindricum	Sorites marginalis	Schlumbergella sp.	Cycloclypeus eidae	C. sp.	Coral	Nephrolepidina angulosa	N. inflata	N. japonica	N. ferreroi	N. sumatrensis	N. verbeeki	N. sp.	N. parva	Eulepidina formosa	E. ephippioides	E. sp.	E. monstrosa	Miogypsina polymorpha	M. sp.	Marginopora vertebralis	Miniacina miniacea	Amphistegina radiata	A. sp.	Austrotrillina howchini	Acervulina inhaerens	Borelis pygmaeus	B. philippinensis	Benthonic foraminifera	Flosculinella bontangensis	F. philippinensis	Planorbulinella larvata	Planktonic foraminifera	Pararotaria sp.	Textularia sp.	Gypsina globulus	G. vesicularis	Rotalia sp.	Geological Age
Phase I	1	A- 2	121°39'	16°15'			○			○							○									○			○	○																		○	○		U. Oligocene
Phase I	2	A- 3	121°39'	16°14'			○	○		○							○												○	○										○											U. Oligocene
Phase I	3	A- 6	121°32'	16°10'							○						○									○		○							○																U. Oligocene
Phase I	4	A- 29	121°31'	15°40'								○																							○		○					○									L. Miocene
Phase I	5	B-332	120°56'	16°09'																			○													○							○	○							L. Miocene
Phase I	6	B-333	120°57'	16°08'													○												○																						L. Miocene
Phase I	7	B-395	121°30'	16°29'			○																		○															○								○			M. Miocene
Phase I	8	C- 57	120°49'	16°23'													○								○						○				○		○							○				○	○		L.- M. Miocene
Phase II	9	A-107	121°49'	16°28'																○							○					○										○									L. Miocene
Phase II	10	B- 53	120°57'	16°24'			○										○															○																			Miocene
Phase II	11	B-129	121°31'	16°29'					○													○			○	○			○																						Oligocene- L. Miocene
Phase II	12	C- 65	120°56'	16°04'						○																	○																								Oligocene
Phase II	13	C- 92	120°56'	16°06'																														○							○			○							
Phase II	14	D- 20	120°58'	16°20'		○			○							○					○	○		○		○	○								○			○						○	○						Oligocene
Phase II	15	D- 26	120°58'	16°20'																														○				○			○										
Phase II	16	E- 72	120°57'	16°09'																															○																
Phase II	17	E- 73	120°57'	16°09'					○																○								○	○			○		○		○			○							U. Oligocene- L. Miocene
Phase II	18	E-128	120°56'	16°09'									○																																						
Phase II	19	F- 28	121°03'	16°25'			○											○																	○																
Phase II	20	F- 30	121°03'	16°25'														○																																	
Phase II	21	F- 31	121°01'	16°26'				○								○						○		○	○				○		○				○			○						○							Oligocene
Phase II	22	G- 16	121°03'	16°25'														○																																	
Phase II	23	G- 17	121°02'	16°25'														○																																	
Phase II	24	H-231	121°01'	15°52'																					○																										
Phase II	25	H-306	120°48'	16°16'																																									○						
Phase II	26	H-377	120°46'	16°20'						○															○					○					○																Oligocene
Phase II	27	K- 16	120°59'	16°26'	○	○											○		○																○						○										Miocene
Phase II	28	K- 66	121°31'	16°22'																									○																						Oligocene- L. Miocene
Phase II	29	L- 1	121°42'	16°21'																																									○					○	
Phase II	30	L- 5	121°41'	16°19'											○														○					○											○						
Phase II	31	L- 6	121°41'	16°18'						○	○			○		○											○							○	○											○	○	○			Oligocene
Phase II	32	M-159	120°54'	16°24'													○										○																								Oligocene- L. Miocene
Phase II	33	N- 53	120°58'	16°14'															○	○											○				○																L. Miocene


I
II
III
IV
A
B
16°30'
120°45'
121°00'
15'
30'
120°43'
BAYOMBONG
MOUNT SANTA CLARA
MOUNT KANABUY
Burgos
Campote
Old Gumiad
Ranchería
San Nicolas
Agno
Concordia
Laurin
Delgado Point
Reef


III
IV
15'
30'
45'
122°00'
Quinalabaza
Virgoneza
San Agustin
Masaya Sur
Sinadangan Norte
Palapian Grande
Dabubu
River
Governor Rapids
San Pedro
Maria Aurora
Santa Lucia
Manatad
Rancheria
Old Gumiad
Pinagabihan
Catinanan
Quipang
Angwang
Dakgan
Bayabas
Campote
Canarian
Mangauit
Casiguran
Dakaid
Tinib
Shoal
mud
Bucokbuco
Pasarubo
CASIGURAN BAY
Dipalali
Dibet
Dinipan
Dinalongan
Colabgan
Coral reef
Coral head
sand
Dumog
CASIGURAN SOUND
SAN ILDEFONSO PENINSULA
Strong current
CAPE SAN ILDEFONSO
R'
Cinalawan
Debutunan Point
Delgado Point
Reef
coral
Mount Nangabung
MOUNT BO
Abaca
Paduis
Cawayan
Dilali
Dinalai River
Ditali
A
N
D
S
MADRE
CUPRA
MOUNT DALIMONOC



PL. I

GEOLOGICAL SURVEY OF NORTHEASTERN LUZON PHILIPPINES

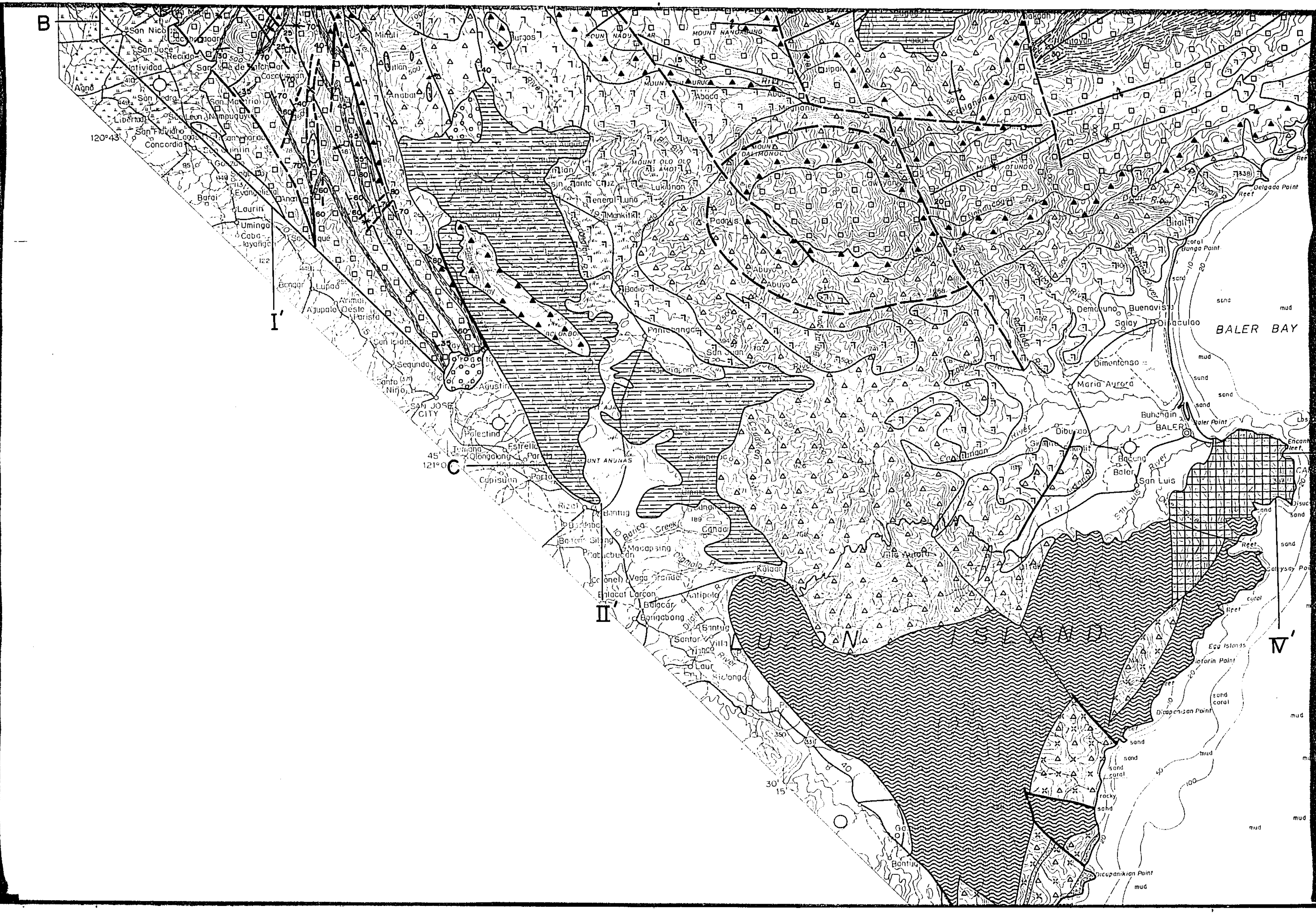
GEOLOGICAL MAP

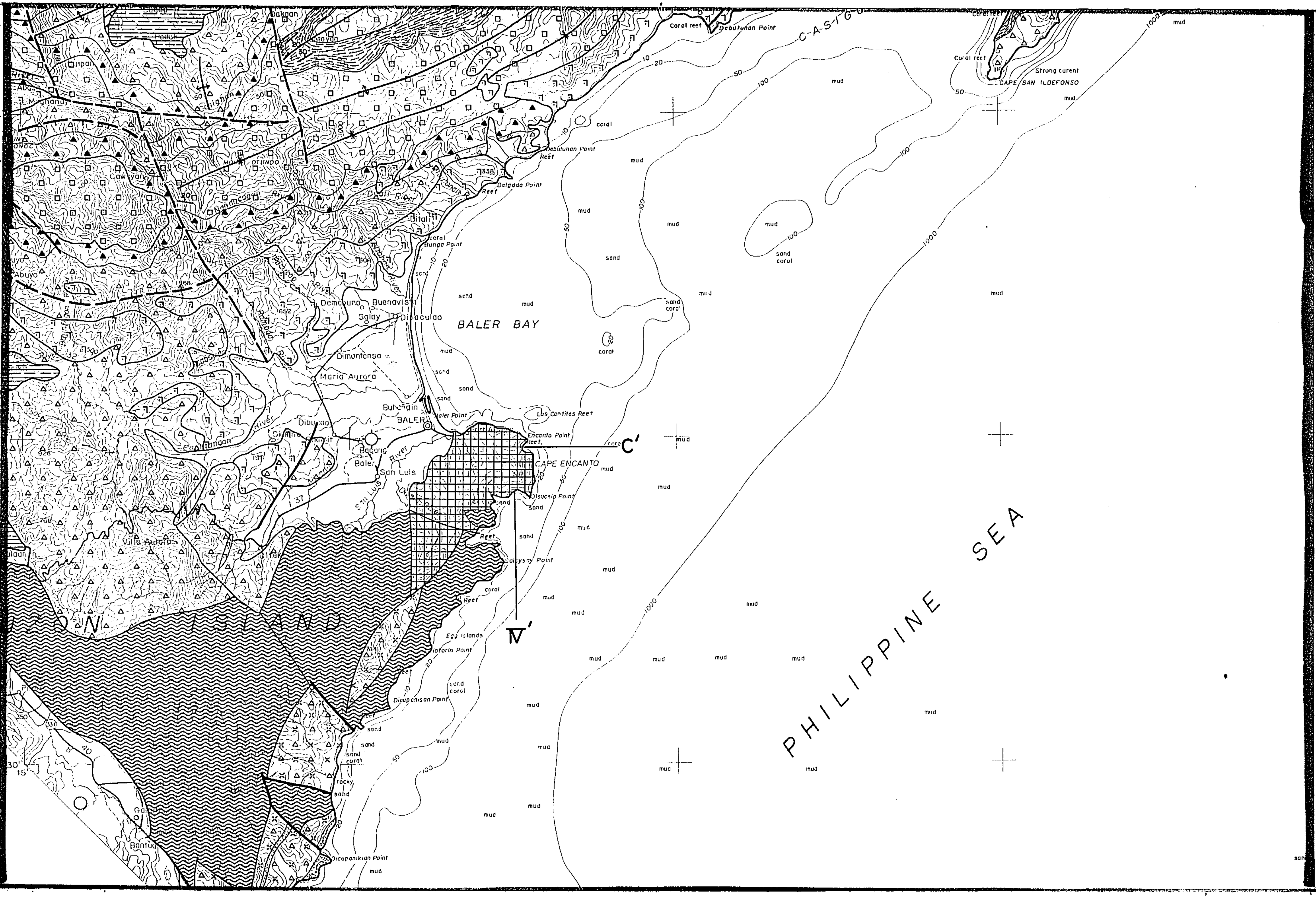
SCALE 1 : 250,000

0 20KM

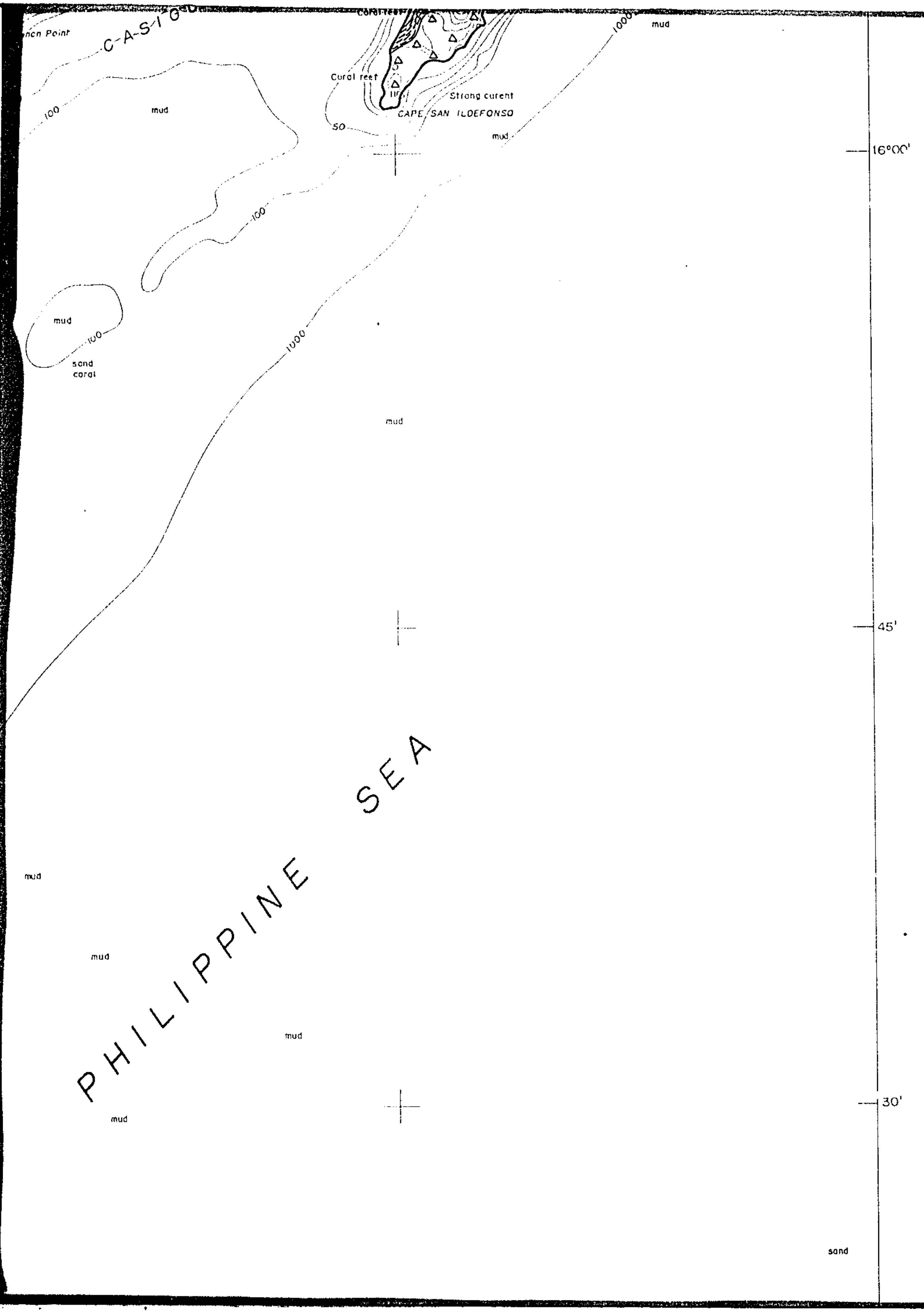
METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1977

Prepared by Bishimetal Exploration Co., Ltd.


B
C
I'
II'
IV'
120°43'
121°0'
45'
30'
15'
BALER BAY
BALER
Baler Point
San Luis
Maria Aurora
Dimentonso
Dipaculao
Buenavista
Delgado Point
Egg Islands
Dicapanisan Point
Dicapanikian Point
MOUNT NANOABUNG
SAN JOSE CITY
Palestina
Rizal
Bantug
Agustin
Segunda
Concordia
Libertad
San Pedro
Agno
Villa Aurora
Macapsing
Vega Grande
Bulacar
Antipolo
sand
mud
coral
Reef



Coral reef
Debutunan Point
C-A-S-I-G-U
Strong curent
CAPE SAN ILDEFONSO
Debutunan Point Reef
Delgada Point
Reef
Bitali
Dibuli River
Bunga Point
BALER BAY
Demabuno
Buenavista
Salay
Dibaculao
Dimanfonso
Maria Aurora
Buhangin
BALER
Baler Point
Los Contites Reef
Encanto Point Reef
C'
CAPE ENCANTO
Bacong Baler
San Luis
San Luis River
Disucsip Point
Calisysay Point
Villa Aurora
Cawayan
Abuyo
Mt. DIBUNDO
ISLAND
IV'
Ego Islands
Diafarin Point
Dicapanisan Point
Dicupanikian Point
PHILIPPINE SEA
Bantug



0 20KM

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1977

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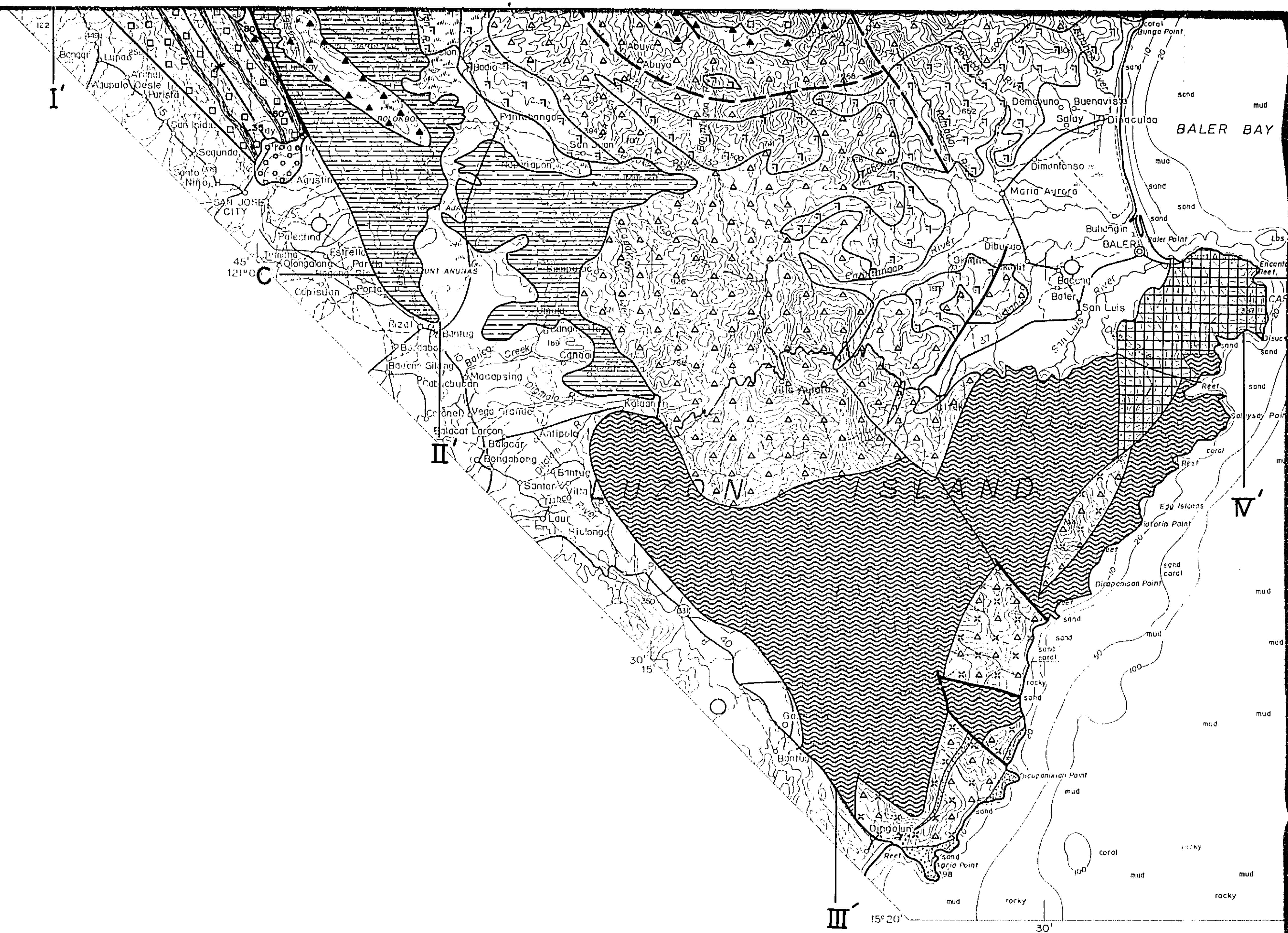
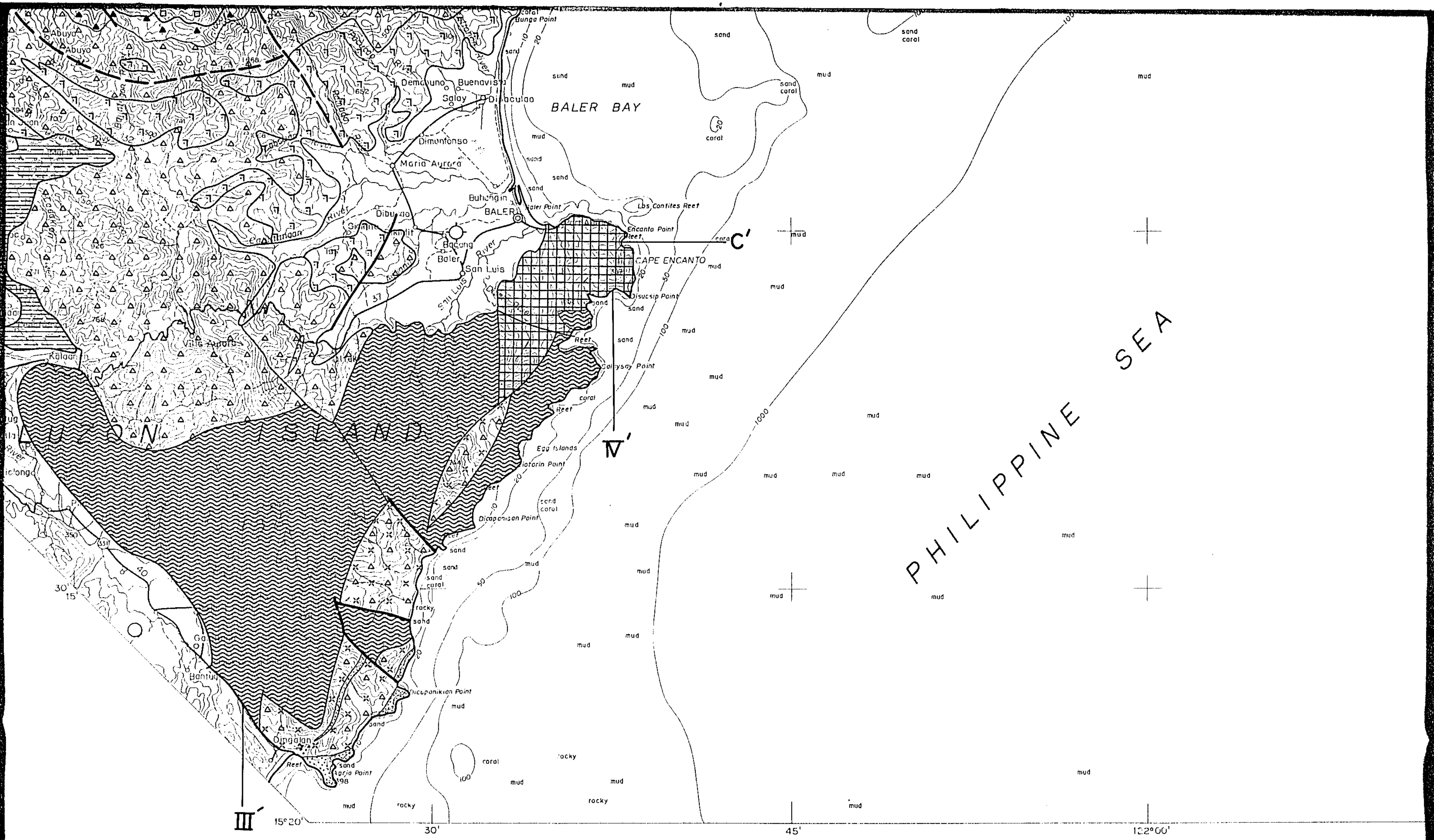
LEGEND

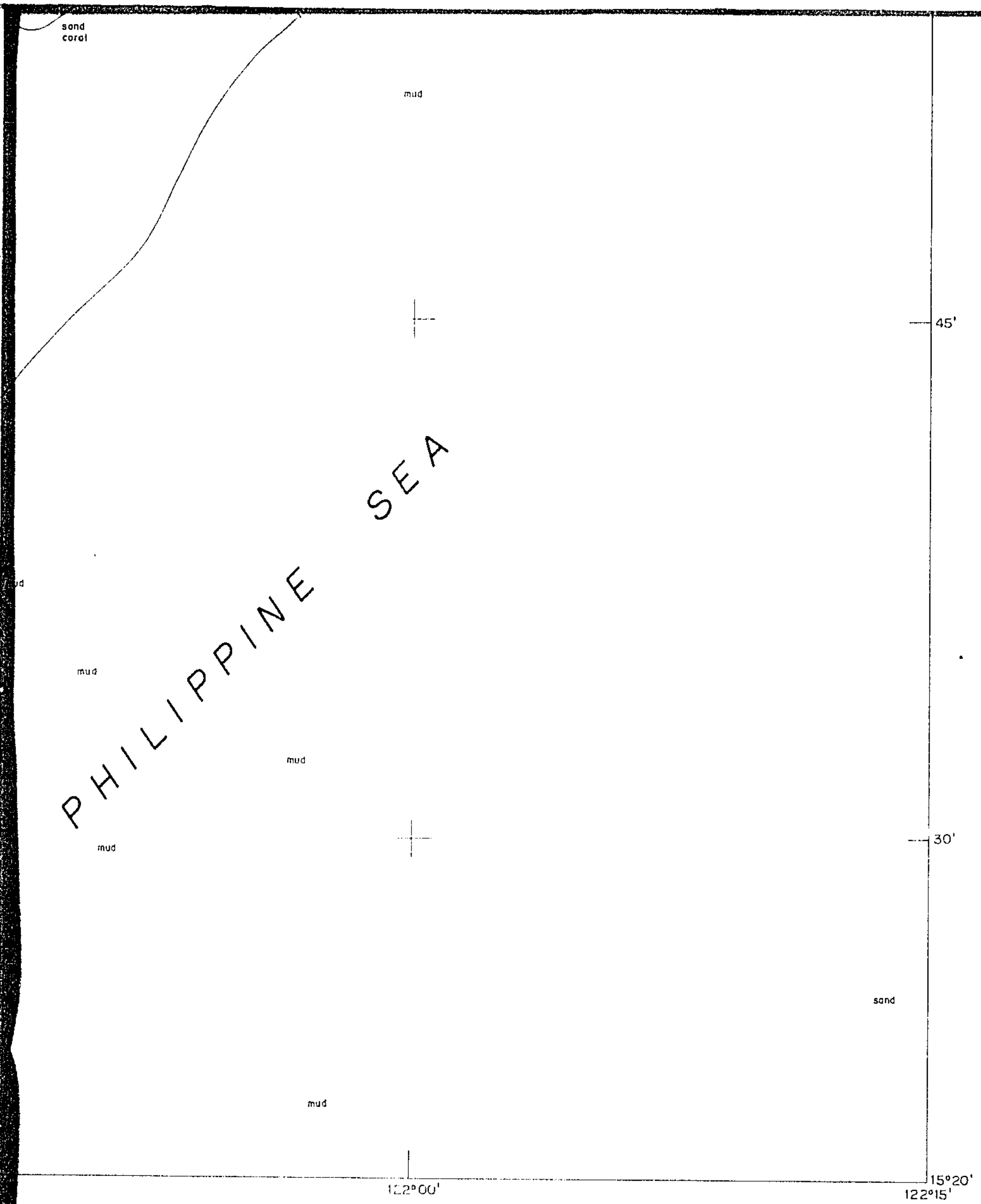
- RECENT
  - Gravel
  - Talus deposit
- PLEISTOCENE
  - Terrace deposit
- MIOCENE
  - Matuno F. — Mud st, s.s. and cgl.
  - Santa Fe F. — Ls
  - Aglipay F. — Ls
  - Matbang F. — s.s, Cgl. and md st.
  - Palali F. — Mud st, and s.s
  - Palali F. — Volcanics
- OLIGOCENE
  - Columbus F. — Ls
  - Mamparang F. — cgl.; s.s.
  - Mamparang F. — Volcanics
- U.CRETACEOUS-EOCENE
  - Caraballo G. — Formation III; Shale, s.s. and tf
  - Caraballo G. — Formation II
  - Caraballo G. — Formation I
- Basement
  - Schist
- Unknown stage
  - Dacite
- INTRUSIVES
  - Dacite
  - Andesite
  - Syenite and Monzonite (Sy-porphyry and Mon-porphyry)
  - Qz-diorite and Diorite (Qz-porphyry and Dio-porphyry)
  - Tonalite
  - Ultra basic r.

Bedding



I'
II'
III'
IV'
C
45'
121°0
30'
15'
15°20'
30'
BALER BAY
LUZON ISLAND
Baler
Baler Point
Bunga Point
Buenavista
Salay
Dimanfonso
Maria Aurora
Dibuyao
Bacong
San Luis
San Luis River
Villa Aurora
Dingalan
Egg Islands
Dicapanisan Point
Dicapanikian Point
Dimalaga Point
Colisay Point
Encanto
Abuyo
Pantabangan
San Juan
Badio
Bantug
Rizal
Macapsing
Vega Grande
Antipolo
Bongabong
Palestina
Estrella
Conisuan
Qlongalong
San Jose City
Agustin
Santo Niño
Segunda
Lupao
Agupalo Oeste
Baloc Creek
Creek
River
reef
coral
sand
mud
rocky


BALER BAY
PHILIPPINE SEA
LUZON ISLAND
Bunga Point
Dempuno
Buenavista
Salay
Dibacuiao
Dimanfonso
Maria Aurora
Buhangin
BALER
Baler Point
Los Contites Reef
Encanto Point
CAPE ENCANTO
Disucsip Point
San Luis
San Luis River
Bacong
Baler
Dibutao
Villa Aurora
Calaysay Point
Egg Islands
Dicapanisan Point
Dicapanikian Point
Dingalan
Abuyo
Bantug
C′
Ⅳ′
Ⅲ′
sand
mud
coral
rocky
Reef
15°20′
30′
45′
122°00′



RECENT
- Gravel
- Talus deposit

PLEISTOCENE
- Terrace deposit

MIOCENE
- Matuno F. — Mud st, s.s. and cgl.
- Santa Fe F. — Ls
- Aglipay F. — Ls
- Matbang F. — s.s, Cgl. and md st.
- Patali F. — Mud st, and s.s
- Patali F. — Volcanics

OLIGOCENE
- Columbus F. — Ls
- Mamparang F. — cgl.
- Mamparang F. — s.s.
- Mamparang F. — Volcanics

U.CRETACEOUS–EOCENE
- Caraballo G. — Formation III
- Caraballo G. — Shale, s.s. and tf
- Caraballo G. — Formation II
- Caraballo G. — Formation I

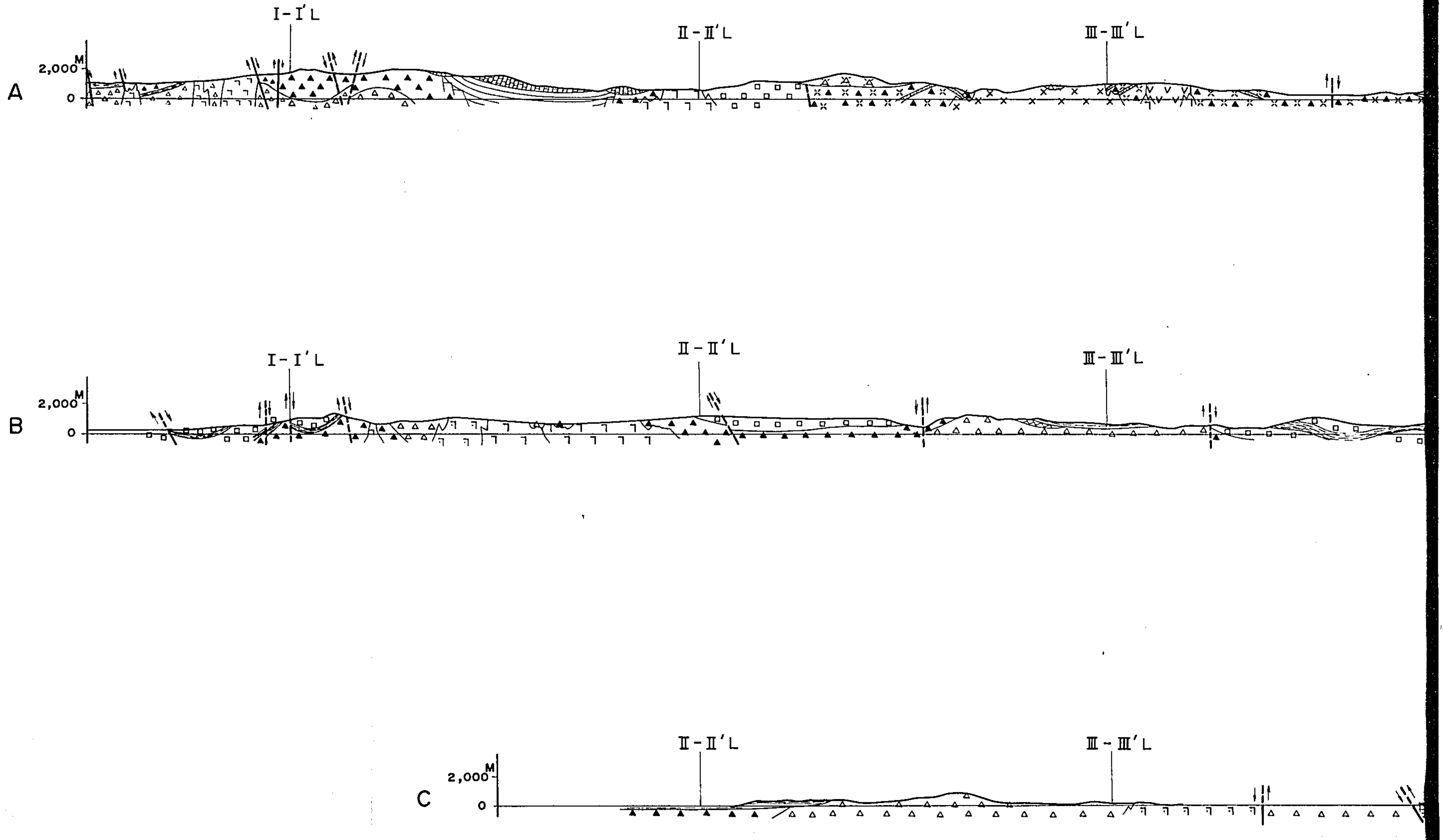
Basement
- Schist

Unknown stage
- Dacite

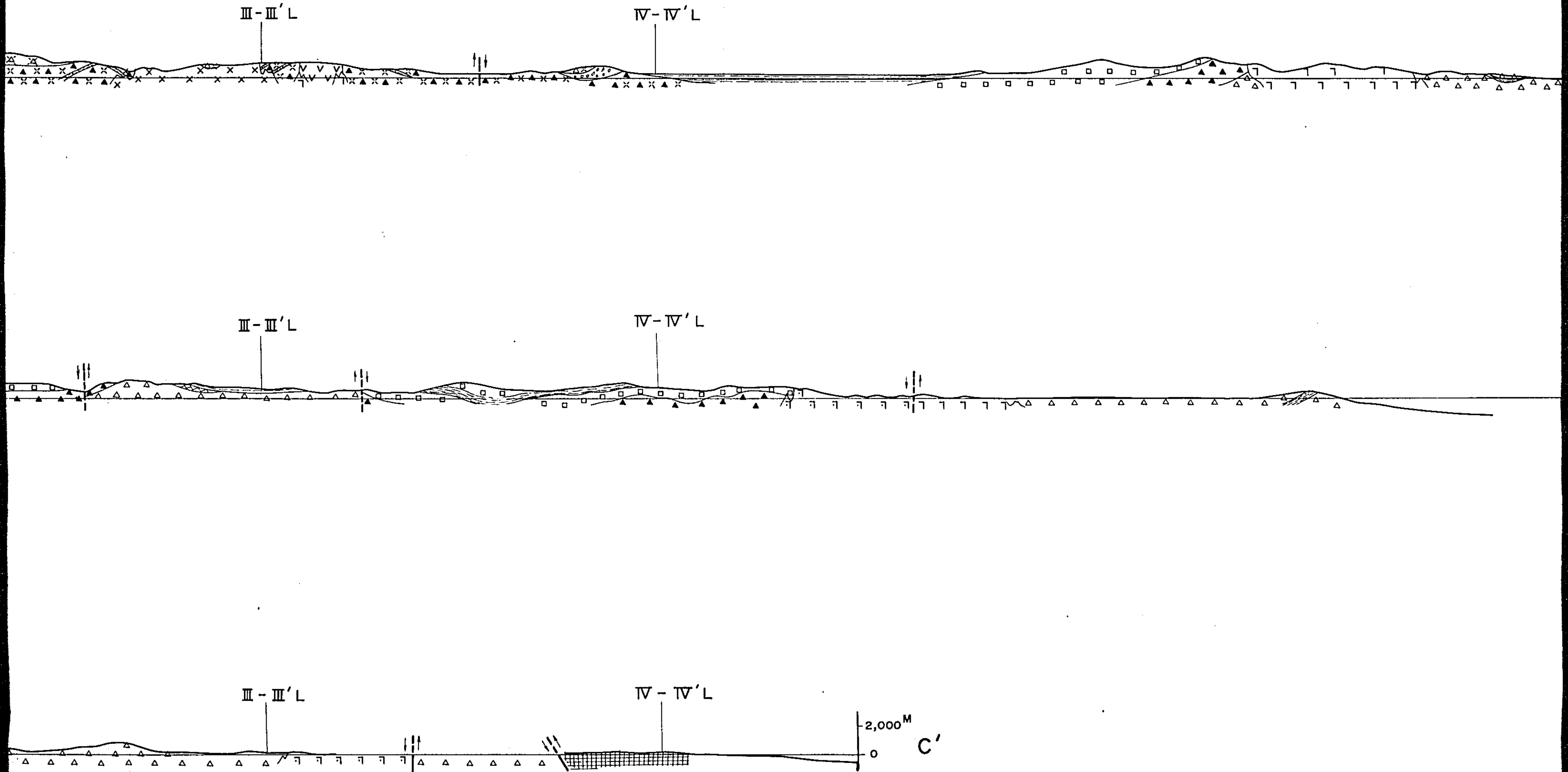
INTRUSIVES
- Dacite
- Andesite
- Syenite and Monzonite (Sy-porphyry and Mon-porphyry)
- Qz-diorite and Diorite (Qz-porphyry and Dio-porphyry)
- Tonalite
- Ultra basic r.

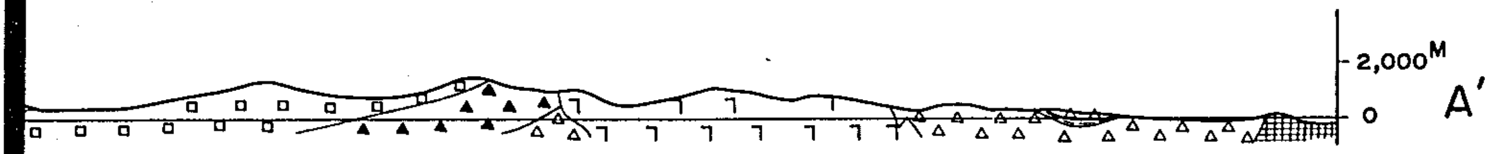
- Bedding (50, 80)
- Syncline
- Anticline
- Fault
- Approximate fault
- Basin structure

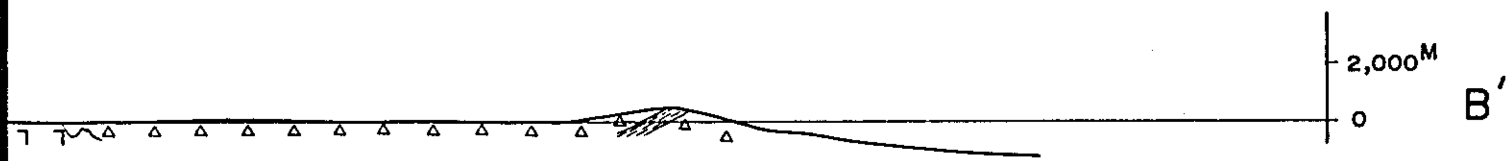
W - E LINE



W - E LINE





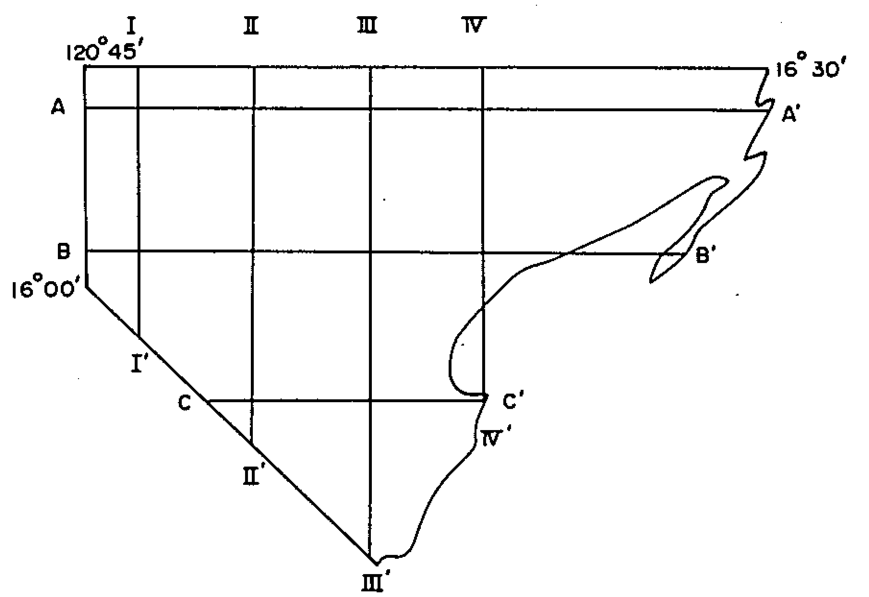


PL. 2

GEOLOGICAL SURVEY OF NORTHEASTERN LUZON PHILIPPINES

GEOLOGICAL PROFILE

LOCATION INDEX

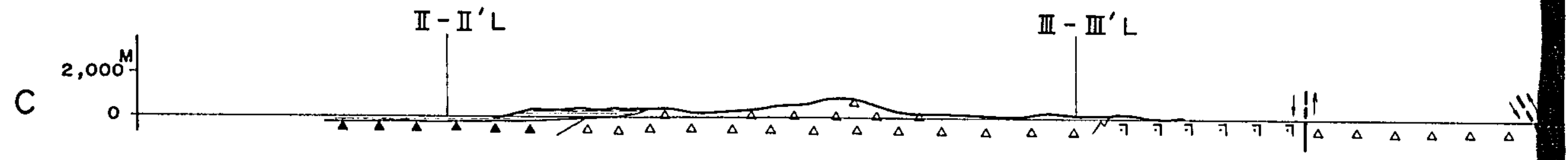


SCALE 1 : 250,000

0 20KM

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1976

Prepared by Bishimetal Exploration Co., Ltd.



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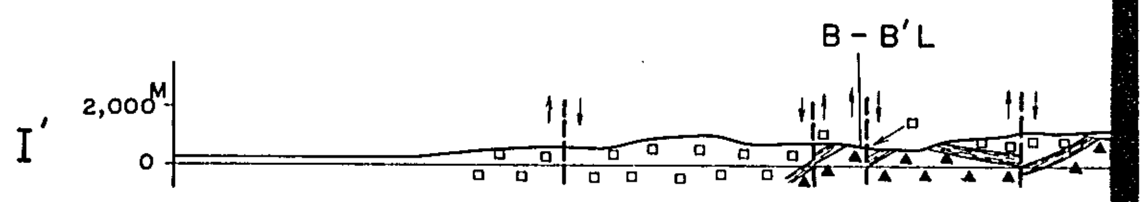
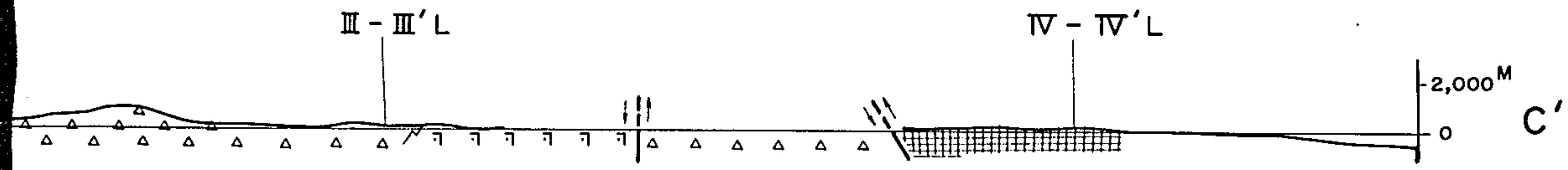
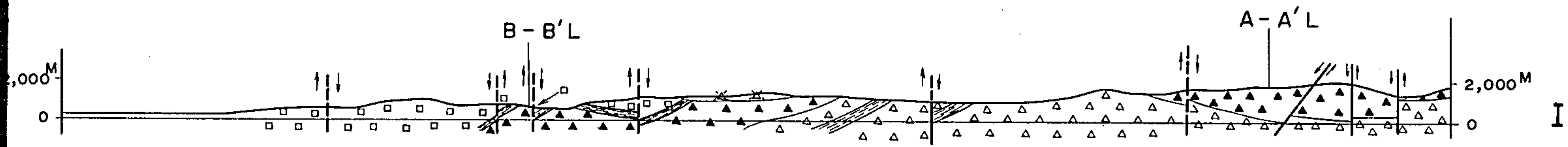
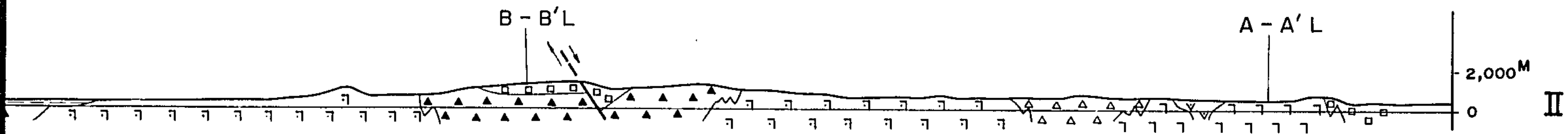
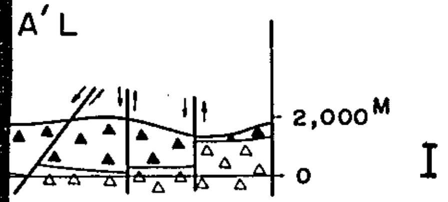


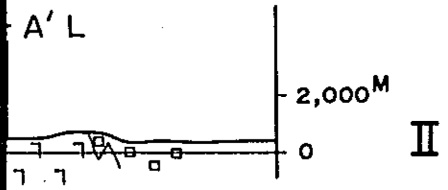


S – N LINE









SCALE 1 : 250,000

0 — 20KM

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1976

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LEGEND

RECENT
- Gravel
- Talus deposit

PLEISTCENE
- Terrace deposit

MIOCENE
- Matuno F. — Mud st, s.s. and cgl.
- Santa Fe F. — Ls.
- Natbang F — s.s, cgl and s.s.
- Palali F. — Mud st and s.s.
- Palali F. — Volcanics

Unknown stage
- Dacite

OLIGOCENE
- Columbus F. — Ls.
- Mamparang F. — cgl.
- s.s.
- Mamparang F. — Volcanics

U.CRET ~ EOCENE
- Caraballo G. — Formation III
- Shale, s.s. and tf
- Caraballo G. — Formation II
- Caraballo G. — Formation I

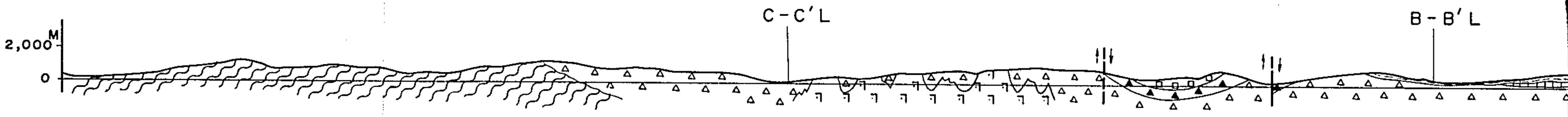
Basement
- Schist

INTRUSIVES
- Dacite
- Andesite
- Syenite and Monzonite (Sy-porphyry and Mon-porphyry)
- Qz-diorite and Diorite (Qz-porphyry and Dio-porphyry)
- Tonalite
- Ultra basic r.

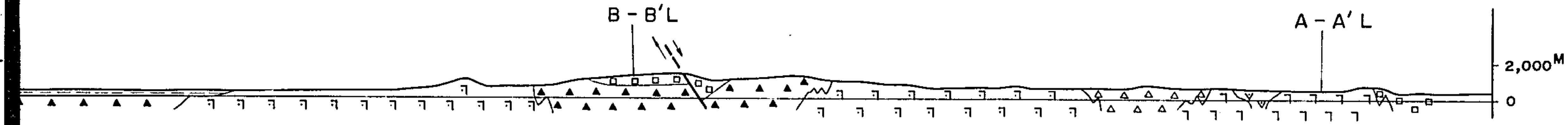
- Fault

Ⅱ′

Ⅲ′



Ⅳ′



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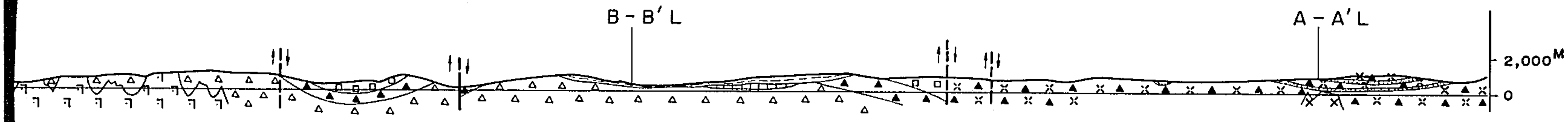
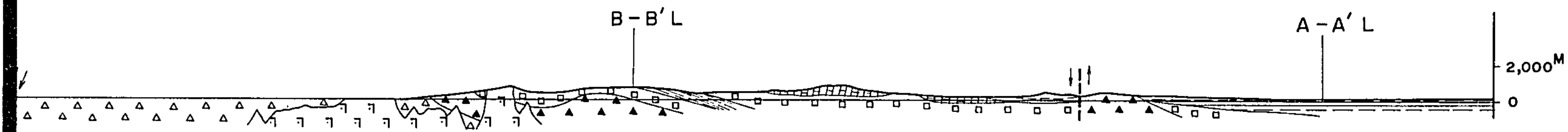
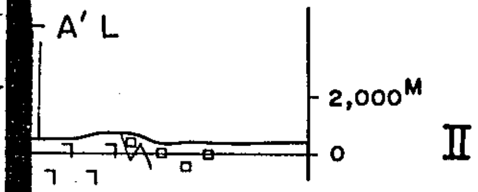
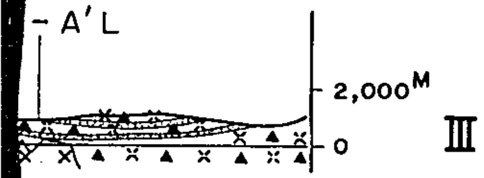


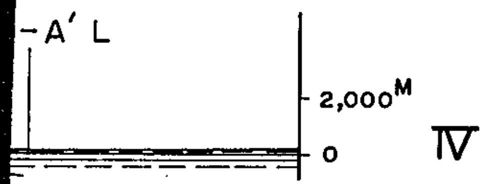
III



IV





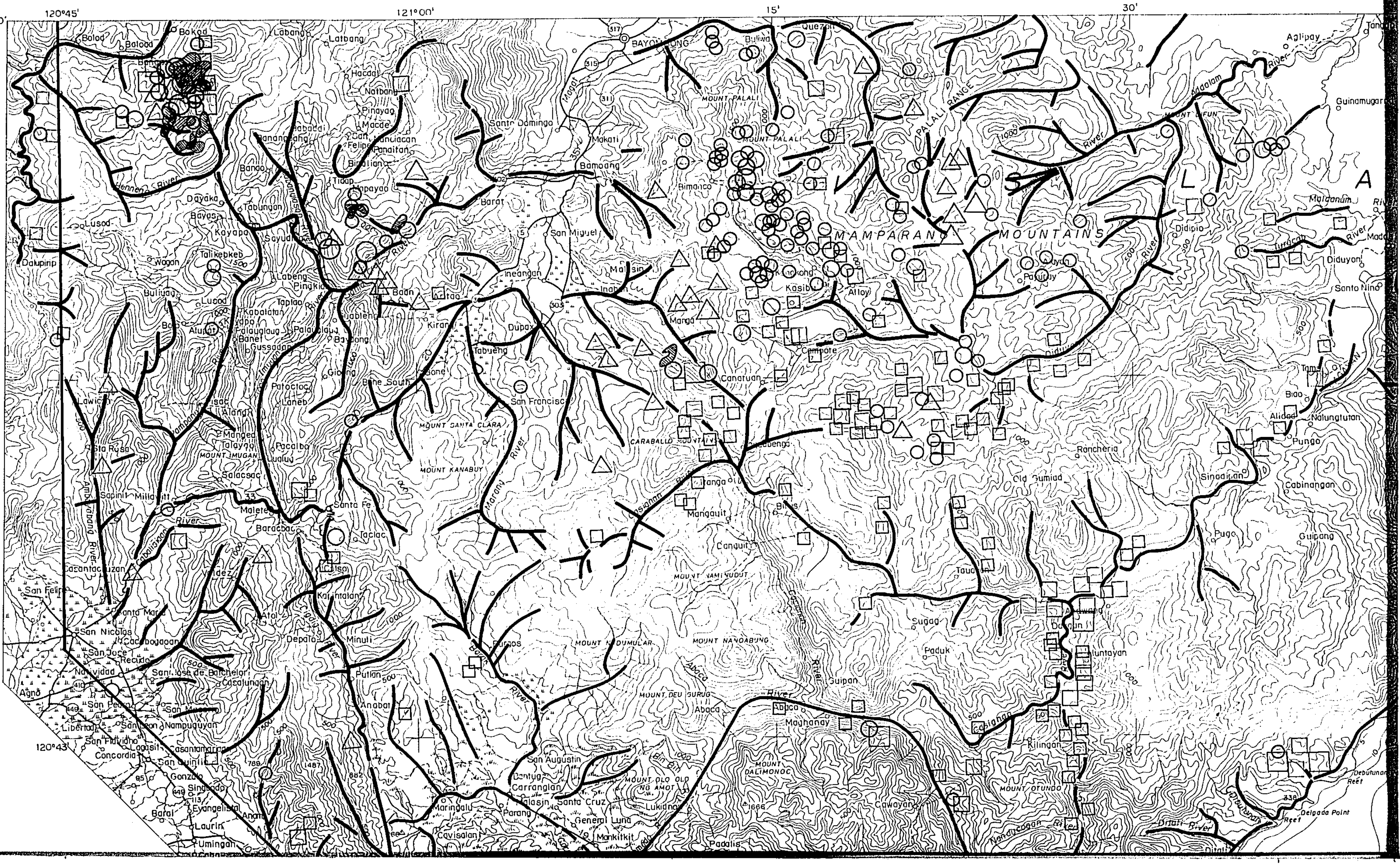


Basement — Sthist

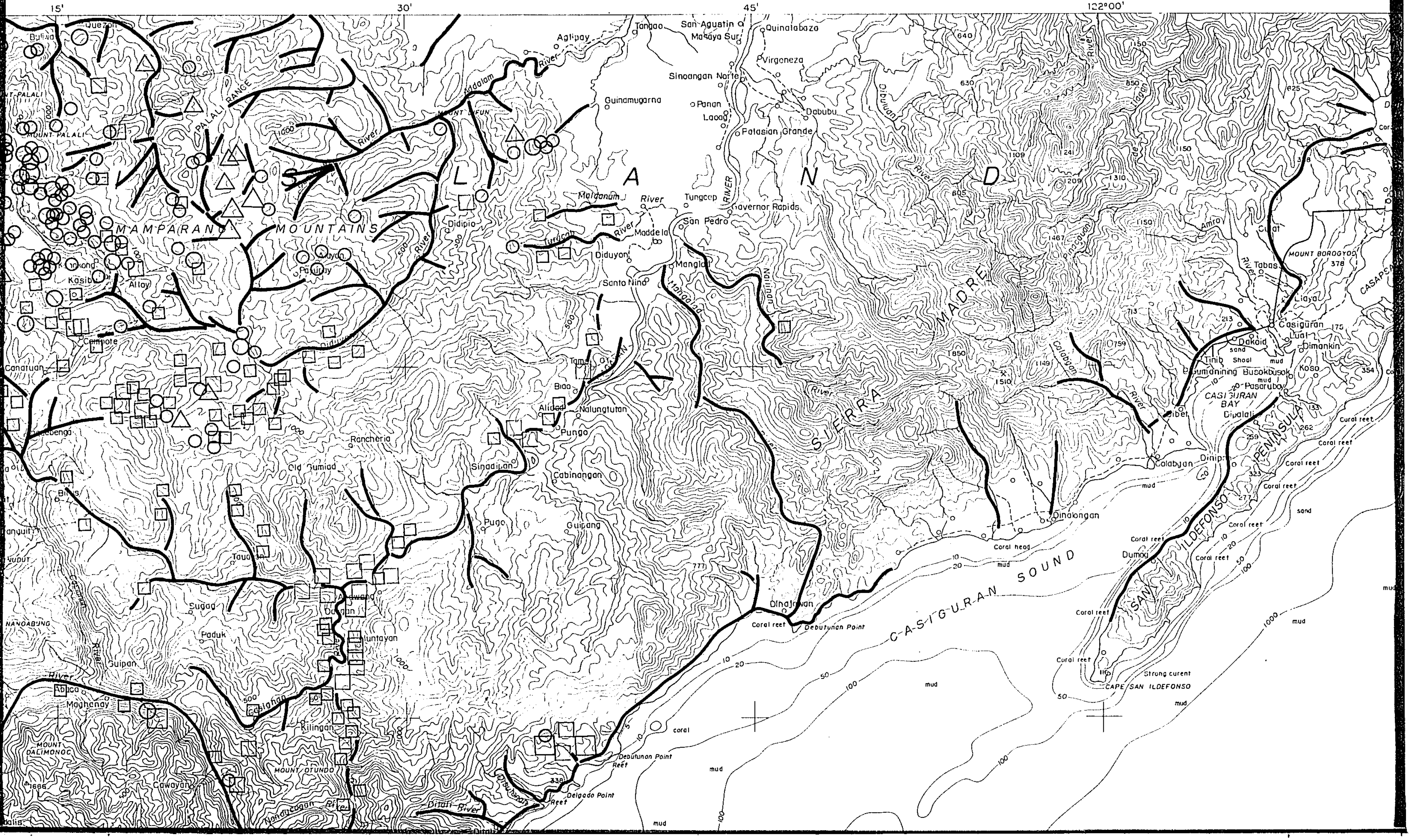
INTRUSIVES

- Dacite
- Andesite
- Syenite and Monzonite (Sy-porphyry and Mon-porphyry)
- Qz-diorite and Diorite (Qz-porphyry and Dio-porphyry)
- Tonalite
- Ultra basic r.

- Fault
- Approximate fault



16°30'
120°45'
121°00'
15'
30'
120°43'
BAYOMBONG
MOUNT PALALI
PALALI RANGE
MAMPARANG MOUNTAINS
CARABALLO MOUNTAINS
MOUNT SANTA CLARA
MOUNT KANABUY
MOUNT IMUGAN
MOUNT NAMINUDUT
MOUNT NADUMULAR
MOUNT NANOABUNG
MOUNT DEU SURUG
MOUNT DALIMONOC
MOUNT OTUNDO
Quezon
Buliwa
Bokod
Balood
Bolod
Labang
Latbang
Hacdal
Natbang
Pinayag
Macde
Santo Domingo
Makati
Bamoang
Bimanco
Barat
San Miguel
Ineangan
Dupax
Tabueng
San Francisco
Canatuan
Campote
Kasibu
Alloy
Manga
Mangauit
Canguit
Sugao
Paduk
Guipan
Abaca
Maghanay
Cawayan
Padalis
Kilingan
Dibuluan
Muntayan
Tauaca
Old Gumiad
Rancheria
Sinaadian
Pugo
Guipang
Cabinangan
Pungo
Alidoc
Nalungtutan
Biao
Tama
Santo Niño
Diduyon
Didipio
Maldanum
Aglipay
Guinamugan
Kayapa
Dayaka
Bayas
Tabungan
Lusod
Wagan
Talikebkeb
Dalupinp
Buliuag
Lucod
Kabalatan
Banet
Gussadan
Labeng
Pingkian
Taptao
Palaugalaug
Baydong
Gioleng
Bone South
Patoctoc
Laneb
Alang
Manged
Talayag
Pacalba
Sta Rosa
Salacsac
Sapinit
Millagett
Malete
Baracbac
Santa Fe
Taclac
Lawick
Casantacluzan
Valdez
Atol
Depato
Kajintalan
Minuli
Putlan
Anabat
Santa Maria
San Felipe
San Nicolas
San Jose
Recuerdo
Cacabayagan
Natividad
San Jose de Batchelor
Casalunagan
Agno
San Pedro
San Manuel
Libertad
San Leon
Nampuguyan
San Fabiano
Concordia
Casantamaran
San Quintin
Gonzalo
Singsodo
Evangelista
Baral
Laurin
Umingan
Anam
Maringalu
Carranglan
Parang
Santa Cruz
General Luna
Lukidnay
Mankitkit
Cavisalan
San Augustin
Cantug
Burnos
Baan
Kiran
Bone
Tidap
Dayaya
Bangangbang
Banao
Sayudan
Malasin
Inahan
Marang River
Casignan River
Abaca River
Casignan
Cagayan River
Nanducogan River
Dibuluan River
Addalam River
Ditali River
Debutunan Reef
Delpada Point
Ditali
Ambayabang River
Cabaliwan River
Denlen River
Santo Domingo
Diduyon River
Tubo River
Agno River
Bin Bin River
1000
500
1500


15'
30'
45'
122°00'
Quezon
Buliva
MOUNT PALALI
PALALI RANGE
MAMPARANG MOUNTAINS
Aglipay
Addalam River
MOUNT UFUN
Tangao
San Agustin
Masaya Sur
Quinalabaza
Virgoneza
Sinoangan Norte
Guinamugarna
Panan
Laoag
Dabubu
Palasian Grande
L
A
N
D
Maldanum River
Tungcap
Governor Rapids
San Pedro
Didipio
Turucan River
Maddela
Diduyon
Mangla
Santo Niño
Kasibu
Alloy
Canatuan
Tama
Biao
Alicao
Nalungtutan
Pungo
Rancheria
Old Gumiad
Sinadipan
Cabinangan
Pugo
Guipang
Taua
Sugag
Paduk
Guipan
Abaca
Maghenay
MOUNT DALIMONOC
MOUNT OTUNDO
Cawayan
Kilingan
Ditali River
Nanacagan River
Delgado Point
Reef
Debutunan Point
Dinalongan
Dinajawan
Coral reef
Coral head
SIERRA MADRE
Casiguran
Dakoid
Luat
Dimankin
Tinib
Sand
Shoal
Koso
CASIGURAN BAY
Dipalali
Sibet
Calabgan River
Colabyan
Dinipan
Cujat
Tabas
Ligaya
MOUNT BOROGYOD
SAN ILDEFONSO PENINSULA
CASIGURAN SOUND
Dumog
Strong current
CAPE SAN ILDEFONSO
mud
coral
sand
1000
500
100
50
20
10
1150
1310
1209
1467
1510
1850
1109
241
850
630
640
625
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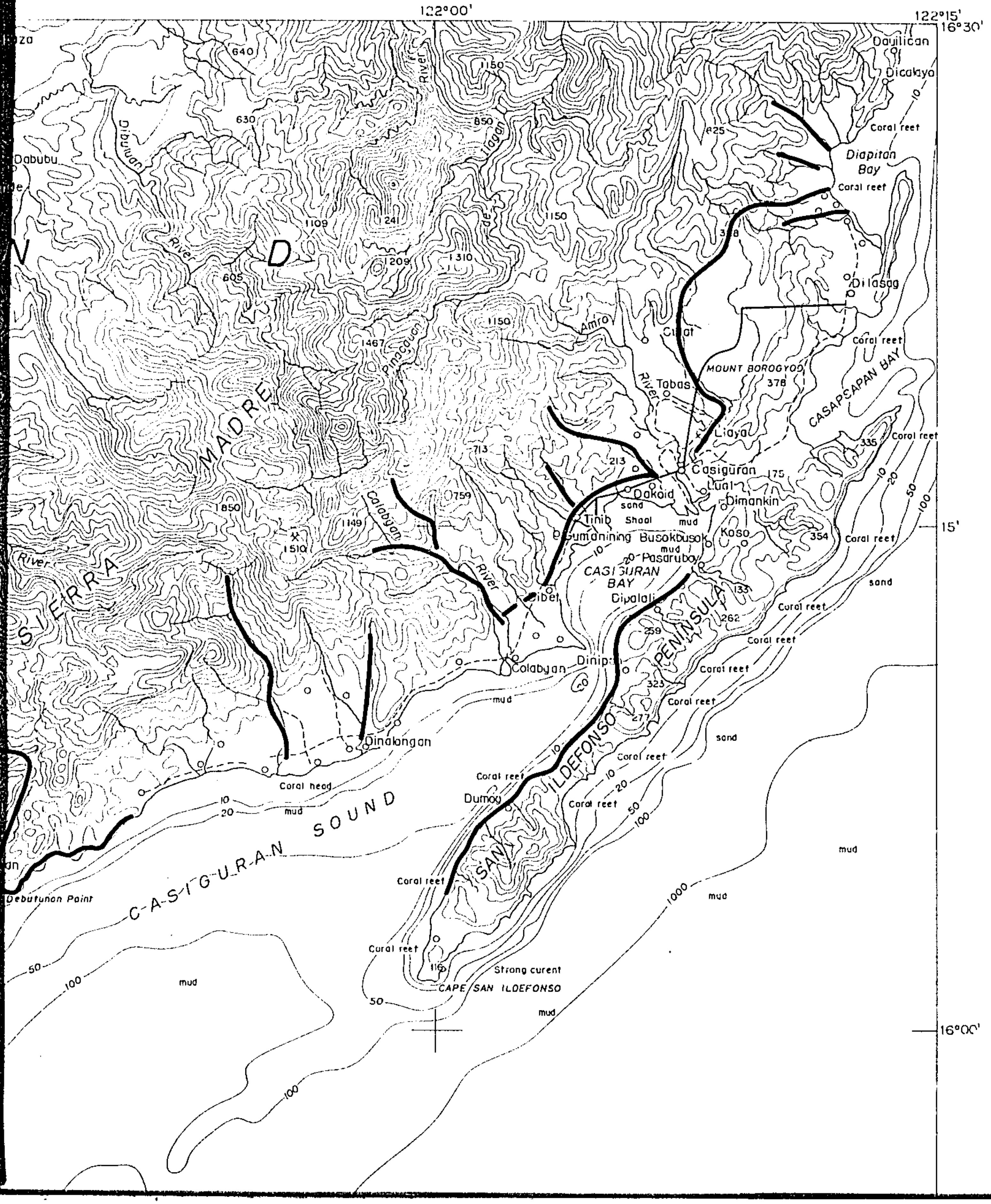
713
759
1149
338
1686



PL.3

GEOLOGICAL SURVEY OF NORTHEASTERN LUZON PHILIPPINES

GEOCHEMICAL ANOMALIES OF STREAM SEDIMENT AND SOIL

SCALE 1 : 250,000

0 20KM

METAL MINING AGENCY OF JAPAN
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GOVERNMENT OF JAPAN
December 1977

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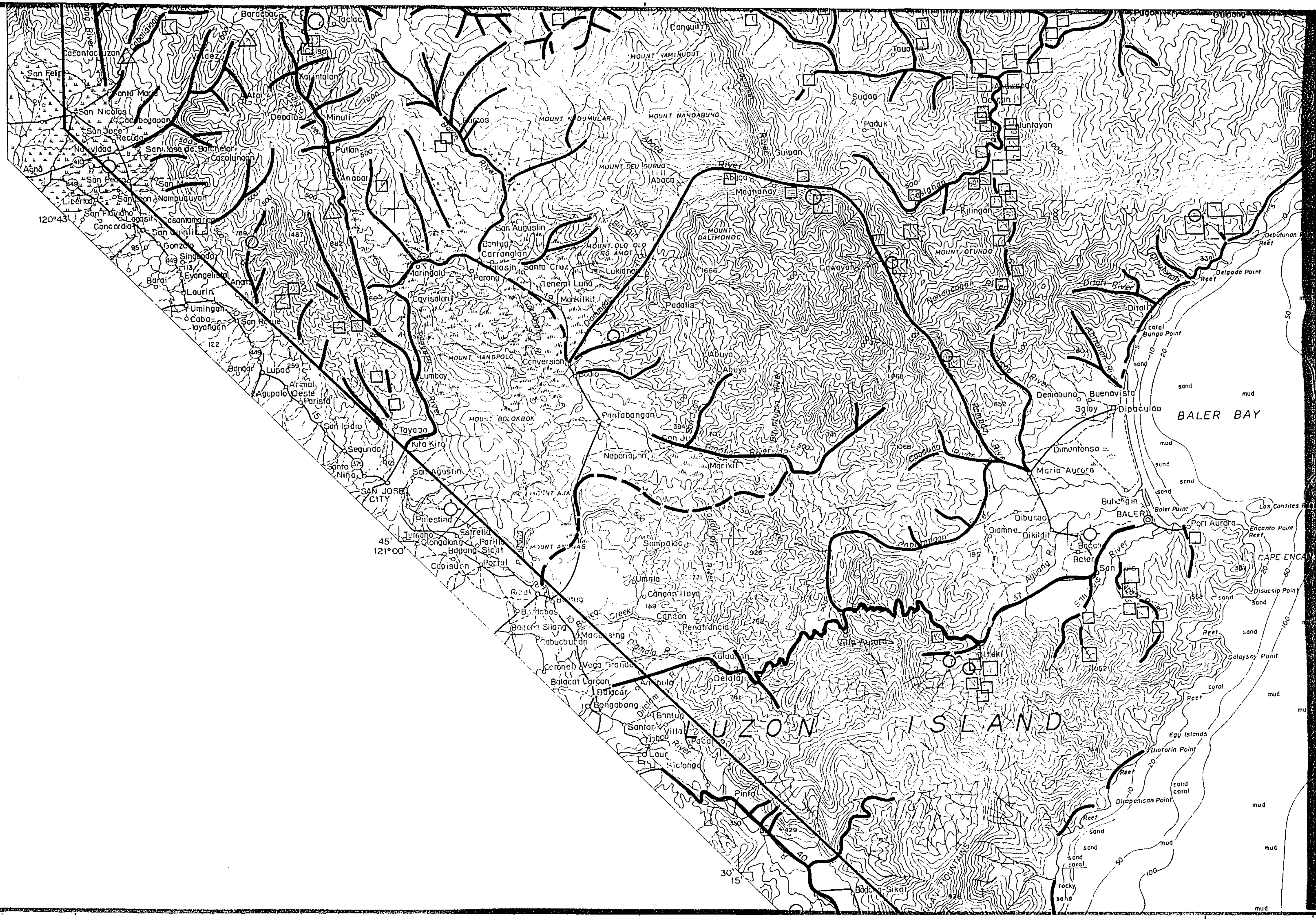
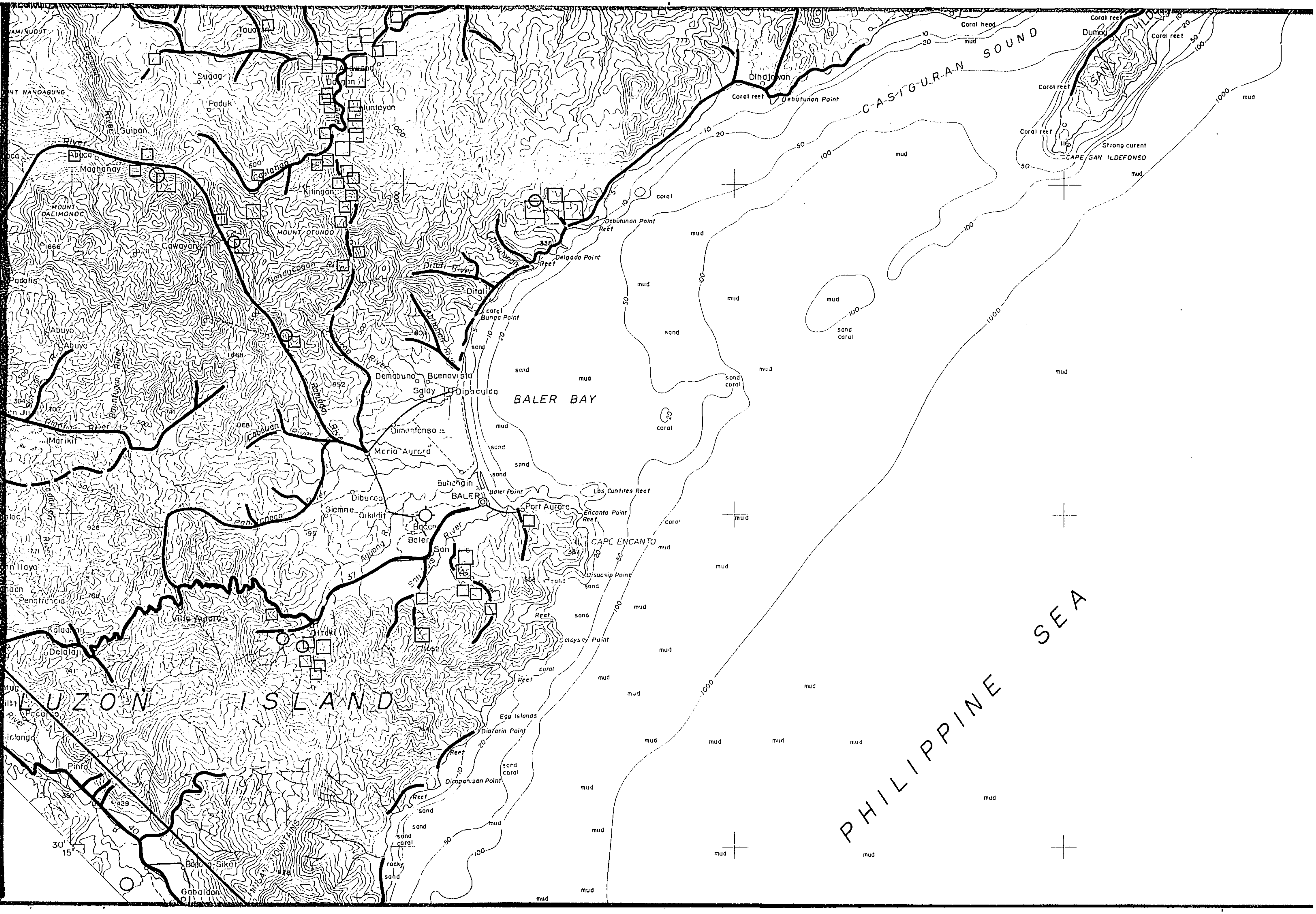
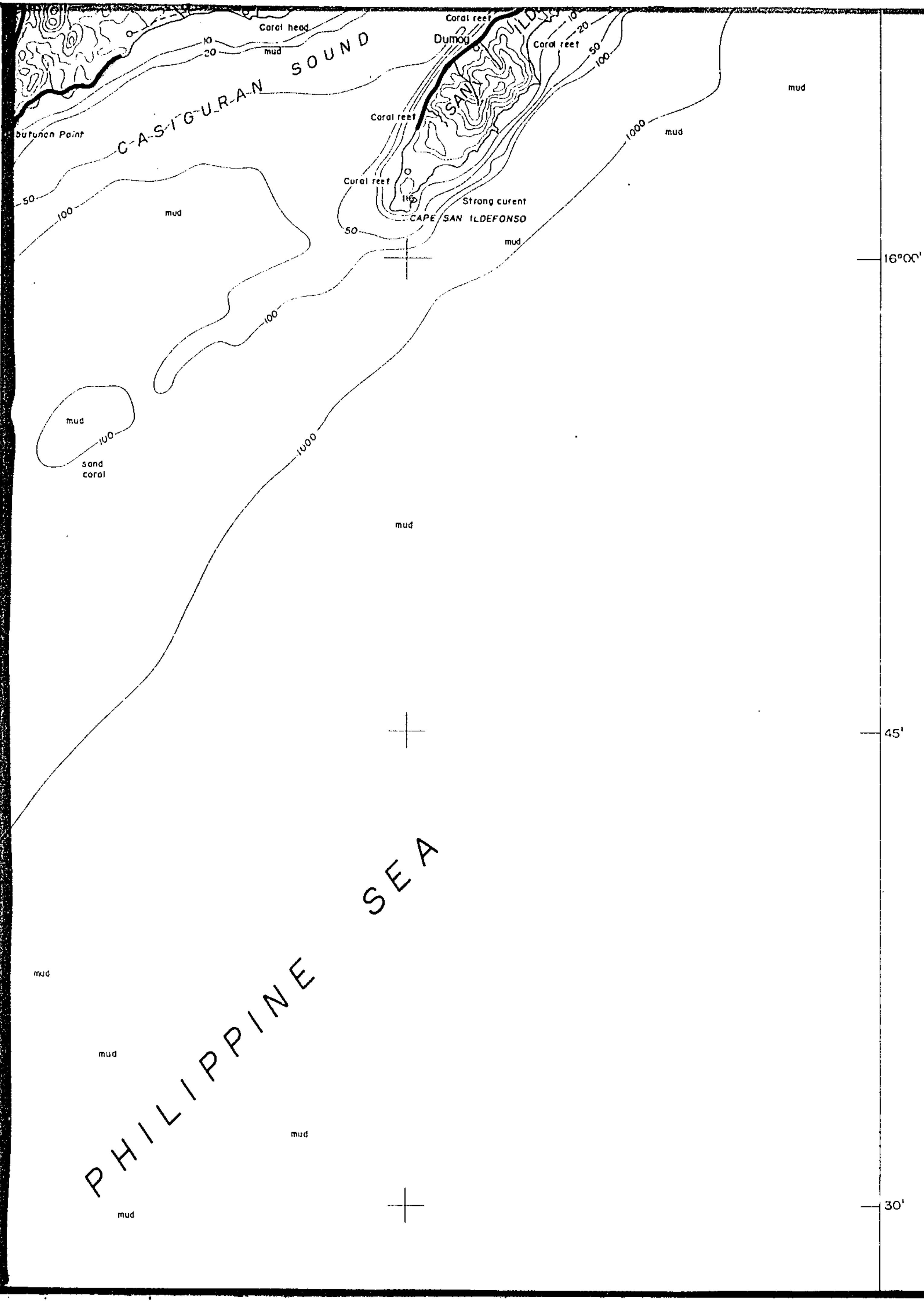


LUZON ISLAND
BALER BAY
BALER
Port Aurora
Maria Aurora
Dipaculao
Buenavista
Dimanpudso
Dibucao
Baler Point
Los Contites Point
Encanto Point
Disucsip Point
Dicaloyangan Point
Egu Islands
Diotorin Point
Dicapanisan Point
Delgado Point
Debutunan Point
Bunga Point
Ditali
Ditali River
Pugo
Dumaplag
Reef
sand
mud
coral
Villa Aurora
Ditale
Pantabangan
Conversion
Napoñapan
Marikit
MOUNT DALIMONOC
MOUNT OTUNDO
MOUNT NAGOABUNG
MOUNT YAMI NUDUT
MOUNT MANGPOLO
MOUNT BOLOKBOK
MOUNT NDUMULAR
MOUNT DEU GURUG
MOUNT OLO OLO
Abaca
Maghanoy
Padalis
Abuyo
Cawayan
Sugag
Paduk
Suipan
Canguin
Carranglan
Santa Cruz
General Luna
Minuli
Putlan
Anabat
Cavisalan
Lumboy
Tayabo
Kita Kita
San Agustin
SAN JOSE CITY
Palestina
Estrella
Parilla
Bagong Sikat
Capisuan
Portal
Rizal
Bantug
Baldabas
Bagong Silang
Cabucbucan
Macapsing
Coronel
Vega Grande
Balacat Larcon
Balacar
Bongabong
Santor
Villa
Laur
Sicloña
Pinfo
Sampaloc
Umala
Canaan Ilaya
Canaan
Pengfruncia
Kalaoan
San Juan
Natividad
San Nicolas
San Jose
San Pedro
San Felipe
Santa Maria
San Leon
Libertad
San Fabiano
Concordia
San Quintin
Gonzalo
Laurin
Umingan
San Roque
Bangar
Lupao
Agupalo Oeste
Parista
San Isidro
Segunda
Santo Niño
Agno
120°43'
45'
121°00'
30'
15'


CASIGURAN SOUND
BALER BAY
PHILIPPINE SEA
LUZON ISLAND
CAPE SAN ILDEFONSO
Strong curent
Coral reef
Coral head
Debutunan Point
Delgado Point
Bunga Point
Ditali River
Ditali
Demabuno
Buenavista
Dipaculao
Dimalonso
Maria Aurora
Butichgin
BALER
Baler Point
Port Aurora
Los Confites Reef
Encanto Point
CAPE ENCANTO
Disucsip Point
Calaysay Point
Egg Islands
Diotorin Point
Dicapanisan Point
Villa Aurora
Ditaki
Diburao
Dikildit
San Luis River
Aujang R.
Cawayan
Kitingan
Muntayan
Sugag
Paduk
Guipan
Maghanay
Abuca
Abuyo
Marikit
Kaluaan
Delalan
Penafruncia
Pinfa
Gabaldon
MOUNT DALIMONOC
MOUNT OTUNDO
Nandacogan River
Ramada River
Cacuan River
San Jose
mud
sand
coral
sand coral
rocky
Reef



SCALE 1 : 250,000

0 20KM

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1977

Prepared by Bishimetal Exploration Co., Ltd.

LEGEND

Stream sediment

	Cu	Zn	Mo	
2t ≦	○	□	△	
t ≦	○	□	△	<2t
t' ≦	○	□		< t

	t'	t	2t
Cu	126 ppm	215 ppm	430 ppm
Zn	208	375	750
Mo	6	7	14

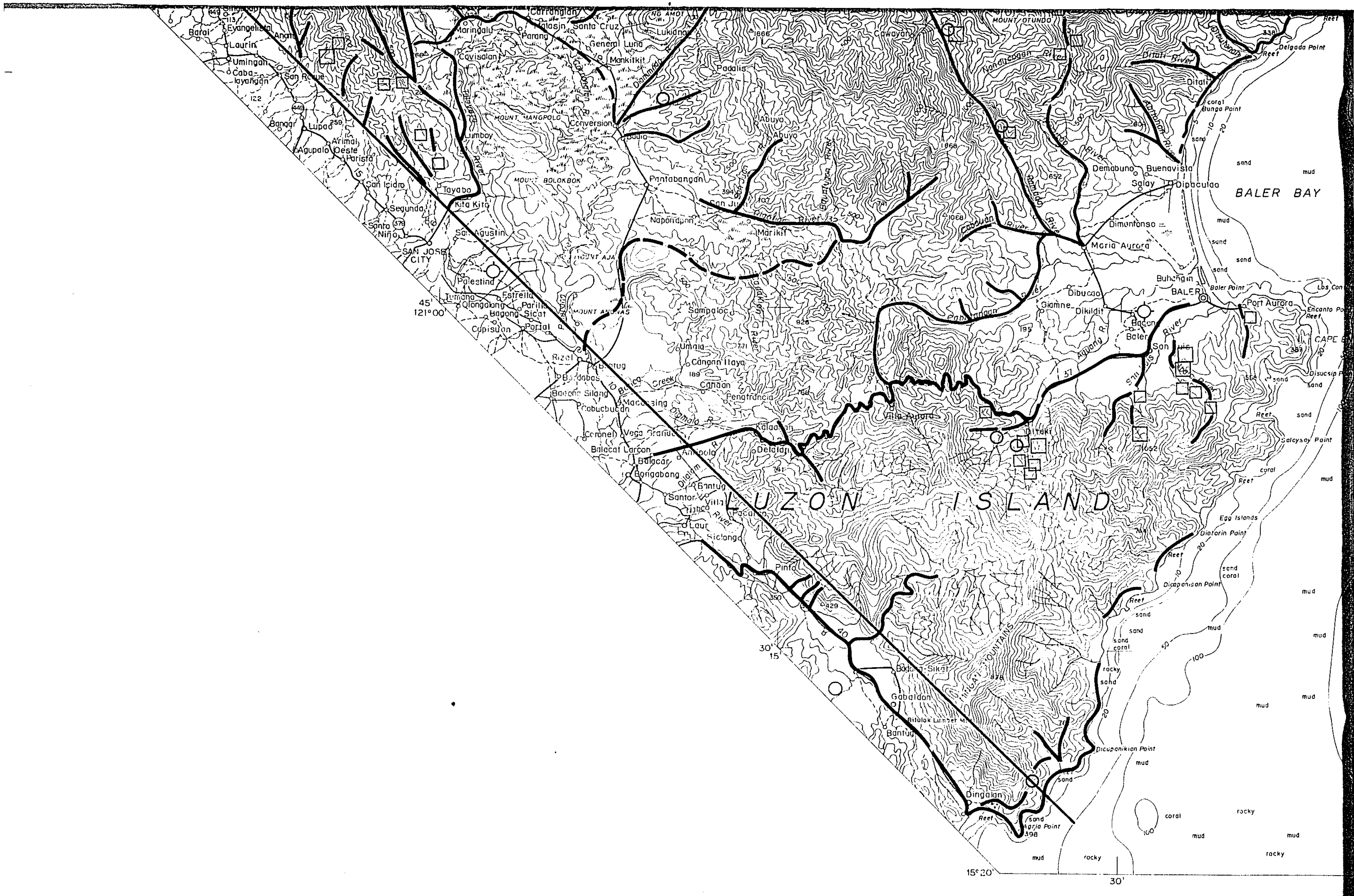
t' : 10% value of total observations from the highest

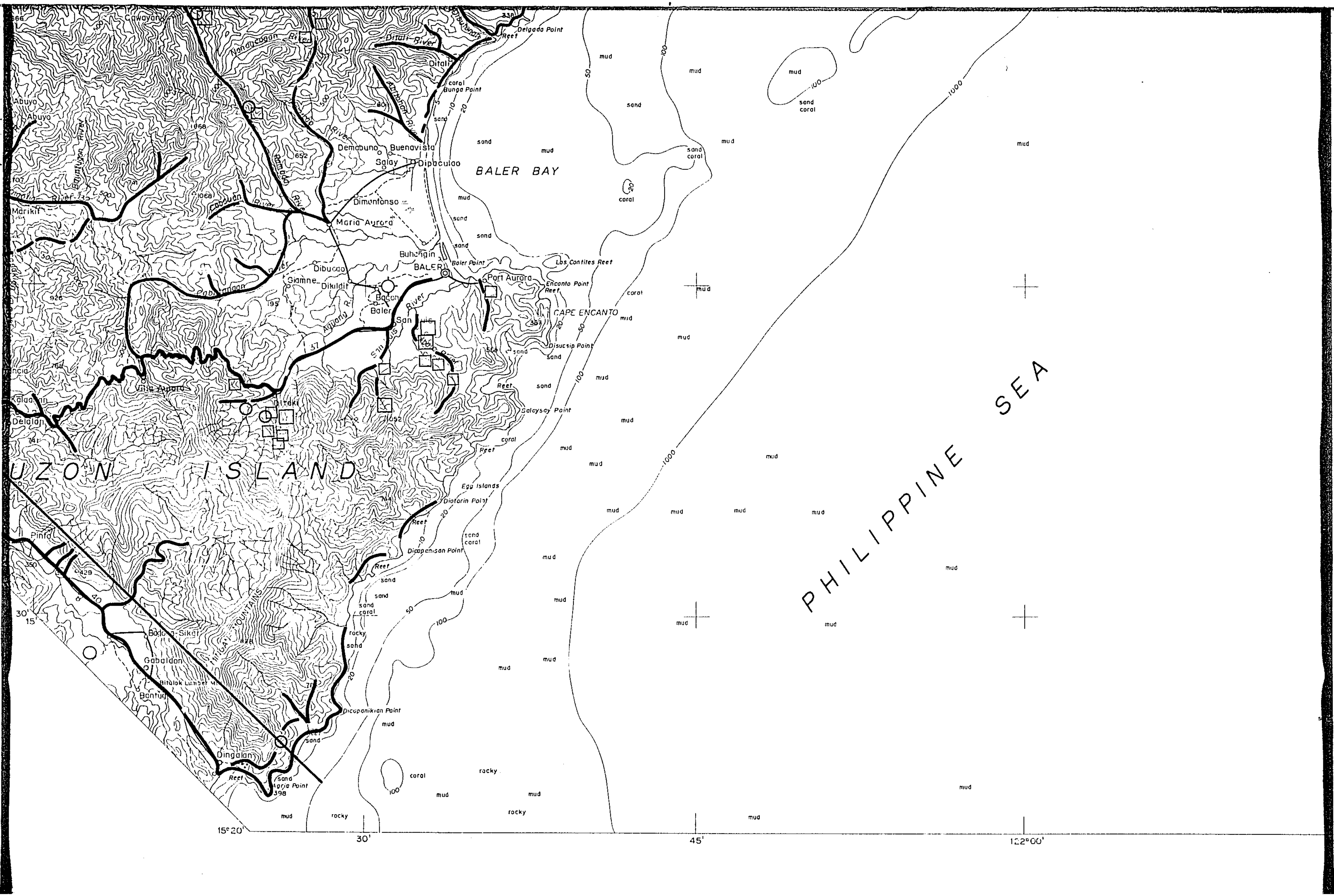
t : threshold value

Soil

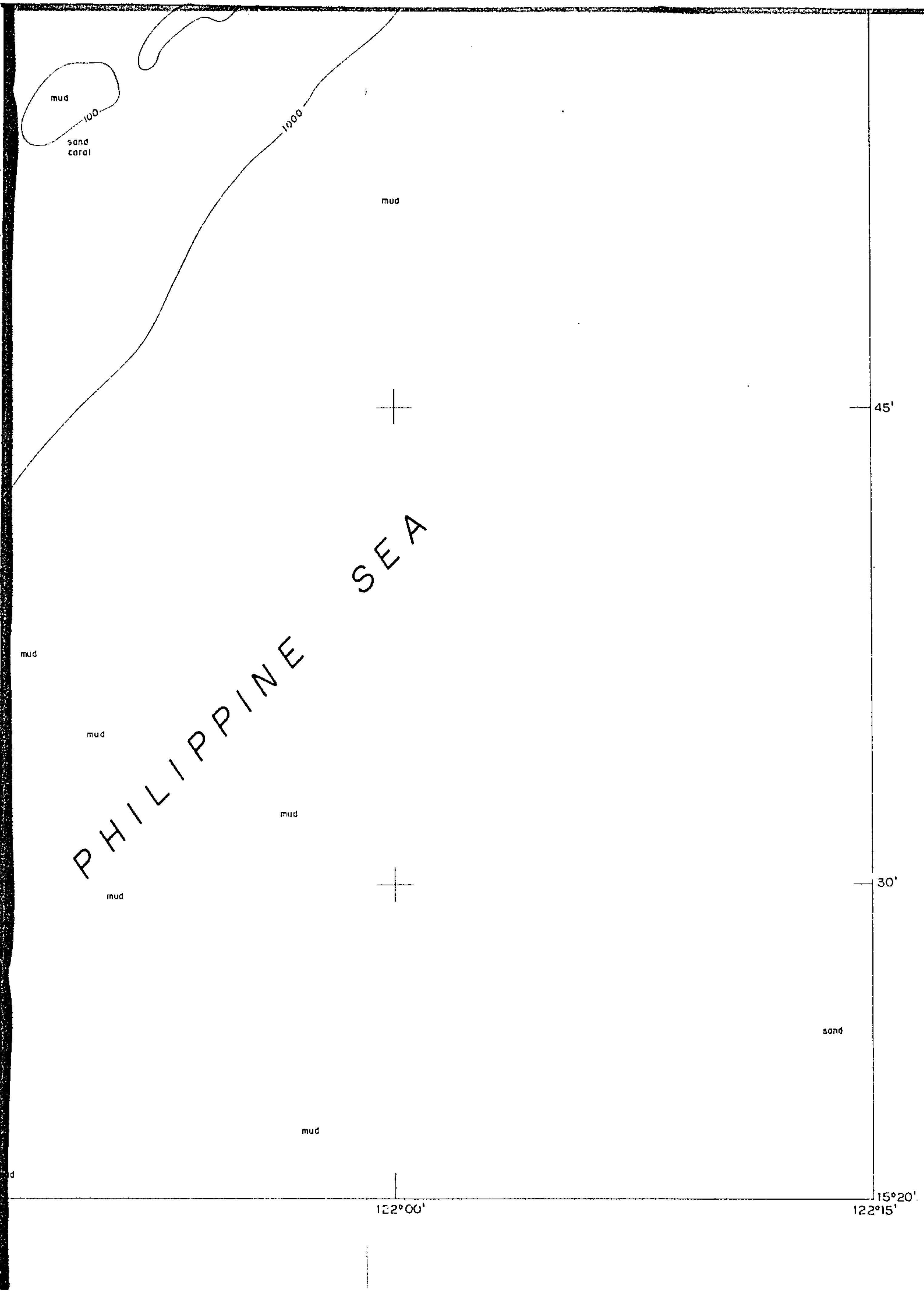
	Cu	Zn
t ≦		

	Bokud	Mongia	Salinas	Kasibu
Cu t	95 ppm	40 ppm	100 ppm	200 ppm




BALER BAY
PHILIPPINE SEA
LUZON ISLAND
Cawayan
Delgado Point
Reef
Ditali River
Ditali
Bunga Point
Nandacugan River
Abuyo
Demabuno
Buenavista
Salay
Dipaculao
Dimanfonso
Maria Aurora
Bubongin
BALER
Baler Point
Port Aurora
Los Contites Reef
Encanto Point
CAPE ENCANTO
Dibucao
Giamne
Dikildit
Bacon
Baler
San Luis
Aguang R.
Disucsip Point
Salaysay Point
Villa Aurora
Ditaki
Marikit
Kaladacan
Delalan
Pinfo
Egg Islands
Diotorin Point
Dicapanisan Point
Dicupanikian Point
Bato Sika
Gabaldon
Bantug
Dingalan
Maria Point
mud
sand
coral
rocky
15°20'
30'
45'
122°00'

Prepared by Bishimetal Exploration Co., Ltd.



LEGEND

Stream sediment

	Cu	Zn	Mo	
2t ≦	○	□	△	
t ≦	○	□	△	<2t
t' ≦	○	□		< t

	t'	t	2t
Cu	ppm 126	ppm 215	ppm 430
Zn	208	375	750
Mo	6	7	14

t' : 10% value of total observations from the highest

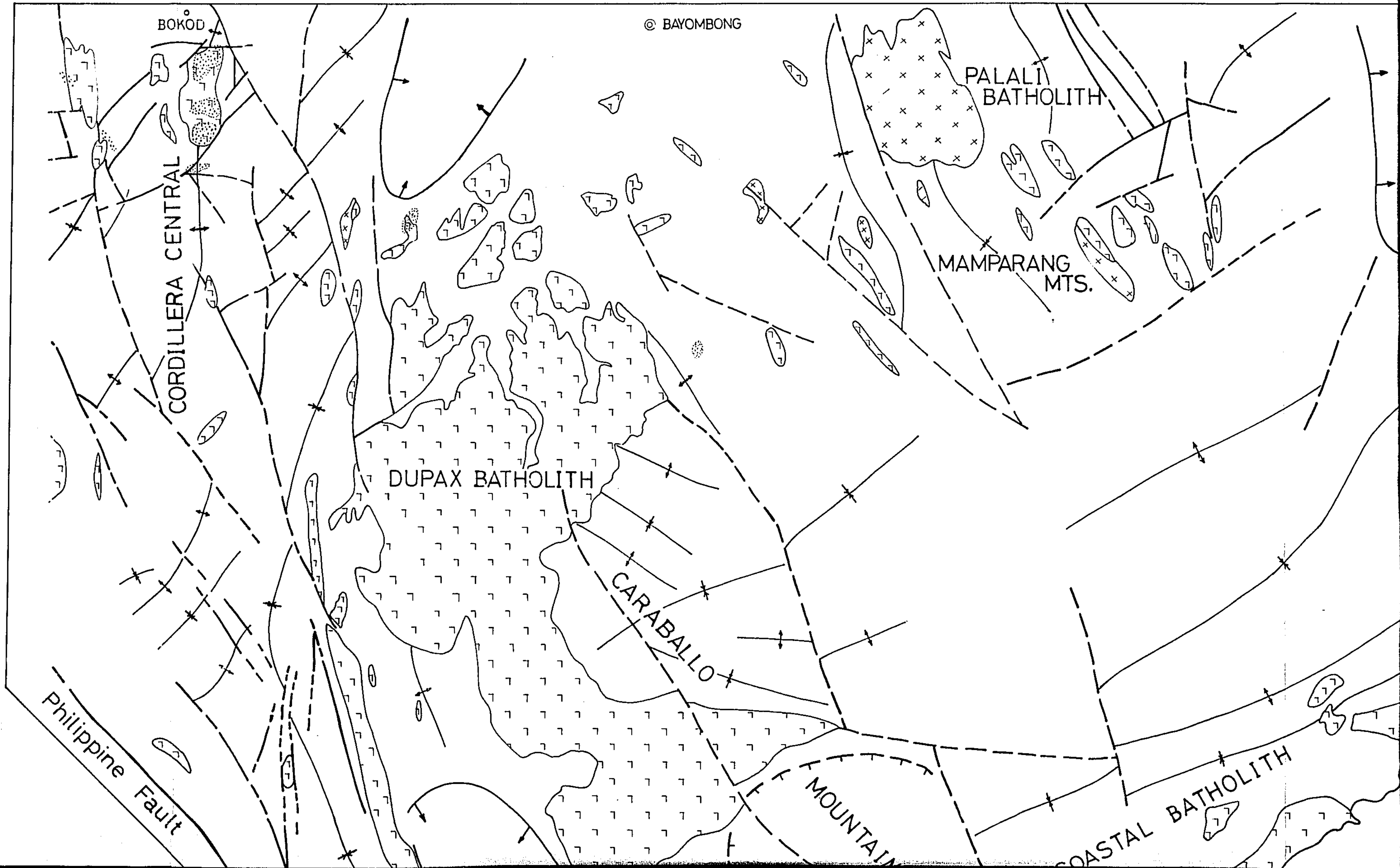
t : threshold value

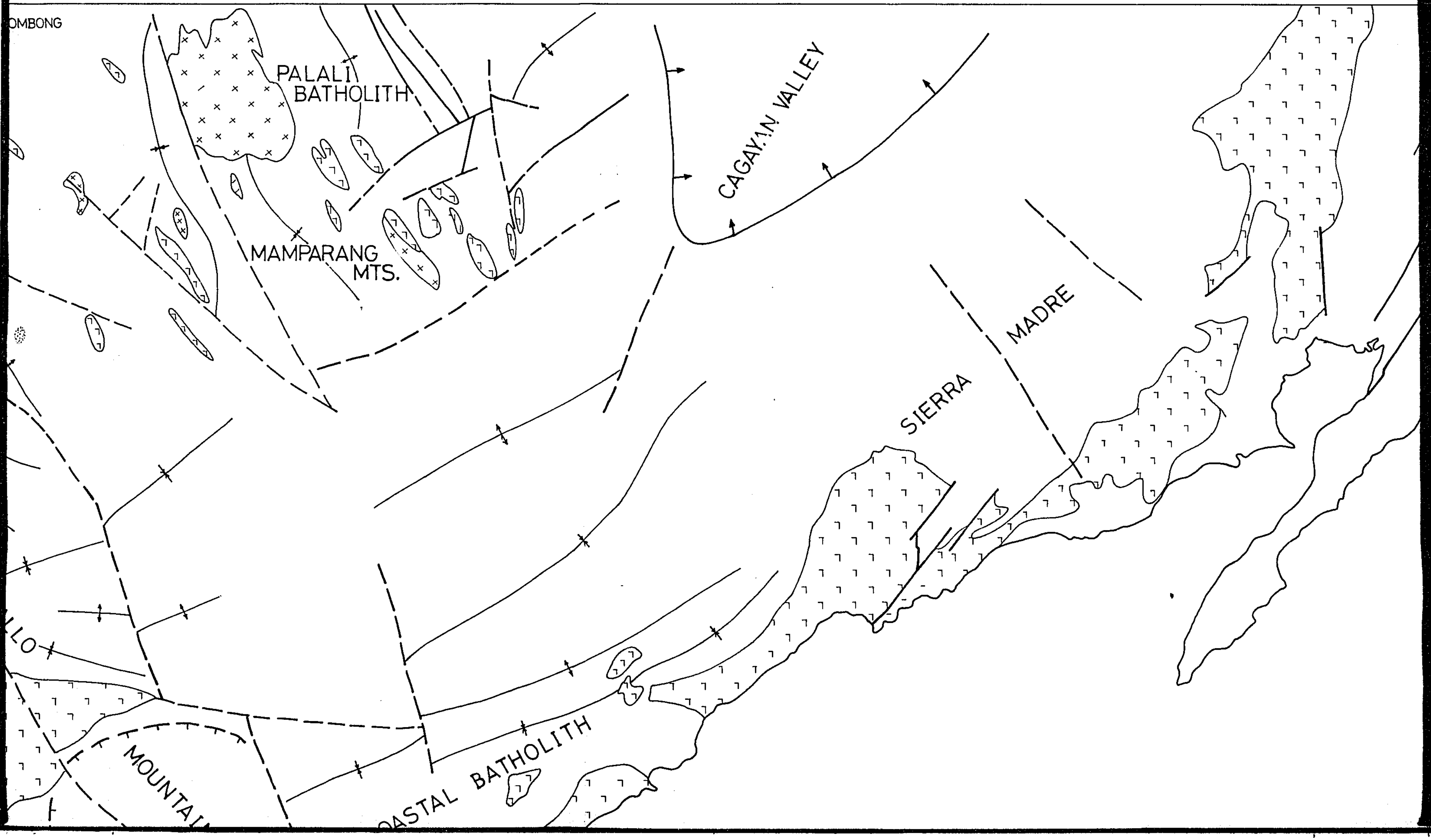
Soil

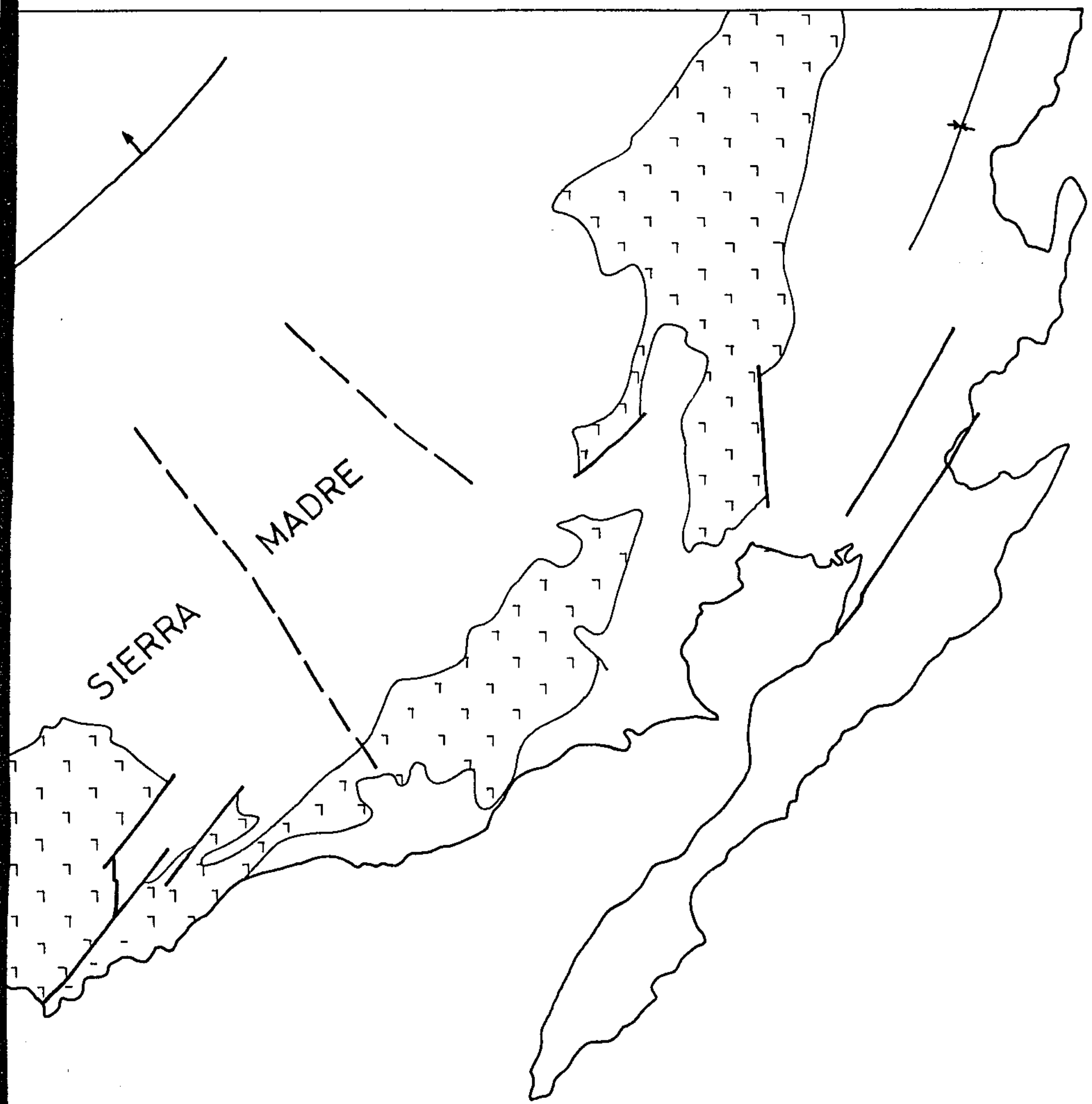
	Cu	Zn
t ≦	(hatched ellipse)	(hatched ellipse)

	Bokod	Mongla	Salinas	Kasibu
Cu t	ppm 95	ppm 40	ppm 100	ppm 200
Zn t	90	75	75	75

t : threshold value


BOKOD
BAYOMBONG
PALALI BATHOLITH
CORDILLERA CENTRAL
MAMPARANG MTS.
DUPAX BATHOLITH
CARABALLO
MOUNTAIN
COASTAL BATHOLITH
Philippine Fault


OMBONG
PALALI BATHOLITH
MAMPARANG MTS.
CAGAYAN VALLEY
SIERRA MADRE
COASTAL BATHOLITH
MOUNTAI
LLO



PL. 4

GEOLOGICAL SURVEY
OF
NORTHEASTERN LUZON
PHILIPPINES

RELATION MAP BETWEEN GEOLOGICAL STRUCTURE AND MINERALIZED ZONE

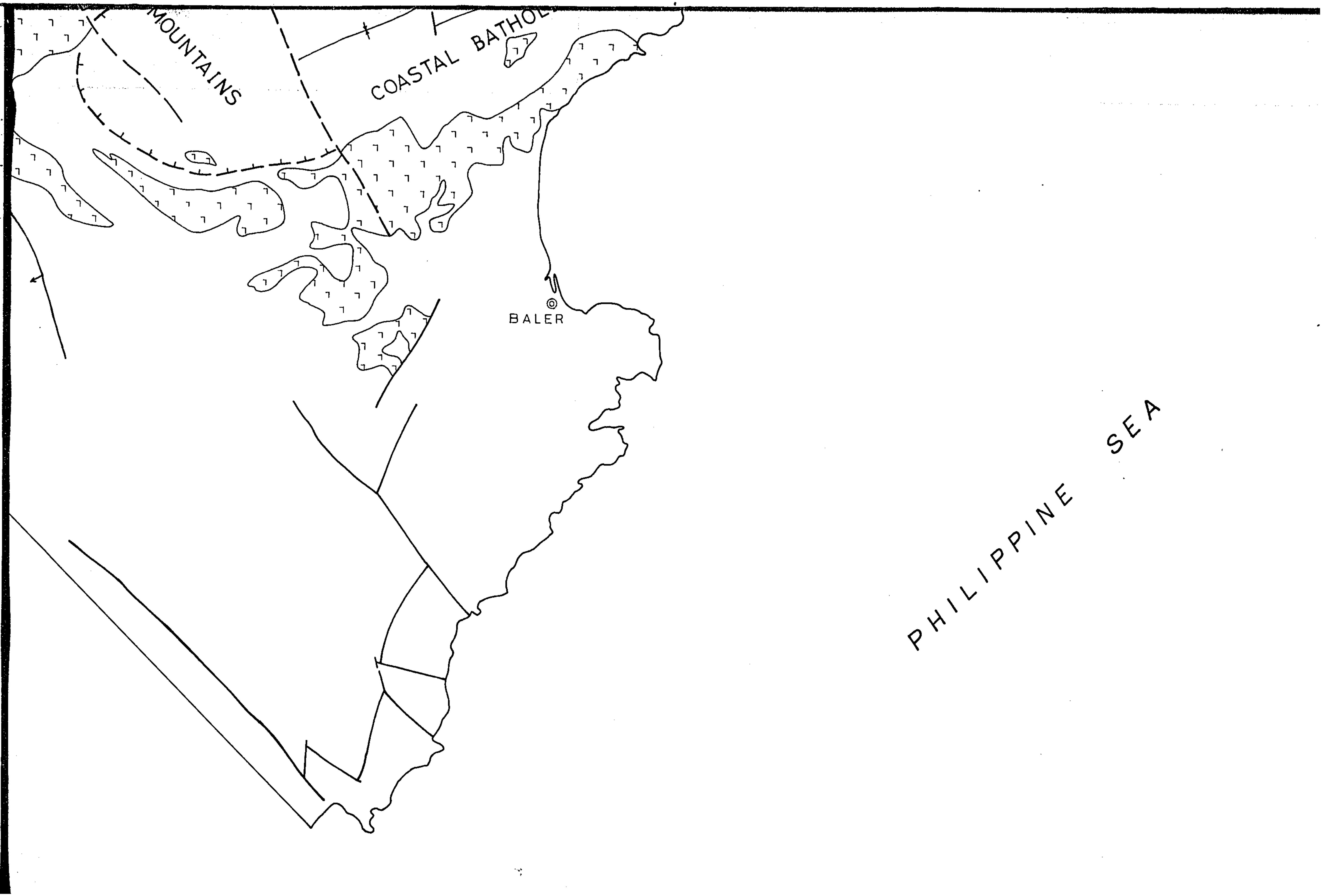
SCALE 1 : 250,000

0 — 20 KM

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1977

Prepared by Bishimetal Exploration Co., Ltd.


Fault
MOUNTAINS
COASTAL BATHOL
BALER


MOUNTAINS
COASTAL BATHOL
BALER
PHILIPPINE SEA

December 1977

Prepared by Bishimetal Exploration Co., Ltd.

PHILIPPINE SEA

LEGEND

Acidic intrusive rocks

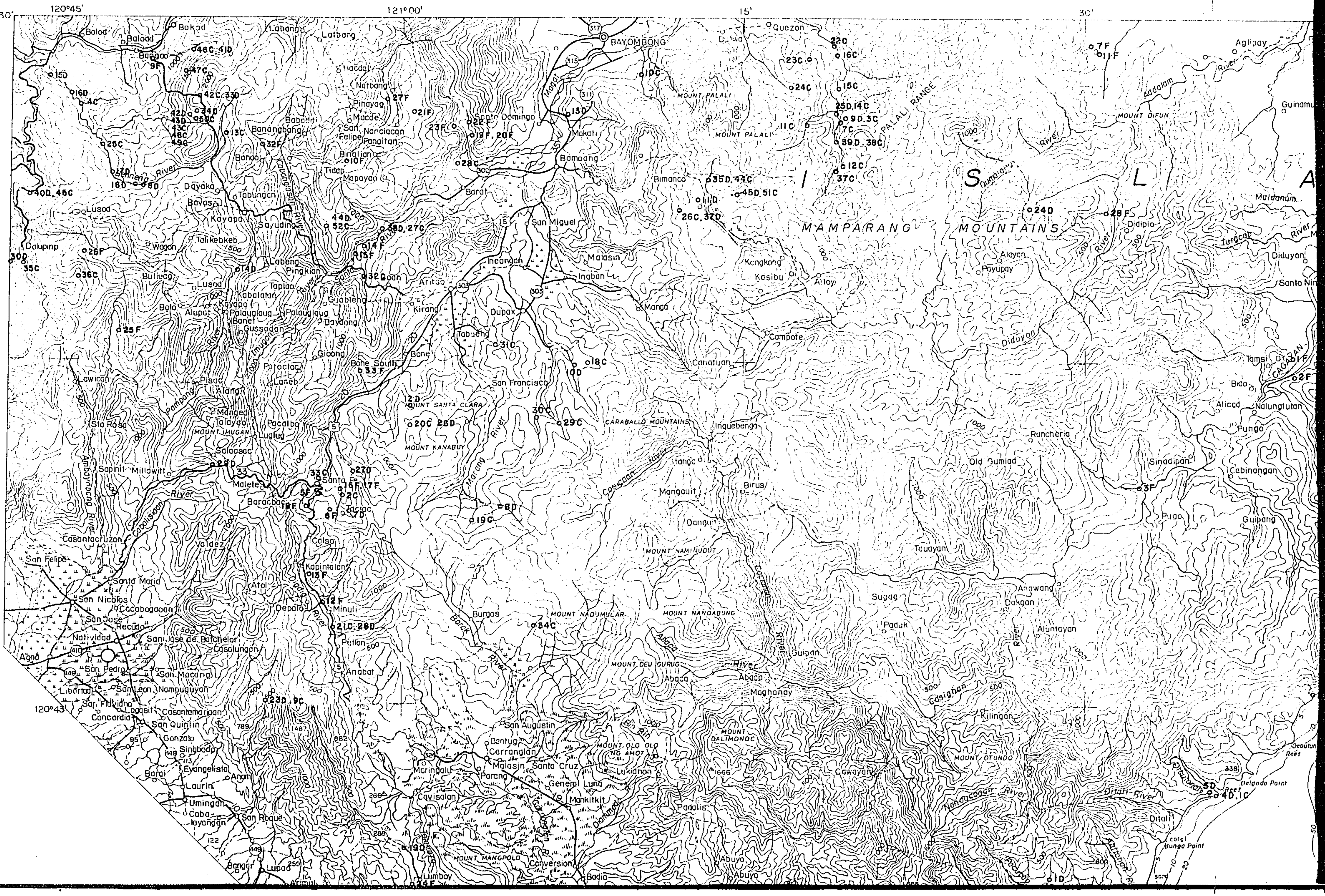
Alkali intrusive rocks

Basin

Fault

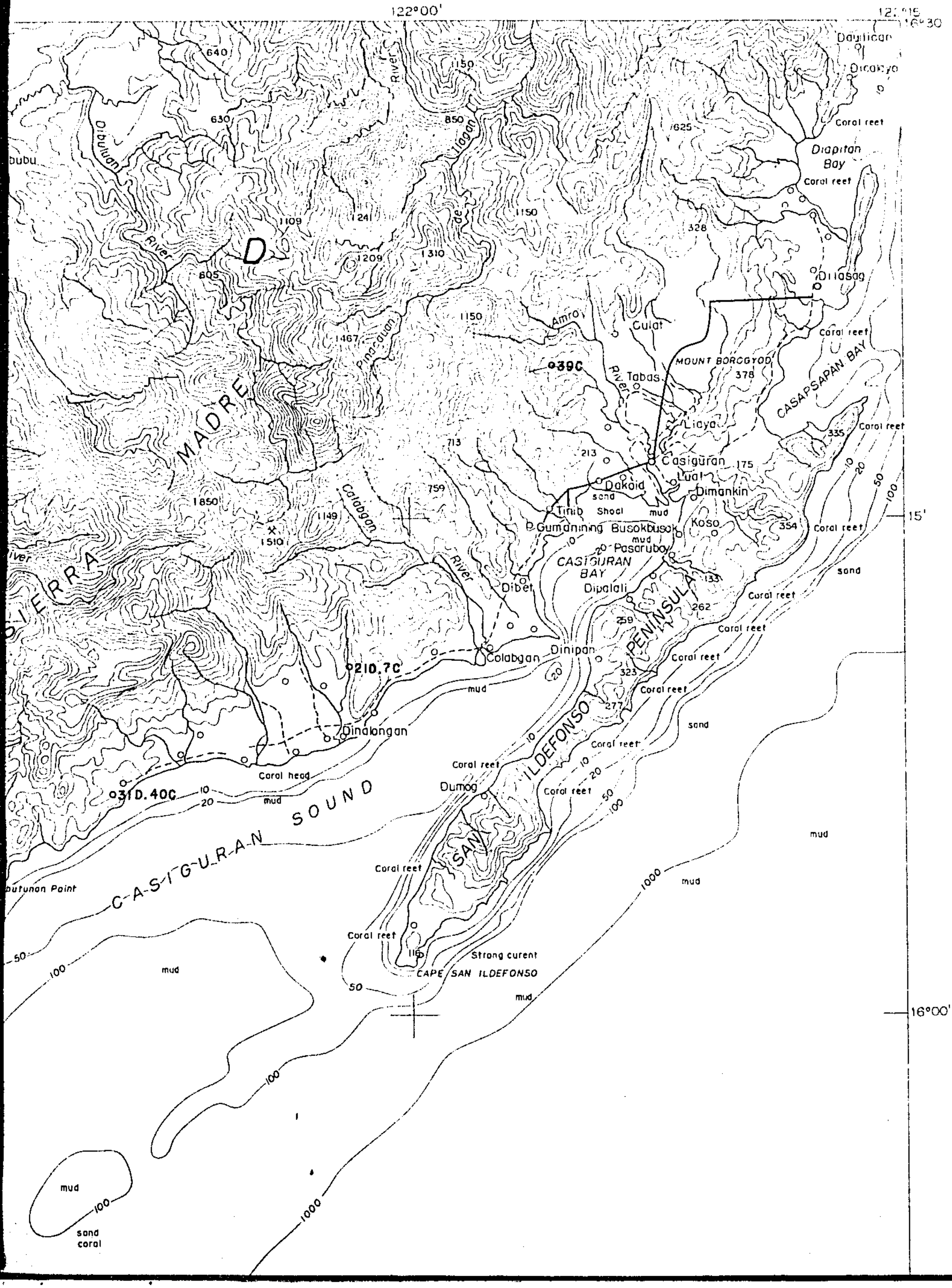
Anticline and Syncline

Mineralized zone



16°30'
120°45'
121°00'
15'
30'
15'
120°43'
BAYOMBONG
Quezon
Aglipay
Guinamu
Bokod
Balod
Baload
Labang
Latbang
MOUNT PALALI
PALALI RANGE
MOUNT DIFUN
Addalam
River
Santo Domingo
Makati
Bamoang
Bimanco
Hacdal
Natbang
Pinayag
Macde
San Felipe
Nanciacan
Panaltan
Binalian
Tidap
Mapayao
Barat
Babadi
Banangbang
Banao
Dayaka
Bayas
Tabungcn
Lusod
Kayapa
Sayuding
Talikebkeb
Wagon
Daupinp
San Miguel
Malasin
Ineangan
Inaban
Aritao
Kirang
Dupax
Manga
Kongkong
Kasibu
Alloy
Campote
MAMPARANG
MOUNTAINS
Alayan
Payupay
Didipio
Maldanum
Diduyon
Santo Nin
Labeng
Pingkian
Santa
Taplao
Guableng
Baydong
Butiuca
Kabalatan
Kayapa
Bola
Alupat
Palayulaug
Bonet
Gussadan
Tabueng
Bone
Gioong
Bone South
Patactac
Laneb
Canatuan
San Francisco
MOUNT SANTA CLARA
MOUNT KANABUY
CARABALLO MOUNTAINS
Inquebenga
Rancheria
Old Gumiad
Tamsi
Bido
CAGAYAN
Alicad
Nalungtutan
Pungo
Sinadipan
Cabinangan
Lawican
Pampang
Pisac
Alang
Manged
Talayao
Pacalbo
MOUNT IMUGAN
Lugtug
Sta Rosa
Salacsac
Sapinit
Millawitt
Malete
Baracbac
Santa Fe
Taciac
Marang
River
Casecnan
Itanga
Mangauit
Birus
Danguit
Guipang
Puga
Casantacruzan
Valdez
Celso
Kapintalan
San Felipe
Santa Maria
San Nicolas
Cacabogaoan
San Jose
Recudo
Natividad
Agno
San Jose de Batchelor
Casalungan
San Pedro
San Macario
San Leon
Nampuguyan
Libertad
San Fluvidno
Lagasit
Casantamarigan
Concordia
San Quintin
Gonzalo
Singbodo
Evangelista
Baral
Laurin
Umingan
Caba-layangan
San Roque
Bangar
Lupao
Atol
Depalo
Minuli
Putlan
Anabat
Burgos
Baack
River
MOUNT NADUMULAR
MOUNT NAMINUDUT
MOUNT NANGABUNG
Sugag
Paduk
Angwang
Dakgan
Aluntayan
Tauayan
MOUNT DEU GURUG
Abaca
River
Guipan
Maghanay
Casignan
Kilingan
San Augustin
Bantug
Carranglan
Malasin
Santa Cruz
MOUNT OLO OLO NG AMOT
Lukidnon
General Luna
Mankitkit
Maringalu
Parang
Cavisalan
MOUNT DALIMONOC
Cawayan
MOUNT OTUNDO
Padalis
Nandinangan River
Dital River
Dital
Debutun Reef
Delgado Point
coral
Bunga Point
sand
MOUNT MANGPOLO
Conversion
Badio
Lumboy
Arimul
Abuyo


30'
45'
122°00'
Quezon
I S L A N D
MAMPARANG MOUNTAINS
PALALI RANGE
MOUNT DIFUN
SIERRA MADRE
Addalam River
Aglipay
Tangao
San Agustin
Masaya Sur
Quinalabaza
Virgoneza
Sinoangan Norte
Panan
Laoag
Dabubu
Palasian Grande
Guinamugarna
Maldanum River
Tungcap
Governor Rapids
San Pedro
Maddela
Diduyon
Santo Nino
Didipio
Alayan
Payupay
Kasibu
Alloy
Campote
Diduyon River
Tamsi
Cagayan River
Bido
Alicad
Nalungtutan
Pungo
Rancheria
Old Gumiad
Sinadipan
Cabinongan
Pugo
Guipang
Tauayan
Angwang
Dakgan
Sugag
Paduk
Aluntayan
Guipan
Maghonay
Casighan
Kilingan
MOUNT OTUNDO
Cawayan
Dingalan River
Ditali River
Ditali
Bunga Point
Delgado Point
Debutunan Point
Dingjawan
Dinalongan
Coral head
CASIGURAN SOUND
Calabgan
Calabgan River
Dinipan
Dibet
Dipalali
CASIGURAN BAY
PENINSULA
SAN ILDEFONSO
Dumog
CAPE SAN ILDEFONSO
Strong current
Casiguran
Dakoid
Lual
Dimankin
Tinib
Guminining
Busokbusok
Pasaruboy
Koso
Liayal
Tabas
Culat
Amro
MOUNT BOROGYOD
CASAPSAPAN BAY
Dipaculao
Diapitan Bay
Dilasag
Coral reef
mud
sand
coral



PL. 5

GEOLOGICAL SURVEY OF NORTHEASTERN LUZON PHILIPPINES

SAMPLE LOCATION MAP OF K-Ar DATING, WHOLE ROCK CHEMICAL ANALYSIS AND FOSSIL

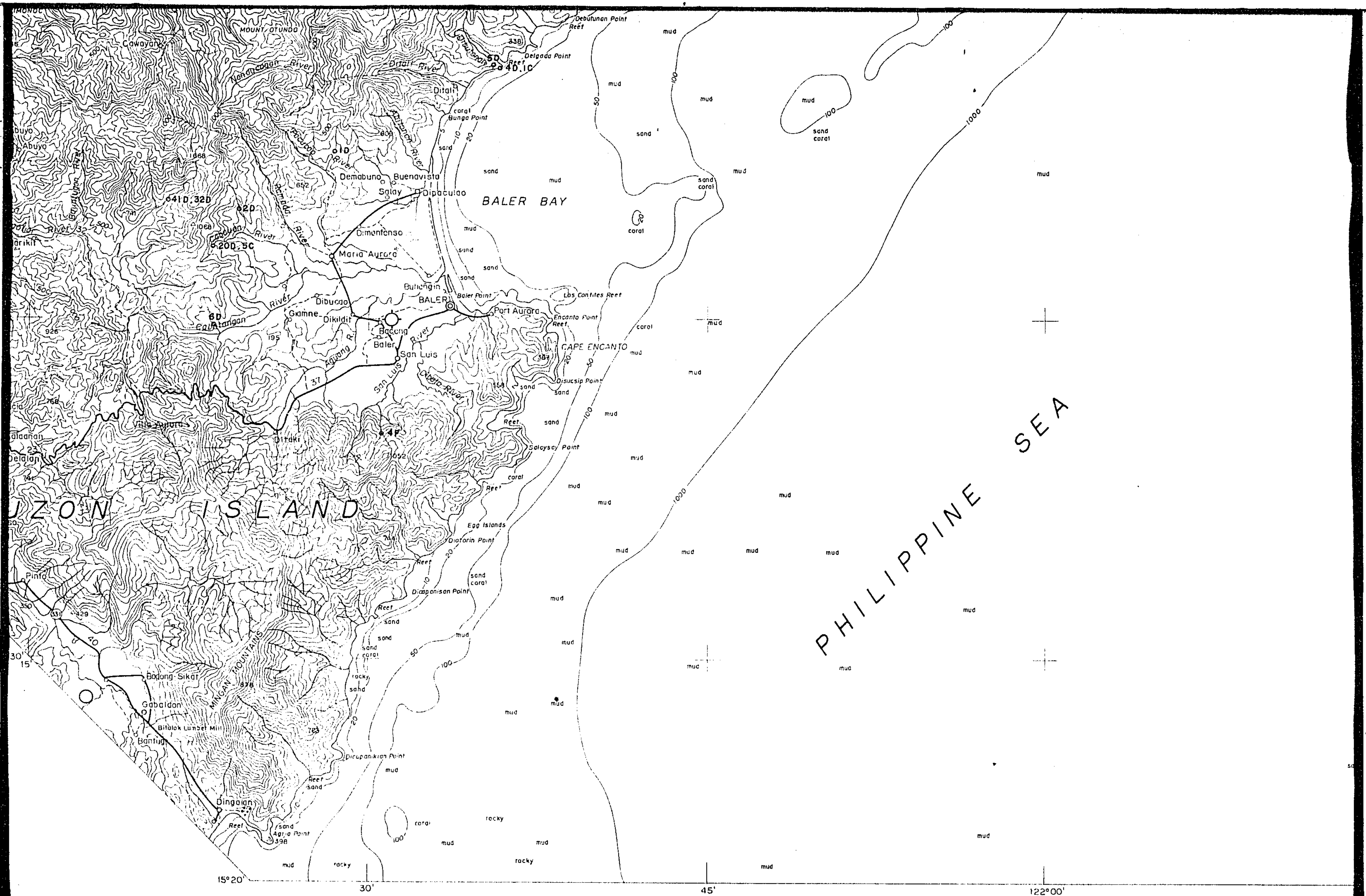
SCALE 1 : 250.000

0 20km

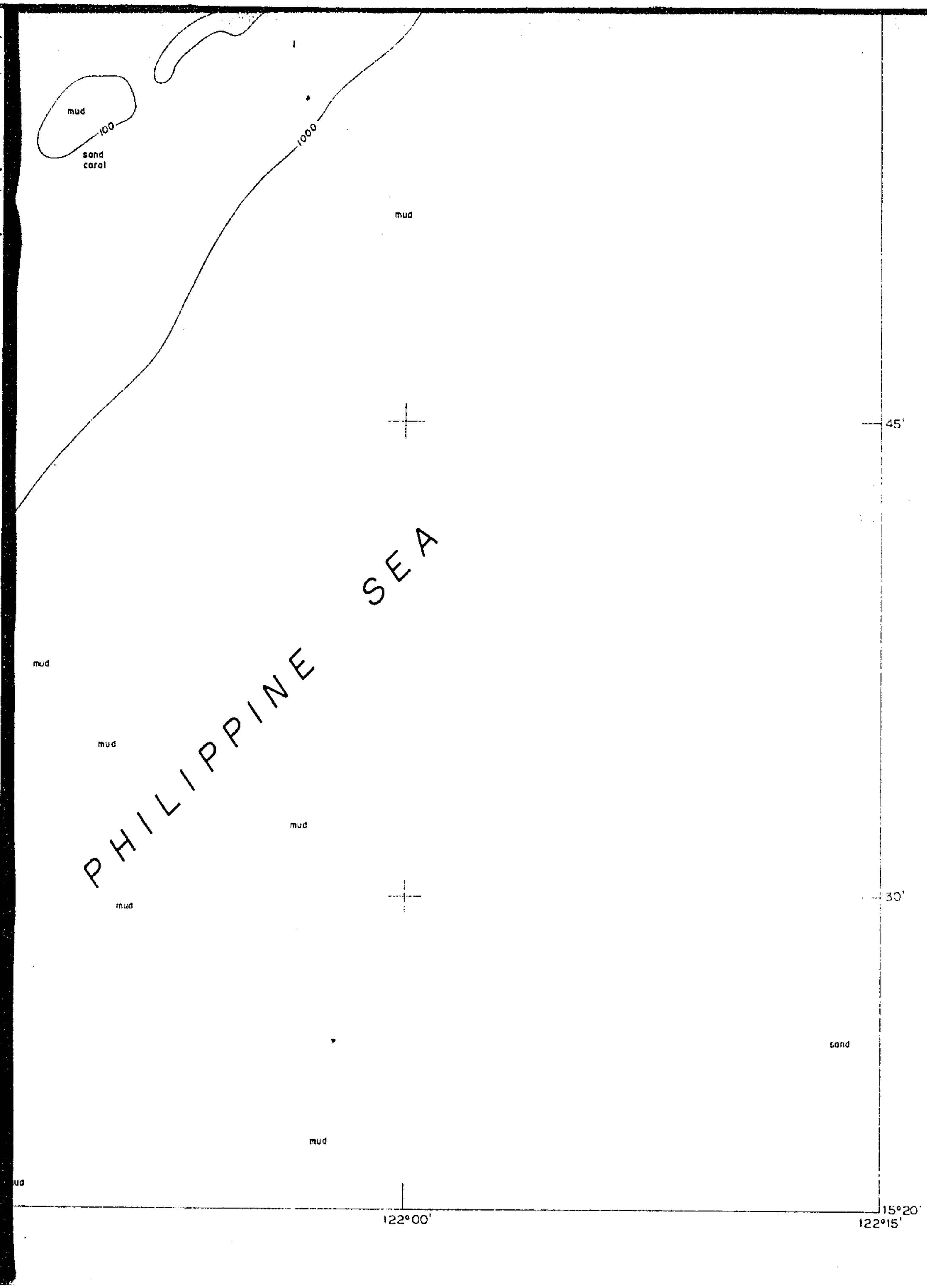
METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1977

Prepared by Bishimetal Exploration Co., Ltd.


LUZON ISLAND
BALER BAY
BALER
Baler Point
Port Aurora
Encanto Point
CAPE EN
Dipaculao
Buenavista
Demabuno
Salay
Dimanfonso
Maria Aurora
Bulengin
Dibucao
Gianme
Dikildit
Bagong Baler
San Luis
San Luis River
Aguang R.
Ditali
Bunga Point
Delgado Point
Galaysay Point
Egg Islands
Diotorin Point
Dicapanisan Point
Dicapanikian Point
Dingalan
Agraa Point
Gabaldon
Bagong Sikat
Bitulok Lumber Mill
Bantug
MINGAN MOUNTAINS
Pinto
Sictong
Laur
Pacorso
Santor
Villa
Nabao
Bongabong
Balacat
Larcon
Antipolo
Delalan
Kaldanan
Vega Grande
Coronel
Cabucbucan
Macapsing
Bagong Silang
Bardabas
Rizal
Bantug
Barica Creek
Canaan Ilaya
Canaan
Penafrancia
Umala
Sampaloc
Villa Aurora
Ditaki
Pantabangan
Naponapon
San Juan
Marikit
Badio
Conversion
MOUNT MANGPOLO
MOUNT BOLOKBOK
MOUNT AJA
MOUNT ANUNAS
Cavisalan
Limboy
Toyabo
Kita Kita
San Agustin
Palestina
Estrella
Tumana
Qiongalong
Parilla
Bagong Sicat
Portal
Capisuan
SAN JOSE CITY
Santo Niño
Segundo
San Isidro
Parista
Agupalo Oeste
Arimul
Lupao
Bangar
San Roque
Cabayangan
Umingan
Laurin
Baral
Anan
Parang
General Luna
Mankitkit
Lukidnon
Padalis
Abuyo
Cawayan
Nanducoran River
Ditali River
Dinalungan River
Dipaculao River
Cabatangan River
Pampanga River
Digalam R.
Dambo R.
Reef
coral
sand
mud
rocky
45'
121°00'
30'
15°
15°20'
30'



MOUNT OTUNDO
Cawayan
Debutunan Point
Reef
Delgado Point
Ditali River
Ditali
Bunga Point
Dipaculao
Buenavista
Demabuno
Salay
BALER BAY
Dimanfonso
Maria Aurora
Butlengin
BALER
Baler Point
Port Aurora
Los Confites Reef
Encanto Point
CAPE ENCANTO
Disucsip Point
Dibucao
Gamne
Dikildit
Bacong
Baler
San Luis
San Luis River
Aguang R.
Villa Aurora
Ditaki
Salaysay Point
Egg Islands
Diotorin Point
Dicapanisan Point
LUZON ISLAND
PHILIPPINE SEA
MINGAN MOUNTAINS
Pinto
Bodong Sikat
Gabaldon
Bitlolok Lumber Mill
Bantug
Dingalan
Dicupanikian Point
Agria Point
Abuyo
mud
sand
coral
rocky
15°20'
30'
45'
122°00'

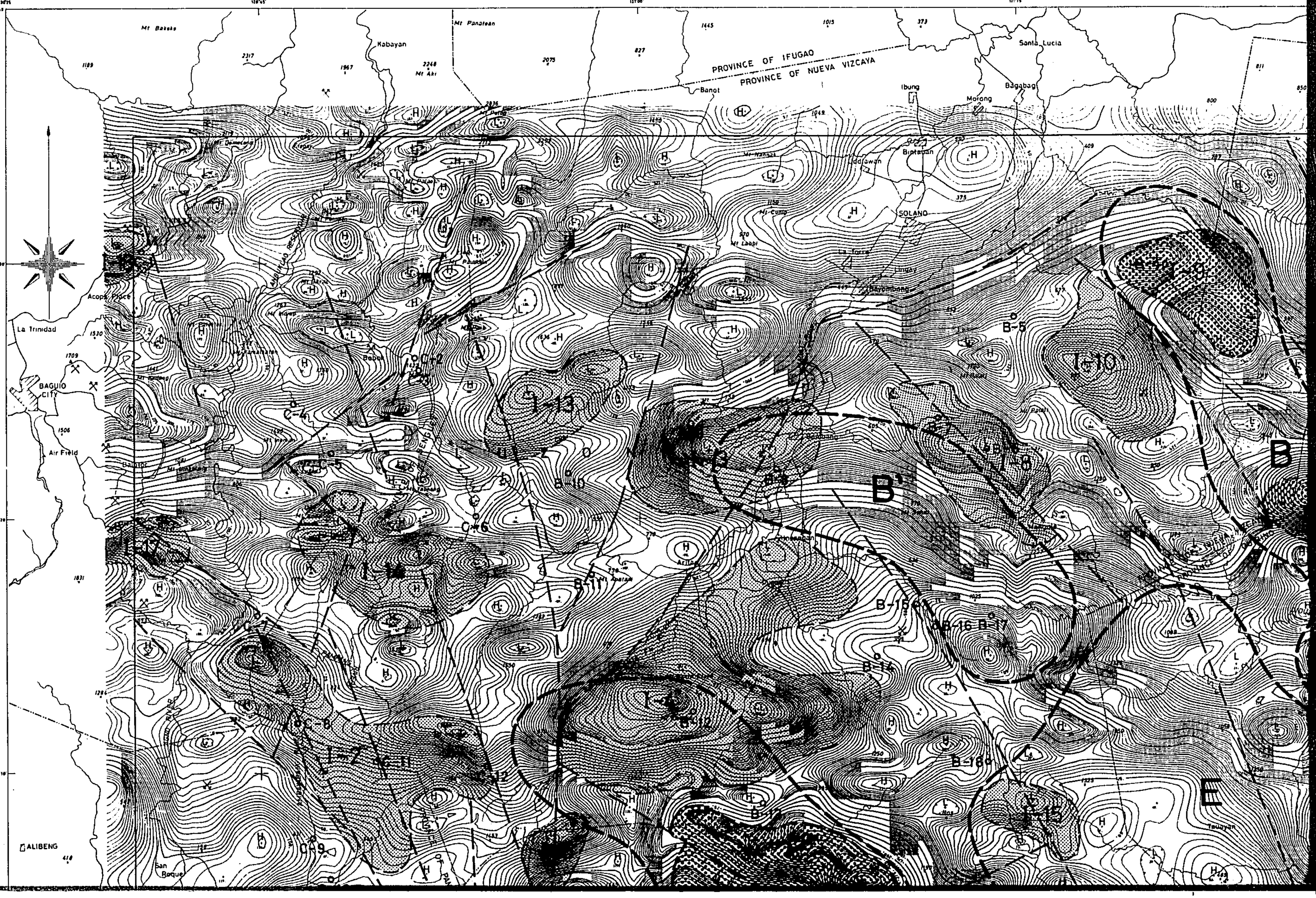


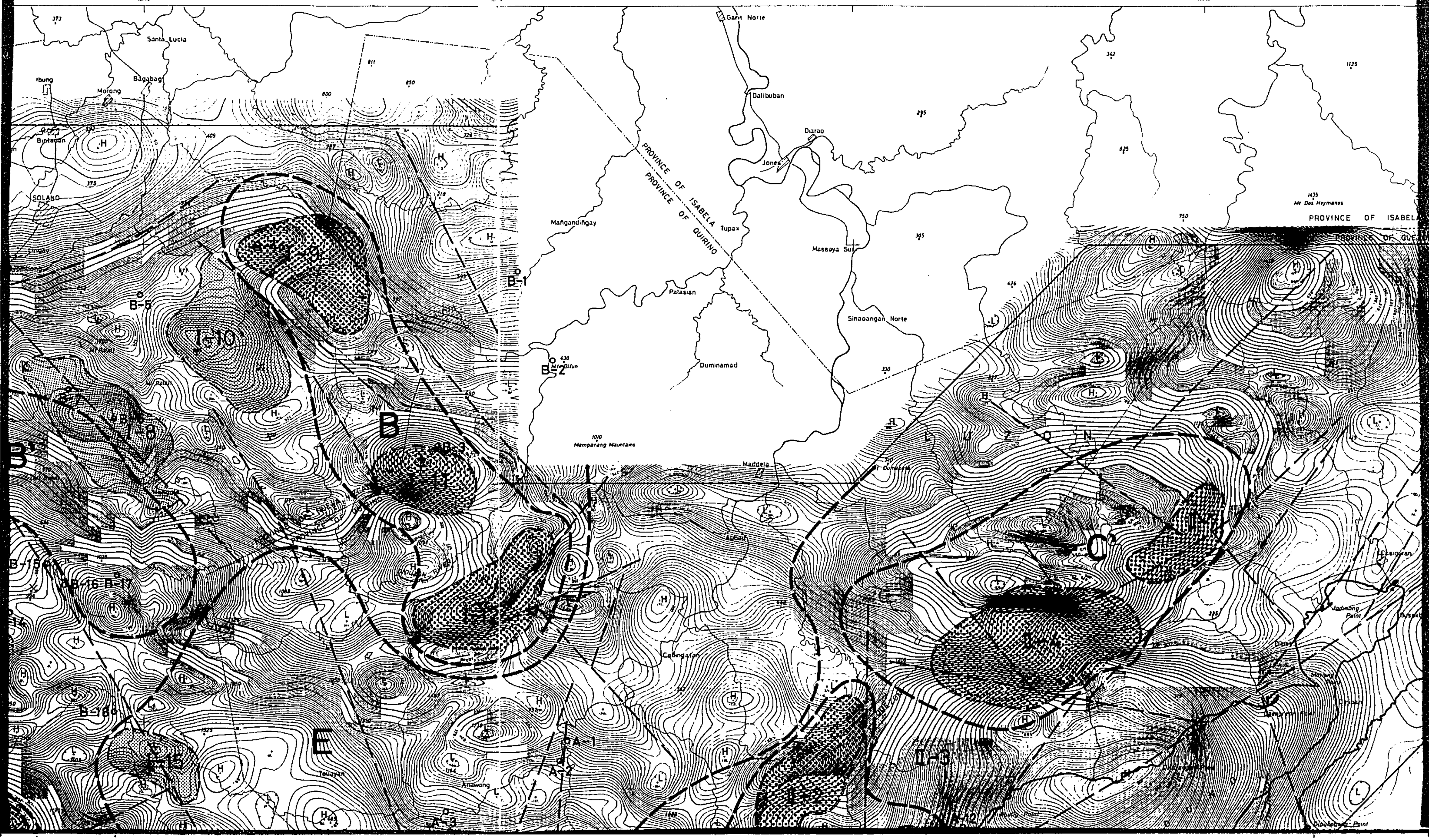
GOVERNMENT OF JAPAN
December 1977

Prepared by Bishimetal Exploration Co., Ltd.

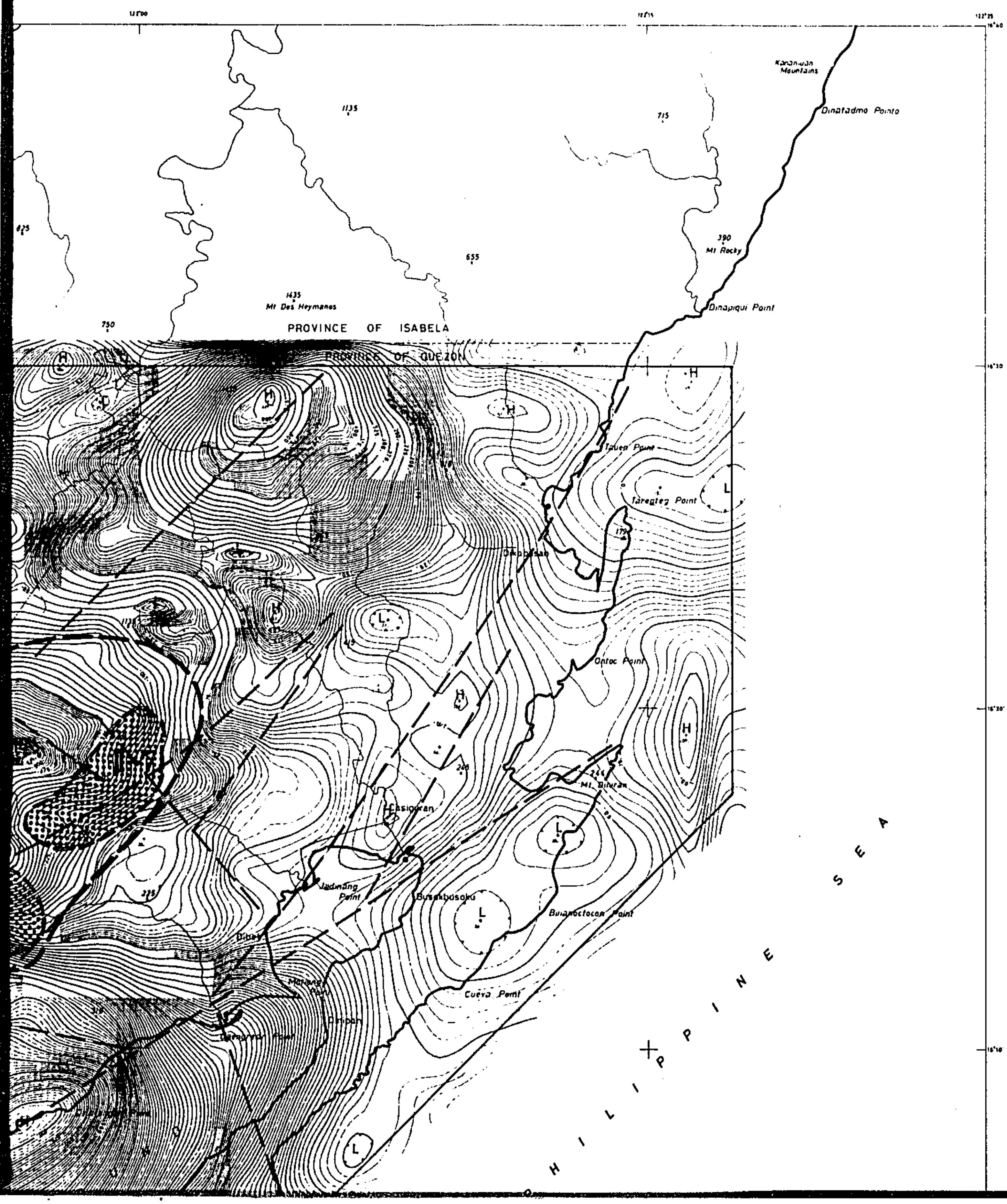
LEGEND

- O 13D Dating sample No.
- O 15C Chemical analysis sample No.
- O 17F Fossil sample No.


Mt Panatean
Kabayan
Mt Aki
PROVINCE OF IFUGAO
PROVINCE OF NUEVA VIZCAYA
Banot
Ibung
Morong
Bagabag
Santa Lucia
Bintauan
SOLANO
La Torre
Lingay
Bayombong
Acop's Place
La Trinidad
BAGUIO CITY
Air Field
San Roque
I-10
I-13
B'
B
E
C-4
C-5
C-6
C-8
B-5
B-10
B-11
B-14
B-17
I-15



Garit Norte
Santa Lucia
Ibung
Bagabag
Morong
Bintauan
SOLANO
Dalibuban
Diarao
Jones
PROVINCE OF ISABELA
PROVINCE OF QUIRINO
Mangandingay
Tupax
Massaya Sur
Palasian
Sinaoangan Norte
Duminamad
Mamparang Mauntains
Maddela
Mt Dos Heymanes
L U Z O N
Cabingatan
Tauayan
Anawang
Casiguran
B
C
E
B-1
B-2
B-5
I-10
I-3
A-1
A-2
A-3

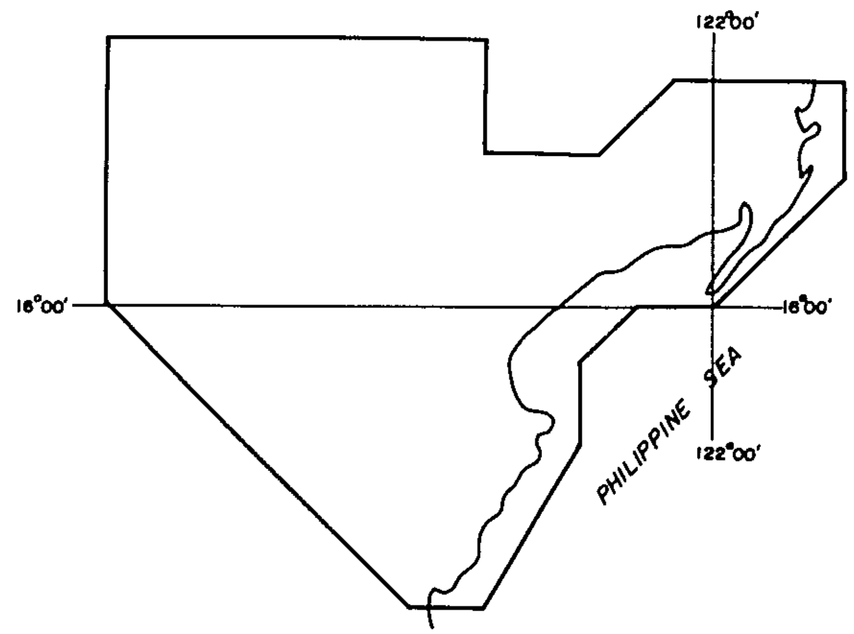


PL. 6

GEOPHYSICAL SURVEY OF NORTHEASTERN LUZON PHILIPPINES

INTERPRETATION MAP OF AIRBORNE MAGNETIC SURVEY

LOCATION INDEX

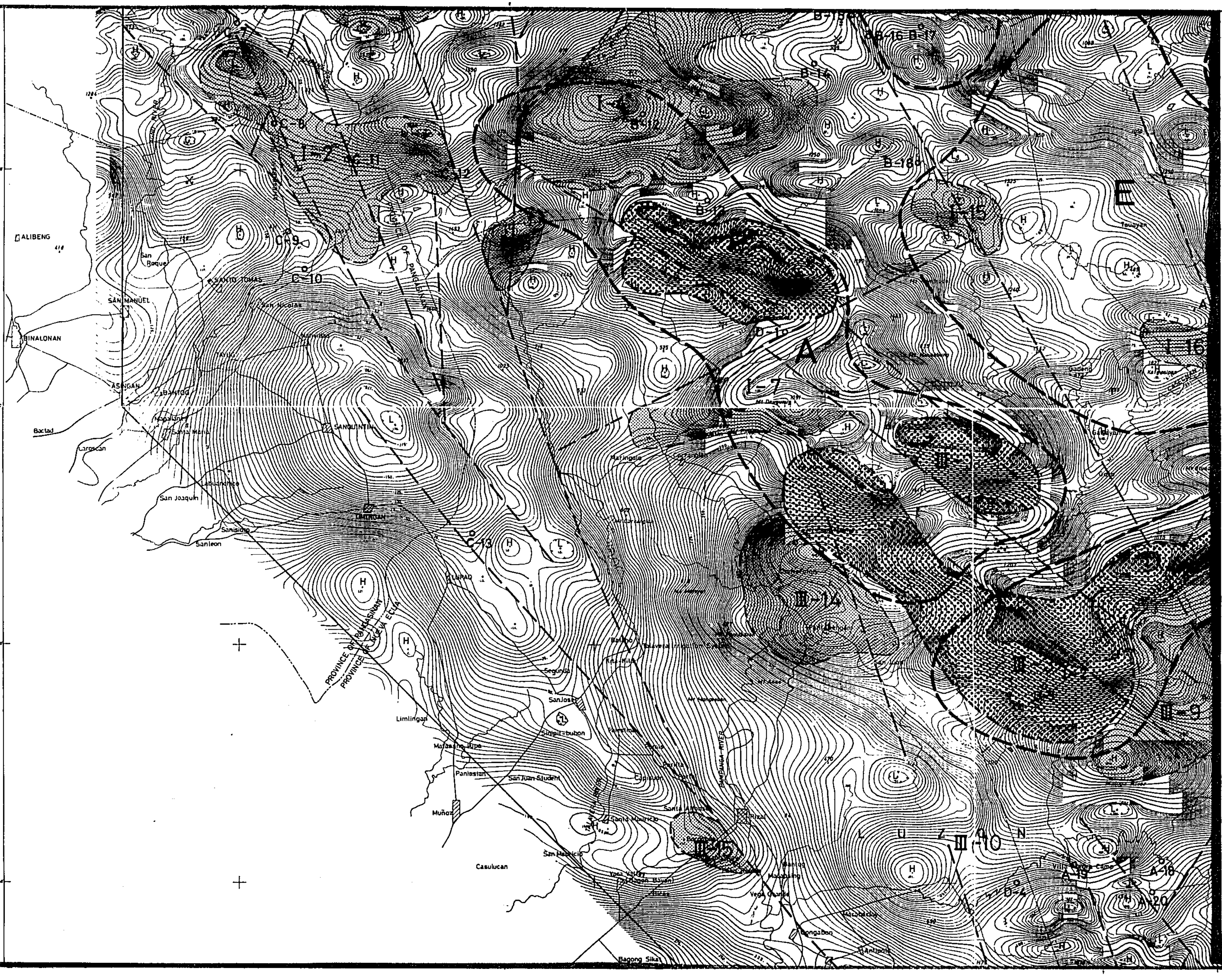


SCALE 1 : 250,000

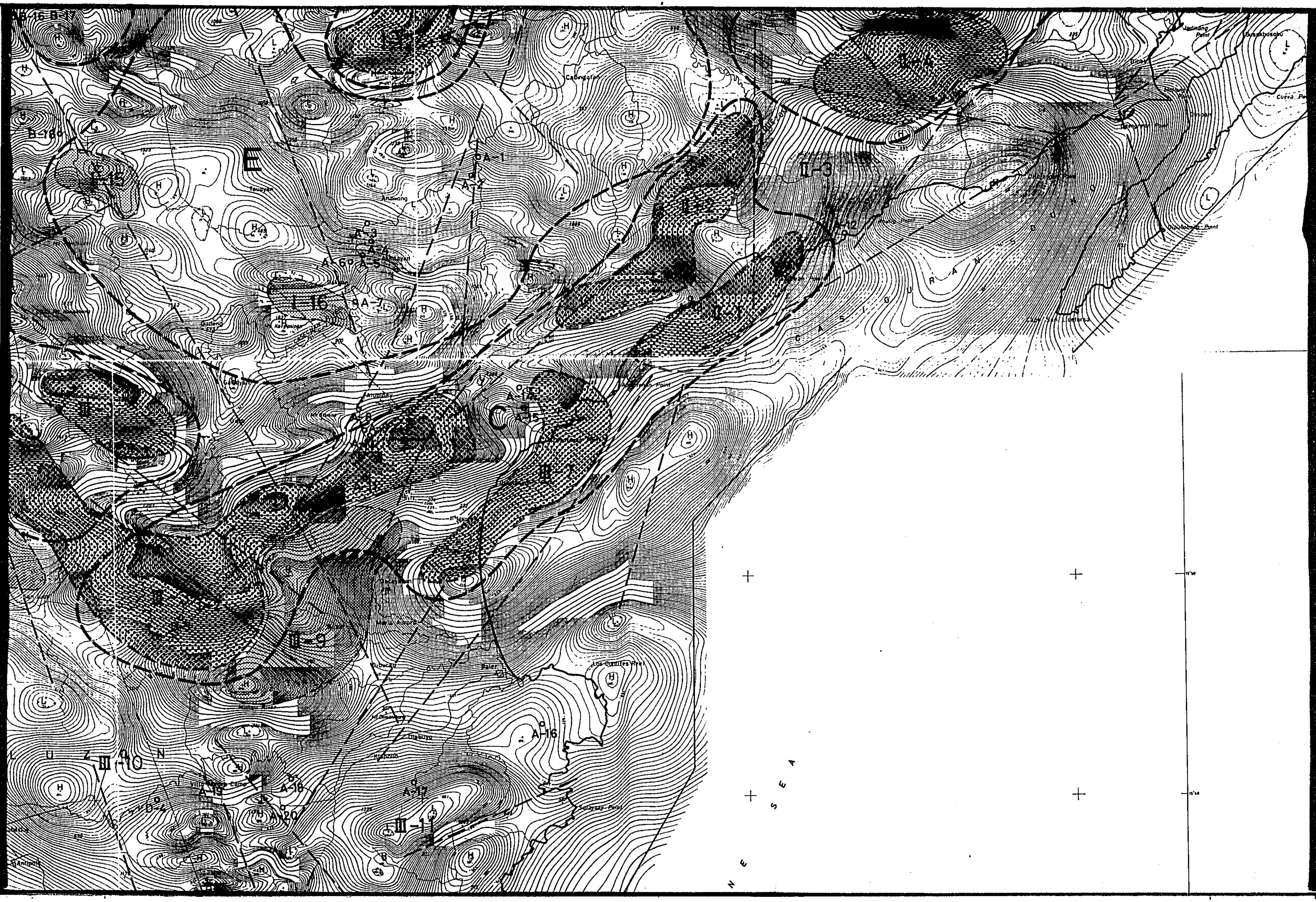
0 20 KM

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1977

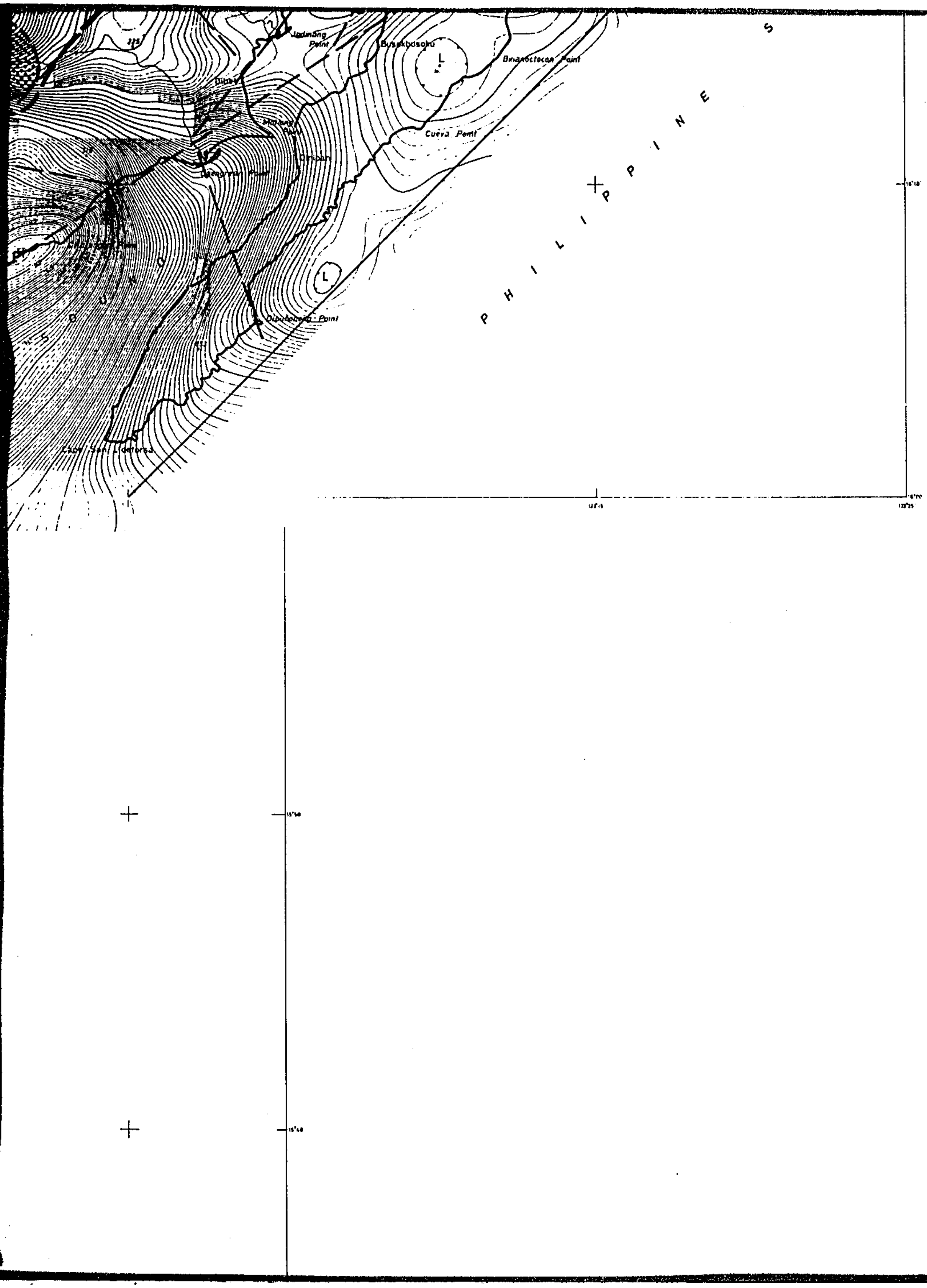
Prepared by Bishimetal Exploration Co., Ltd.



ALIBENG
San Roque
SANTO TOMAS
SAN MANUEL
BINALONAN
ASINGAN
Bactad
Laroscan
San Joaquin
Sanisidro
Sanleon
SANQUINTIN
PROVINCE OF PANGASINAN
PROVINCE OF NUEVA ECIJA
San Jose
Limlingan
Muñoz
Casulucan
San Mauricio
Santa Mauricio
Bagong Sikat
Antipolo
L U Z O N
E
A
I-2
I-4
I-7
I-15
I-16
III-9
III-10
III-14
III-15
C-8
C-9
C-10
C-11
C-12
C-13
B-14
B-16
B-17
B-18
D-4
A-18
A-19
A-20



E
C
I-15
I-16
II-3
III-9
III-10
A-1
A-2
A-3
A-4
A-5
A-7
A-16
A-17
A-18
A-20
B-16
Anawang
Cabangatan
Baler
Los Cuvilles Reef
L U Z O N
C A S I G U R A N



SCALE 1 : 250,000

0 20KM

METAL MINING AGENCY OF JAPAN

JAPAN INTERNATIONAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

December 1977

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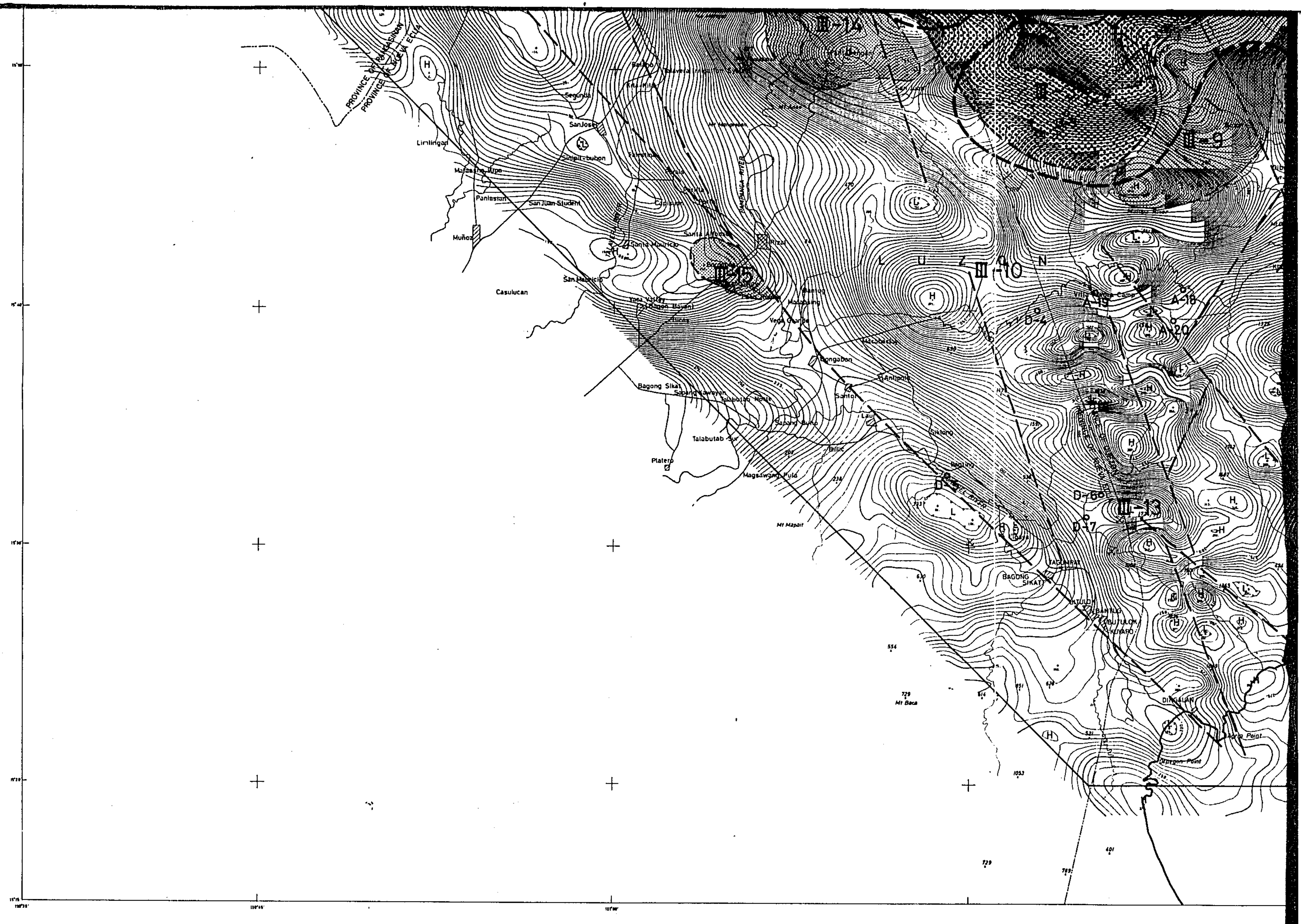
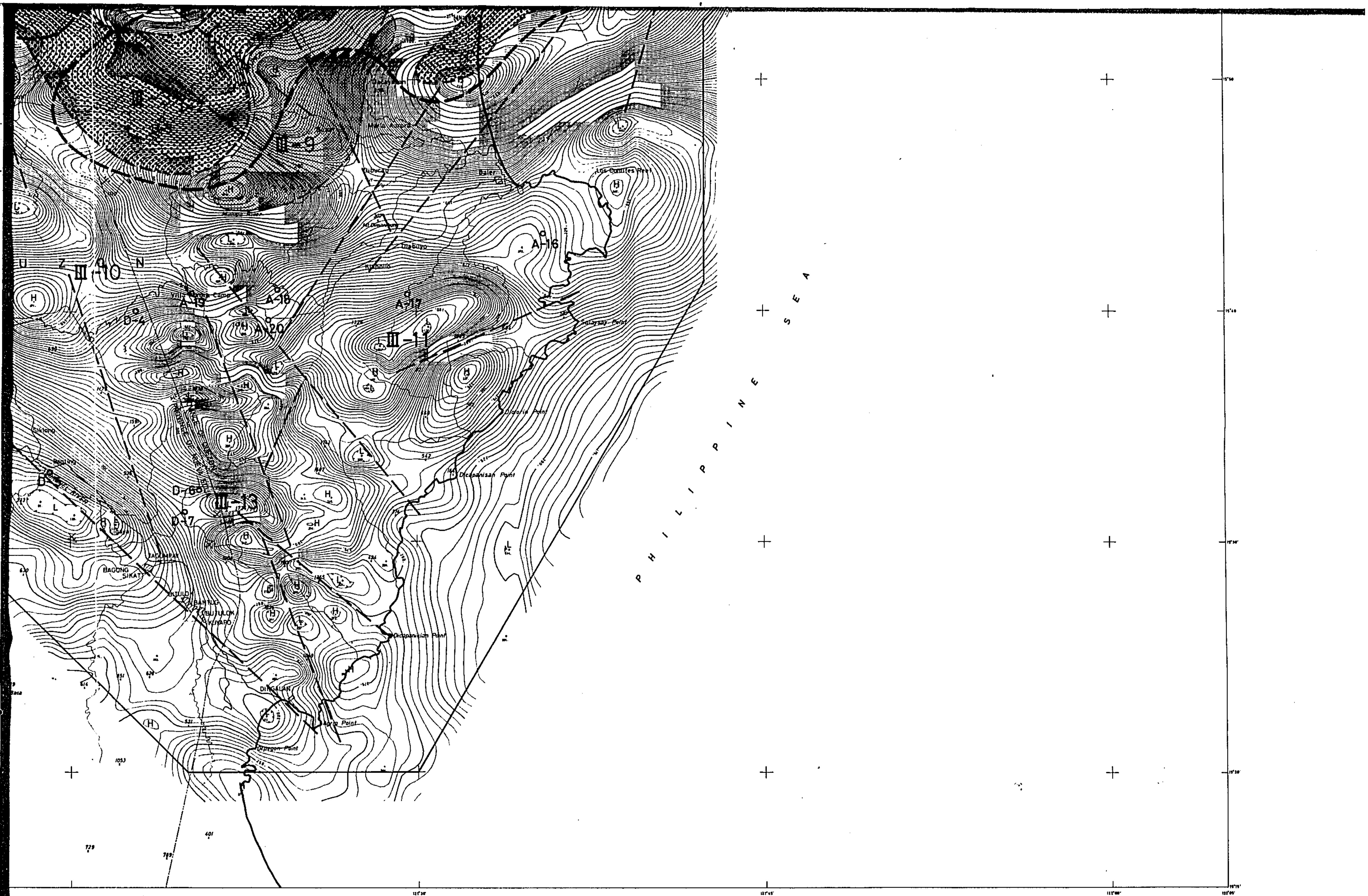
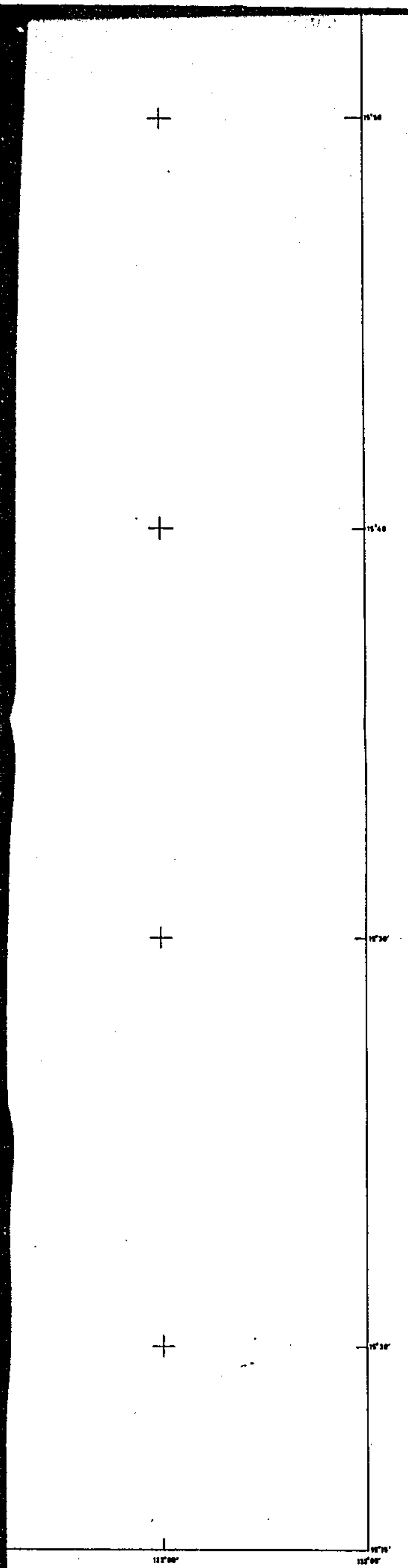
CONTOUR INTERVAL	25gammas
	5 gammas
TOTAL INTENSITY	40,000gammas
FLIGHT ALTITUDE	2,000m A.S.L.
FLIGHT LINE SPACING	
TRAVERSE	1,500meters
TIE	10,000meters
WORKING MINE	⚒
ABANDONED MINE	⚒

LEGEND

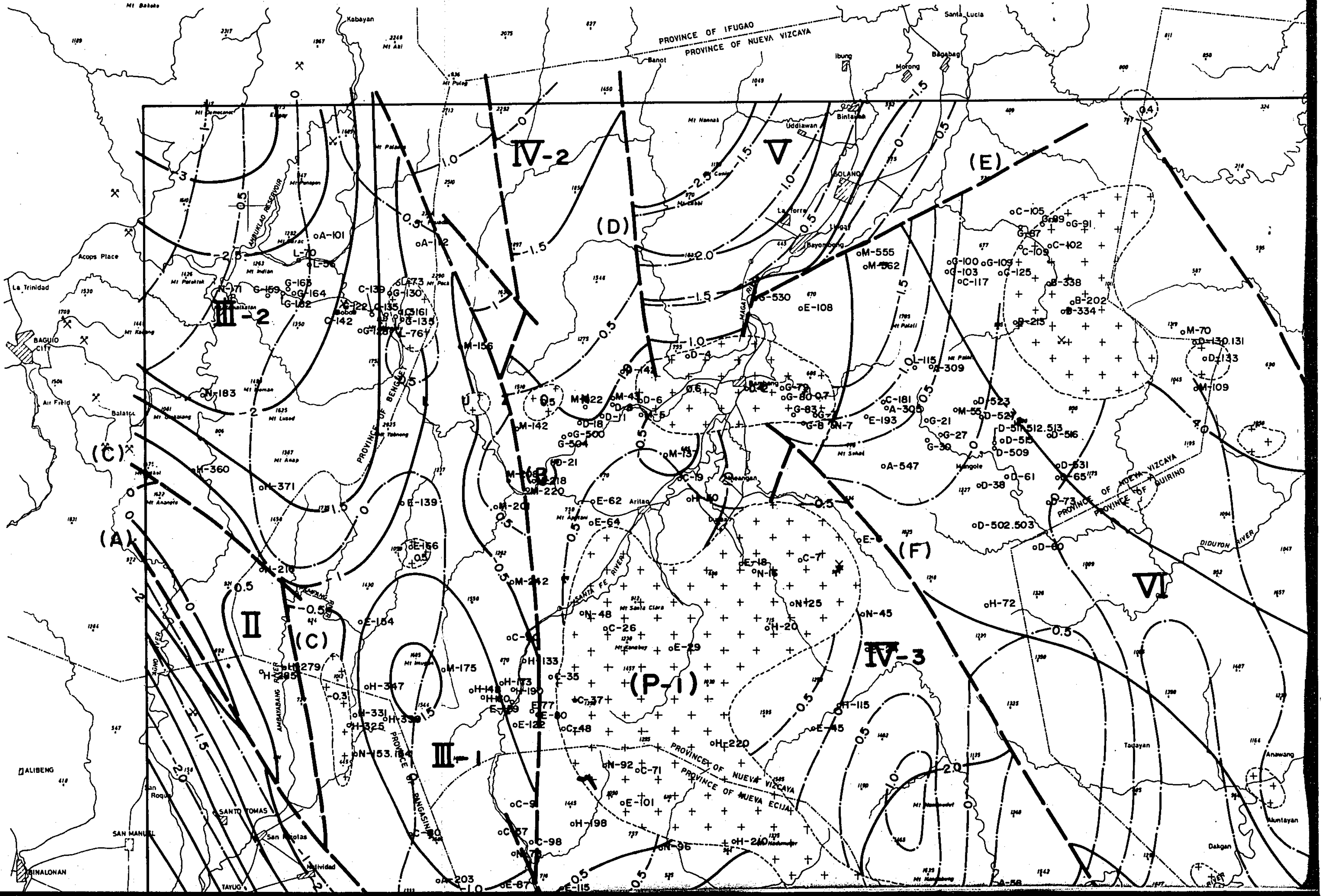
- A — MAIN STRUCTURE
- 1-9 — RANK A MAGNETIC ROCK
- 1-2 — RANK B MAGNETIC ROCK
- MAGNETIC TECTONIC LINE
- o A-5 — LOCATION OF ROCK SAMPLE


PROVINCE OF PANGASINAN
PROVINCE OF NUEVA ECIJA
III-14
III-9
III-15
III-10
III-13
L U Z O N
A-19
A-18
A-20
D-4
D-5
D-6
D-7
Villa Aurora Camp
Segunda
San Jose
Simpit-bubon
Linlingad
Malasiña Tupo
Panlastan
San Juan Student
Muñoz
Santa Mauricio
San Mauricio
Casulucan
Santa Alfonso
Rizal
Bongabon
Vega Grande
Antipolo
Santol
Siktoro
Bagong Sikat
Sabang Kawayan
Talabutab Norte
Talabutab Sur
Sabang Buho
Platero
Magsawang Pulo
Billic
Mt Mapait
TAGUMPAY
BAGONG SIKAT
BUTULOK
BANTUG
KUYAPO
DINGALAN
Mt Baca
Aprgon Point
554
729
1053
401
789

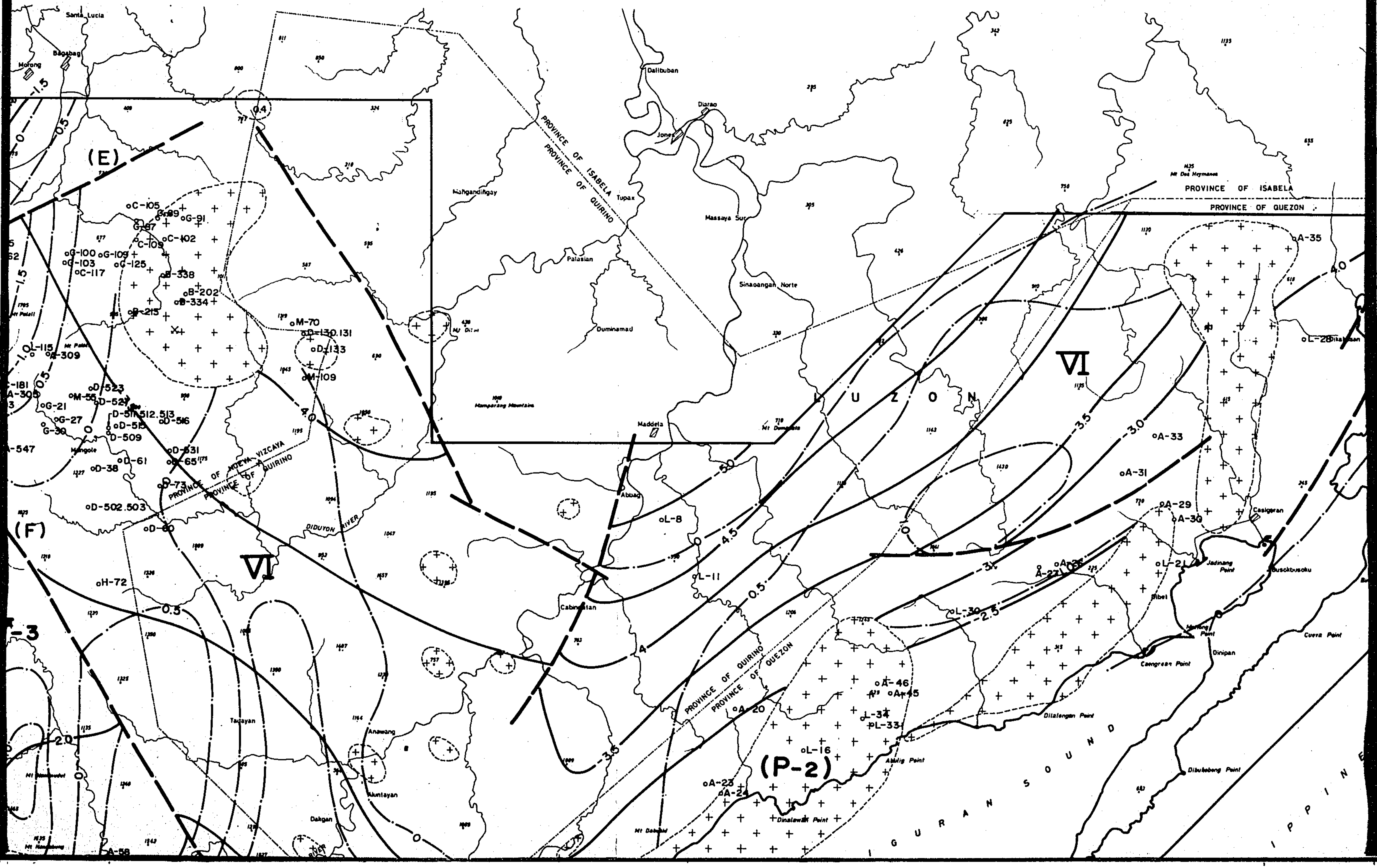

PHILIPPINE SEA
Ⅲ-9
Ⅲ-10
Ⅲ-11
Ⅲ-13
A-16
A-17
A-18
A-19
A-20
D-4
D-6
D-7
Baler
Salaysay Point
Diotorin Point
Dicapanisan Point
Dicapanisian Point
DINGALAN
BAGONG SIKAT
Tinabuyo



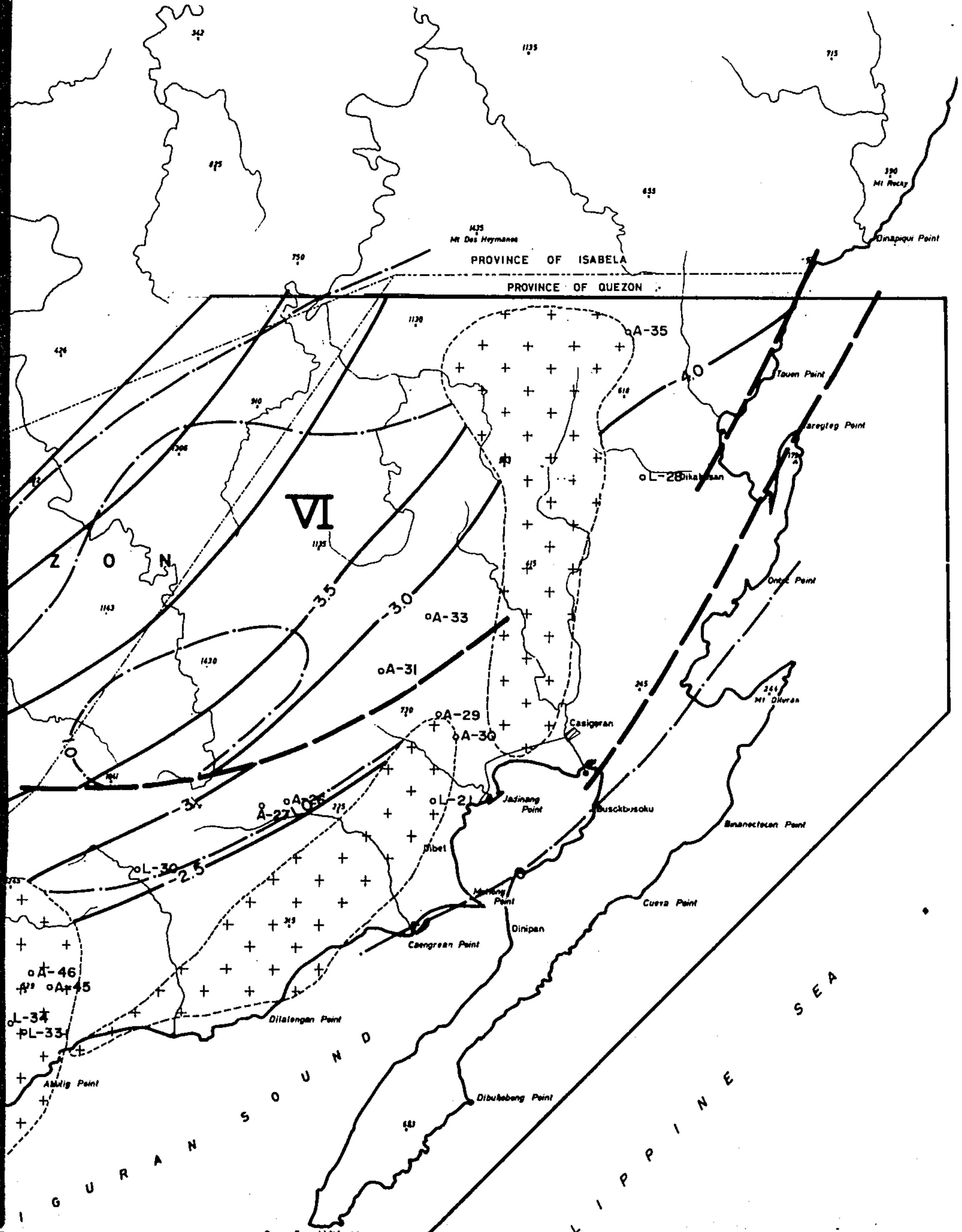
- A — MAIN STRUCTURE
- I-9 — RANK A MAGNETIC ROCK
- I-2 — RANK B MAGNETIC ROCK
- MAGNETIC TECTONIC LINE
- ○ A-5 — LOCATION OF ROCK SAMPLE



PROVINCE OF IFUGAO
PROVINCE OF NUEVA VIZCAYA
PROVINCE OF BENGUET
PROVINCE OF PANGASINAN
PROVINCE OF NUEVA ECIJA
PROVINCE OF QUIRINO
Ⅱ
Ⅲ-1
Ⅲ-2
Ⅳ-2
Ⅳ-3
Ⅴ
Ⅵ
(A)
(C)
(D)
(E)
(F)
(P-1)
BAGUIO CITY
La Trinidad
Acops Place
Air Field
Balatoc
Kabayan
Banot
Ibung
Morong
Bagabag
Santa Lucia
Uddiawan
Bintawan
SOLANO
La Torre
Bayombong
Bambang
Aritao
Dupax
Kasibu
Anawang
Tocayan
Aluntayan
Dakgan
SAN MANUEL
SANTO TOMAS
San Nicolas
Natividad
TAYUG
BINALONAN
ALIBENG
San Roque
DIDUYON RIVER
SANTA FE RIVER
AMBAYABANG RIVER
AGNO RIVER
MAGAT RIVER
AMBUKLAO RESERVOIR
Mt Bakoko
Mt Puleg
Mt Palali
Mt Imugan
Mt Santa Clara
Mt Anap
Mt Lusod
Mt Sohol



Santa Lucia
Bagabag
Morong
Dallbuban
Diarao
Jones
Tupax
Massaya Sur
Palasian
Sinaoangan Norte
Duminamad
Mamparang Mountains
Maddela
PROVINCE OF ISABELA
PROVINCE OF QUIRINO
PROVINCE OF QUEZON
PROVINCE OF NUEVA VIZCAYA
L U Z O N
DIDUYON RIVER
(E)
(F)
VI
(P-2)
Abbag
Tarayan
Anawang
Aluntayan
Dakgan
Casiguran
Jadinang Point
Dinipan
Cueva Point
Dilalongan Point
Dinalawat Point
S O U N D

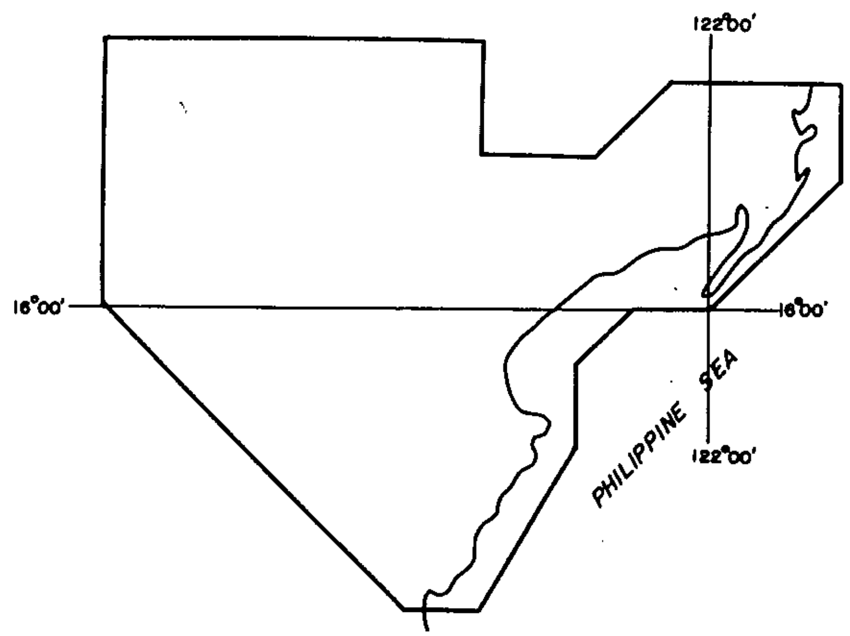


PL. 7

GEOPHYSICAL SURVEY
OF
NORTHEASTERN LUZON
PHILIPPINES

RE-INTERPRETATION MAP OF AIRBORNE MAGNETIC SURVEY

LOCATION INDEX



SCALE 1 : 250,000

0 20KM

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1977

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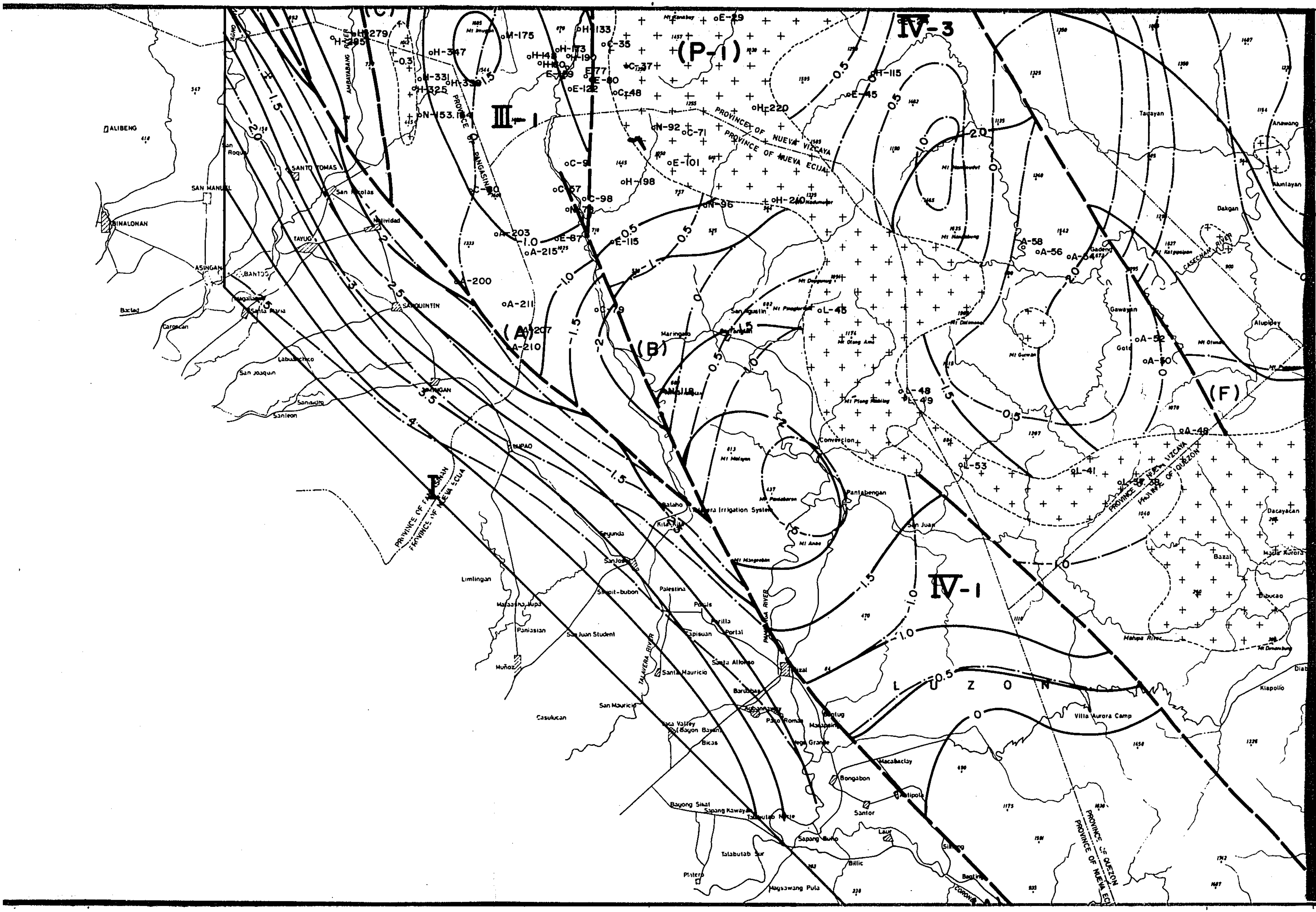
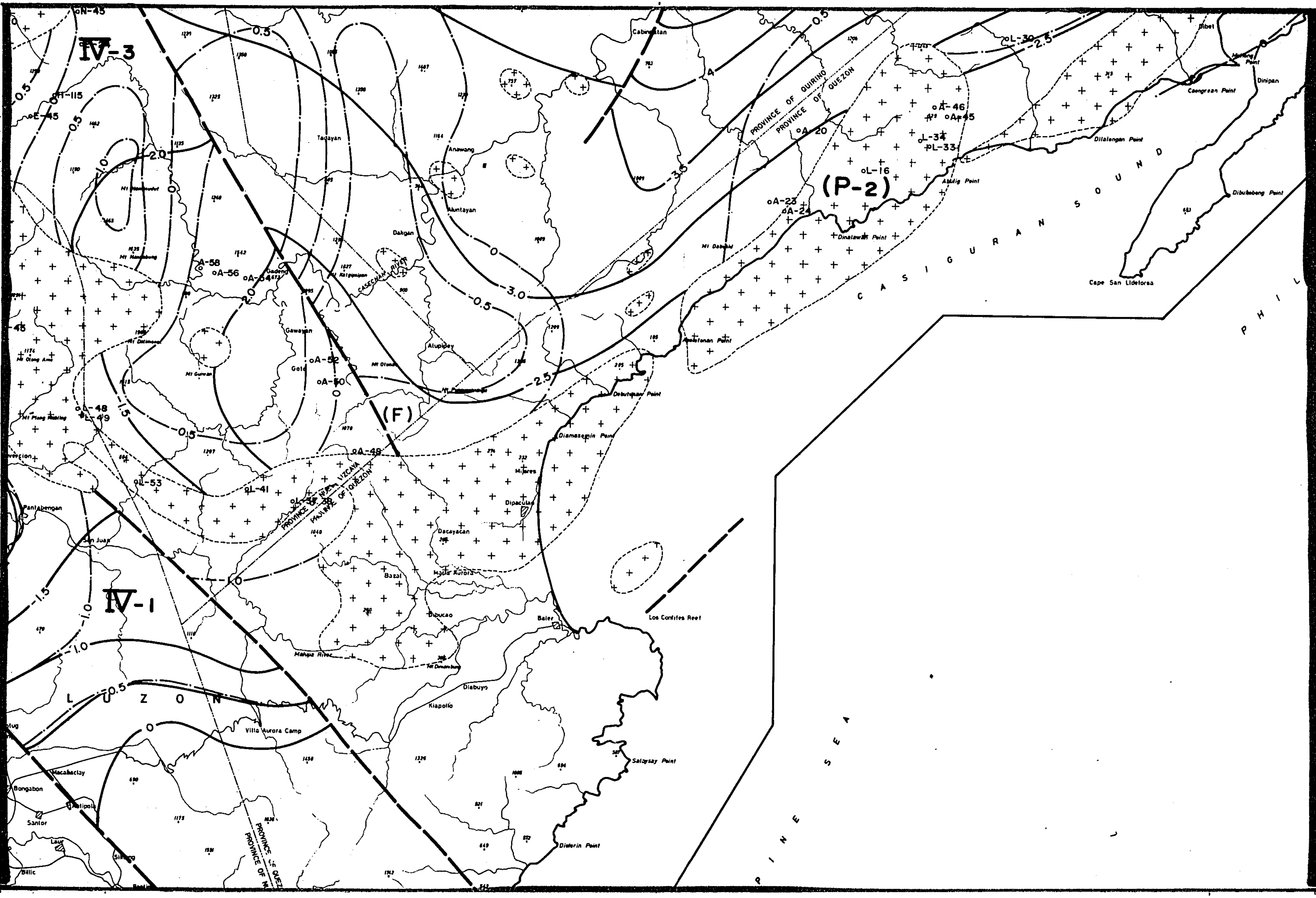
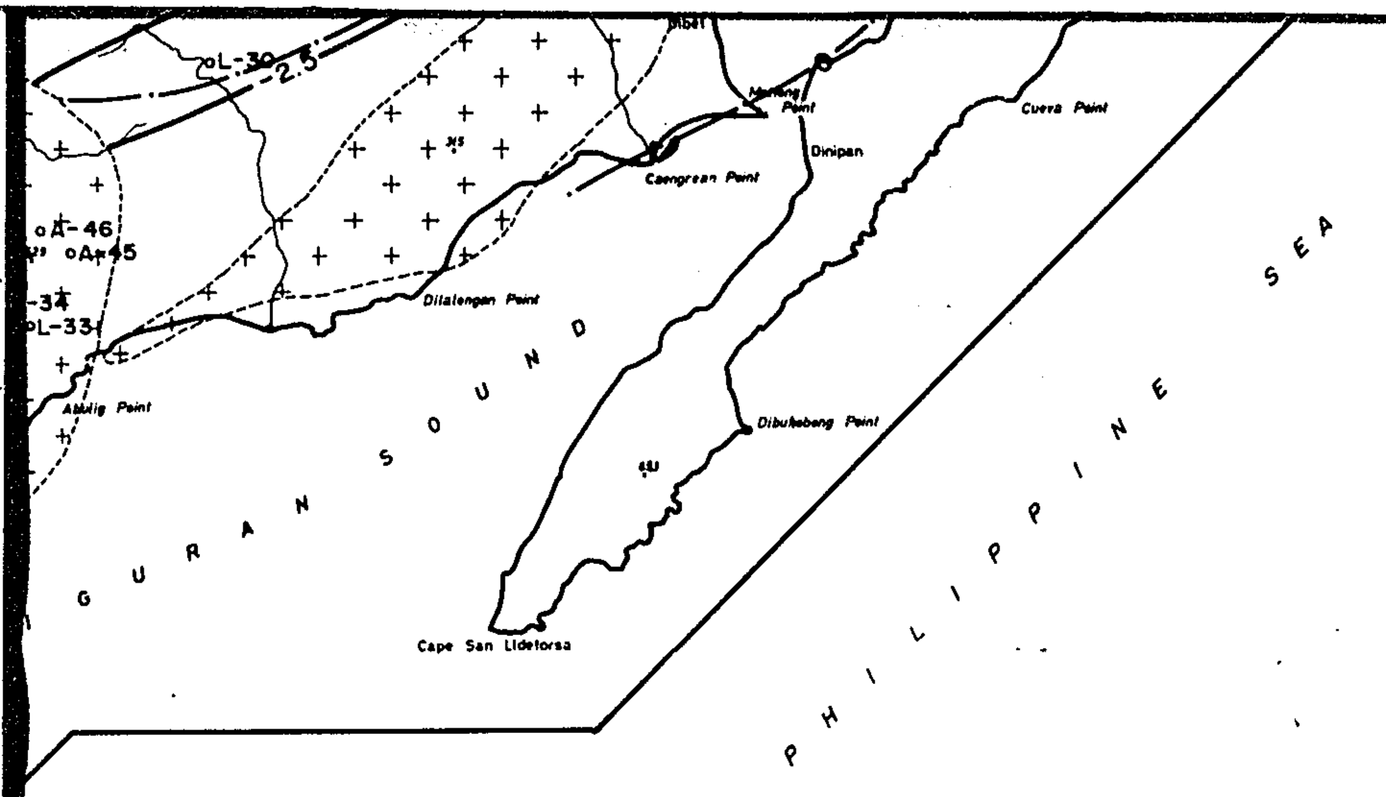

IV-3
(P-1)
III-1
(C)
(A)
(B)
(F)
I
IV-1
L U Z O N
PROVINCE OF NUEVA VIZCAYA
PROVINCE OF NUEVA ECIJA
PROVINCE OF PANGASINAN
PROVINCE OF QUEZON
AMBAYABANG RIVER
PANTABANGAN RIVER
TALAVERA RIVER
CASECNAN RIVER
ALIBENG
SAN MANUEL
BINALONAN
ASINGAN
SANTO TOMAS
San Nicolas
Natividad
TAYUG
BANTOG
Santa Maria
SAN QUINTIN
Bactad
Carosucan
Labuanchico
San Joaquin
Sanleon
UMINGAN
LUPAO
Limlingan
Muñoz
Paniasian
San Juan Student
Casulucan
San Mauricio
Santa Mauricio
San Jose
Segunda
Palestina
Maringalo
San Agustin
Conversion
Pantabangan
Talavera Irrigation System
San Juan
Rizal
Bongabon
Santor
Laur
Bagong Sikat
Sapang Kawayan
Talabutab Norte
Talabutab Sur
Sapang Buho
Billic
Platero
Magsaysay Pula
Villa Aurora Camp
Macabaclay
Tagayan
Anawang
Alunlayan
Dakgan
Gadeng
Gawayan
Alupidey
Gota
Dacayacan
Bazal
Maria Aurora
Dibucao
Kiapolio
Mahipa River


IV-3
IV-1
(P-2)
(F)
L U Z O N
C A S I G U R A N S O U N D
P H I L
P I N E S E A
PROVINCE OF QUIRINO
PROVINCE OF QUEZON
PROVINCE OF NUEVA VIZCAYA
PROVINCE OF QUEZON
Casecnan River
Anawang
Muntayan
Dakgan
Gawayan
Goto
Alupidey
Mijares
Dipaculao
Dacayacan
Bazal
Maria Aurora
Dibucao
Baler
Diabuyo
Kiapolio
Villa Aurora Camp
Pantabengan
San Juan
Macabaclay
Bongabon
Santor
Laur
Bilic
Los Confites Reef
Salaysay Point
Dialerin Point
Dinipan
Dilalangan Point
Dinalawan Point
Abdig Point
Dibutunan Point
Cape San Ildefonsa
A-46
A-45
L-34
L-33
L-16
A-20
A-23
A-24
L-30
A-58
A-56
A-54
A-52
A-50
A-48
L-48
L-49
L-53
L-41
H-115
E-45
N-45



SCALE 1 : 250,000

0 — 20 KM

METAL MINING AGENCY OF JAPAN
JAPAN INTERNATIONAL COOPERATION AGENCY
GOVERNMENT OF JAPAN
December 1977

Prepared by Bishimetal Exploration Co., Ltd.

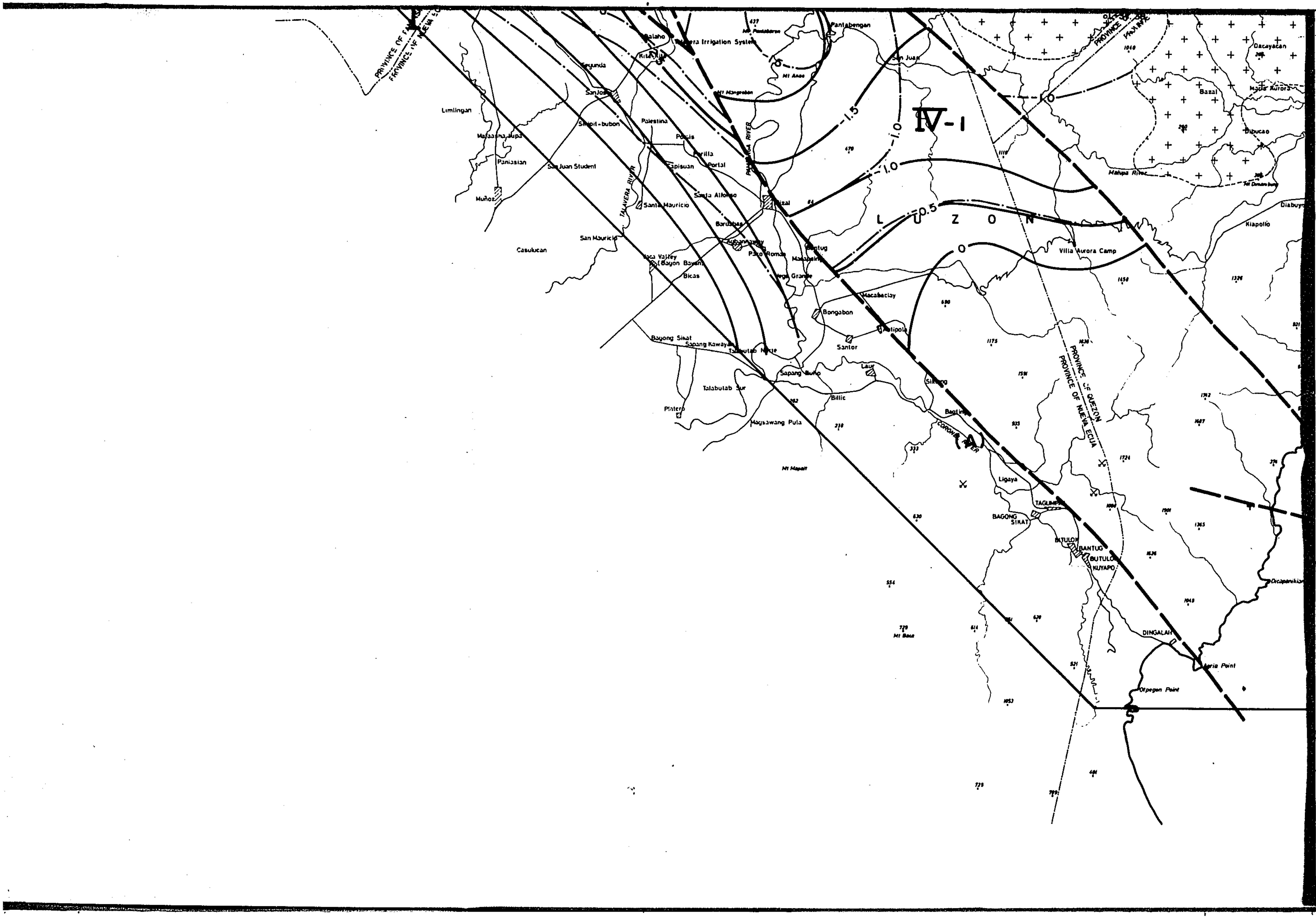
LEGEND

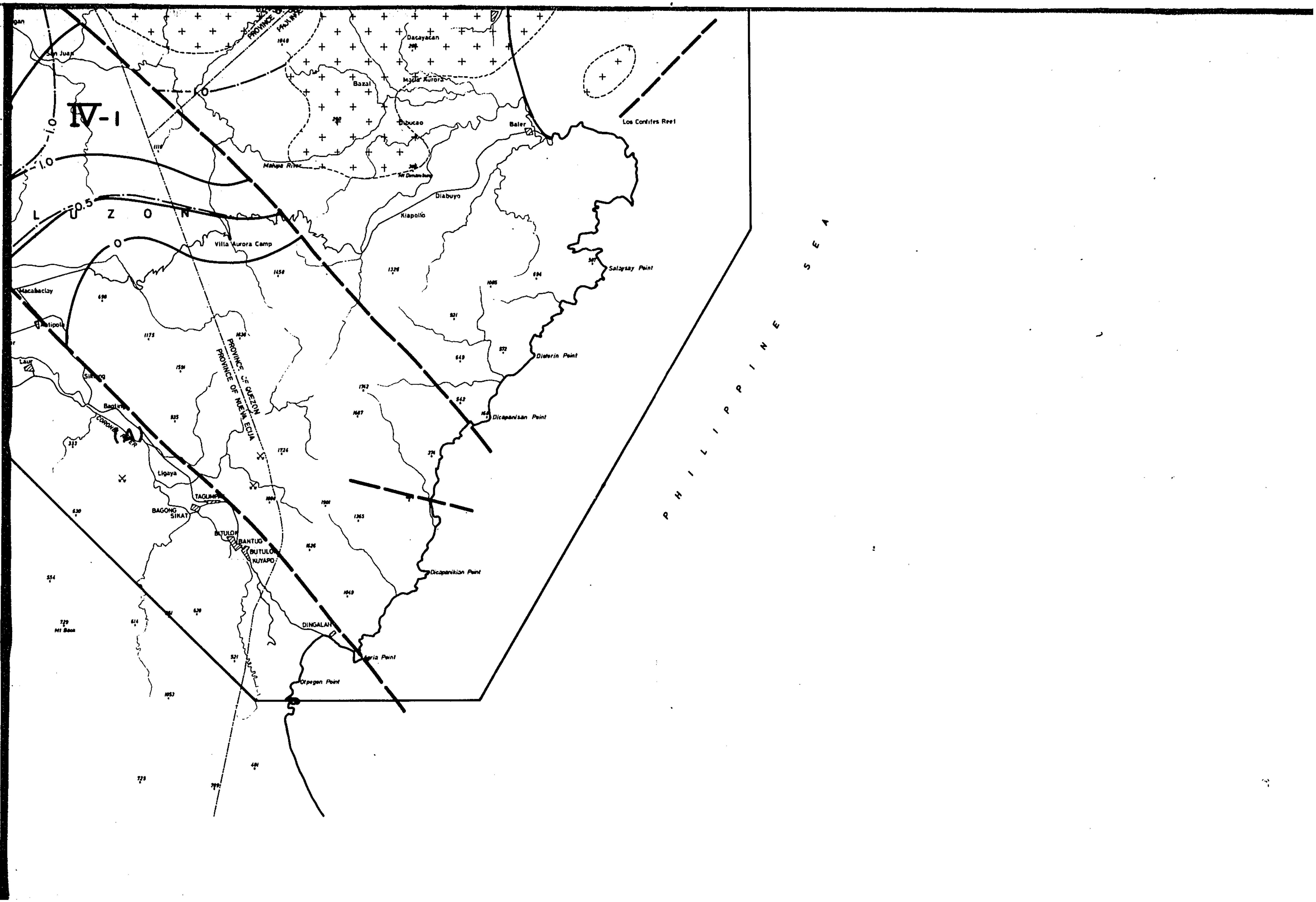
Iso-depth line of the top-surface of the lower layer of the Caraballo Group (above sea level··km) — 1.5

Iso-depth line of the surface of Basement-complex (above sea level··Km) (Shist and plutonic rock etc) (or of the bottom of Caraballo Group) — 2

Plutonic rock (i.e. cliorite~syenjte)

Magnetic Tectonic Line


IV-1
L U Z O N
PROVINCE OF NUEVA ECIJA
PROVINCE OF QUEZON
1.5
1.0
0.5
0
Pantabangan
Mt Pantabangan
Irrigation System
Mt Anoo
Mt Mangraban
San Juan
Bazal
Casayacan
Dibucao
Malupa River
Diabuyo
Kiapolio
Villa Aurora Camp
Limlingan
Munoz
Paniasian
San Juan Student
TALAVERA RIVER
Santa Mauricio
San Mauricio
Casulucan
Palestina
Poblis
Portal
Santa Alfonso
PAMPANGA RIVER
Rizal
Bantug
Macabaclay
Bongabon
Santor
Bayong Sikat
Sapang Kawayan
Sapang Buho
Talabutab Sur
Platero
Magsawang Pula
Billic
Laur
Siklong
Ligaya
TAGUMPAY
BAGONG SIKAT
BUTULO
BANTUG
KUYAPO
DINGALAN
Aria Point
Otpegan Point
Mt Mapait
Mt Baca



IV-1
L U Z O N
1.0
0.5
0
San Juan
Dacayacan
Bazal
Maria Aurora
Dibucao
Baler
Los Confites Reef
Diabuyo
Kiapolio
Villa Aurora Camp
Salaysay Point
Macabaclay
Antipolo
Ligaya
BAGONG SIKAT
BANTUG
KUYAPO
DINGALAN
Disterin Point
Dicapanisan Point
Dicapanikian Point
Olpegen Point
PROVINCE OF QUEZON
PROVINCE OF NUEVA ECIJA
P H I L I P P I N E S E A

Iso-depth line of the surface of Basement-complex (above sea level··Km) (Shist and plutonic rock etc) (or of the bottom of Caraballo Group)

Plutonic rock(i.e. cliorite~syenite)

Magnetic Tectonic Line