REPUBLIC OF THE PHILIPPINES

DEPARTMENT OF NATURAL RESOURCES

BUREAU OF MINES

REPORT ON GEOLOGICAL SURVEY OF EASTERN MINDANAO

(CONSOLIDATED REPORT)

JULY 1974

METAL MINING AGENCY

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

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Preface

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

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

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

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

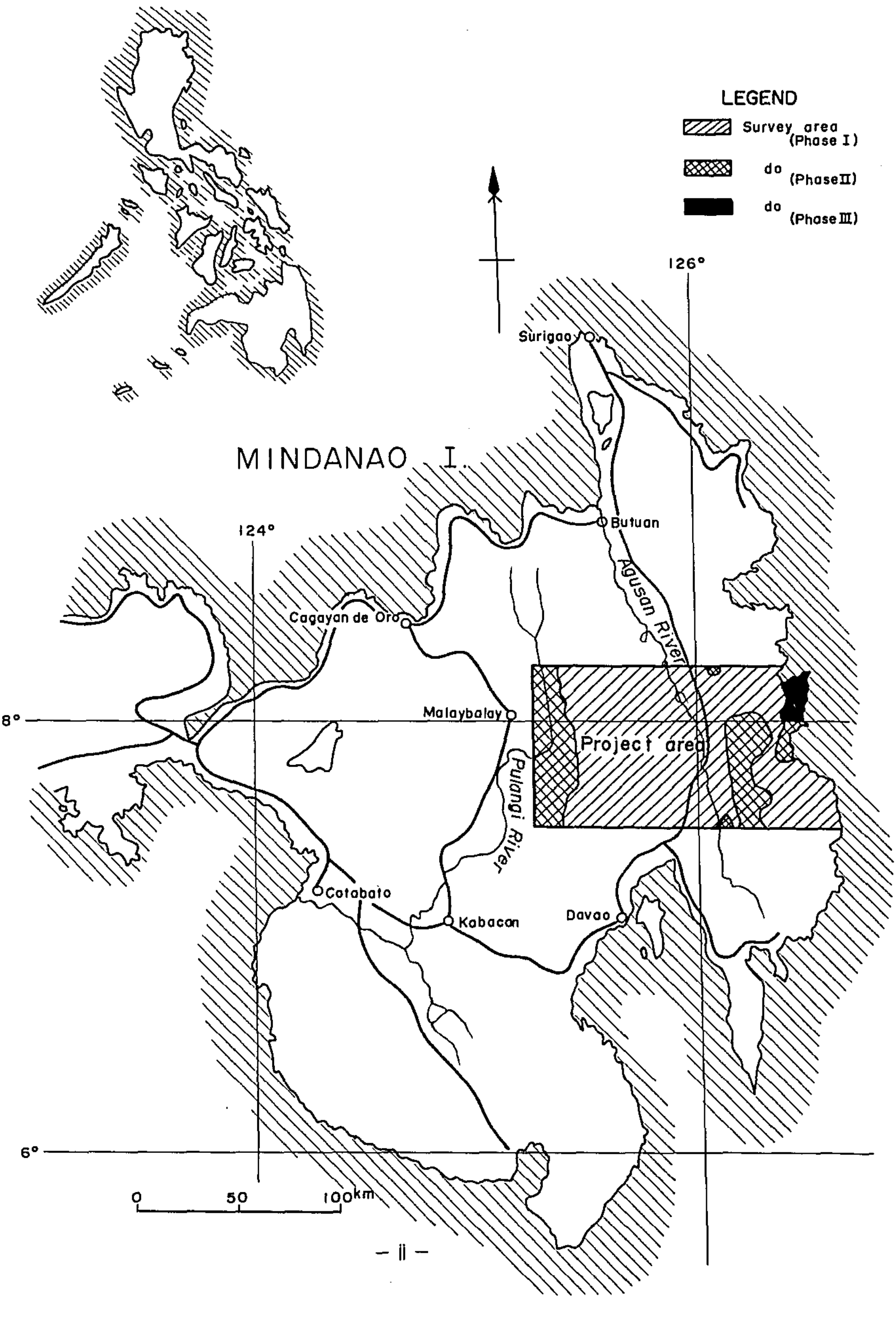
July, 1974

Keiichi Tatsuke

Director General

Overseas Technical Cooperation Agency.

Fig. 1 Location map of the Survey area



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ABSTRACT

The purpose of this survey was to elucidate a potential for mineral resouces and geological structures in eastern Mindanao. For this purpose, geological and geochemical reconnaissance surveys were carried out in 1971, followed by detailed geological, geochemical and geophysical surveys in 1972, and detailed geological and geophysical surveys and drilling exploration in 1973.

The geological survey made clear the ages of rocks (which had been lumped together as undifferentiated volcanic rocks or undifferenciated sedimentary rocks), the geological structures and the sedimentary environments.

In the Bislig and Tagbiga Areas, diorite rocks accompanying copper mineralization were newly discovered. And some problems on the diorite intrusion were also solved.

Geochemical stream sediment survey for Cu, Zn and Ni was conducted over the whole area. It proved to be very useful for selecting the promising area.

As a result of the survey, geochemical Cu anomalies were disclosed in both the Bislig and Tagbiga Areas. Their configurations were made clear by soil survey. The results thus obtained were very useful to establish geophysical survey lines.

Geophysical surveys were conducted centering around the Cu anomalous zones. In the Eastern and Western Areas, IP anomalies corresponding to geochemical anomalies were disclosed. From the systematic studies based on these surveys, it was concluded that the Bislig mineralized zone in the Eastern Area was more important for exploration than the Tagbiga mineralized zone in the Eastern Area.

Drilling was carried out in the Bislig Area. A total of five (5) vertical holes, each up to the depth of 250m were drilled. No. 1 hole, the first from the north, hit the dissemination of porphyry copper type deposits.

The mean content of 150m thickness from 100m to 250m in depth is 0.397% of Cu; 26m thickness from 224m to 250m in depth shows 1.006% and the network at 248 250m in depth is 4.93% of Cu. The copper contents tend to increase towards depth.

This dissemination is, however, considered to be local, from the studies based on other drillings, geophysical surveys and geochemical surveys. But it is probable that the most significant mineralization starts from the vicinity of No. 1 hole. Therefore, the follow-up drillings will be desirable to be undertaken in the vicinity of No. 1 drill hole.

PART I GEOLOGICAL SURVEY

1. Purposes of Survey

The purposes of the survey of eastern Mindanao were to select the most promising area for mineral deposits, to clarify the features of mineralization and the geological structures in the selected area, and further, to investigate the possibility of developing the mineral deposits.

2. Outline of Survey

Such basic survey for development of mineral resources was carried out jointly by the Republic of the Philippines and Japanese Governments for the period from 1971 to 1973. The whole survey area is located within the forest reservation of the Philippine Government.

The promising area was narrowed down by a step by step orthdox procedure, that is, geological and geochemical reconnaissance surveys, detailed geological geochemical and geophysical surveys, and exploratory drilling. Finally, five (5) drill holes were put out whereby a porphyry copper type disseminated zone was disclosed.

In Phase I, nine parties were organized in order to conduct geological survey and geochemical stream sediment survey on the whole area. As a result, one (1) area in the East and one (1) area in the West were selected as having high potential for mineral deposits. These two cover 3,000Km^2 or nearly 30% of the whole survey area.

In Phase II, detailed geological survey and geochemical stream sediment survey were carried out on the selected area by eight parties, and further, the geochemically anomalous zones (disclosed by the stream sediment survey) were investigated by geochemical soil survey, so that the outlines of the anomalous zone became clear.

The field chemical analyses showed the Bislig and Tagbiga Areas as having higher potential for mineral deposits. Subsequetly, IP survey and soil sampling along the IP survey lines were conducted in both areas. From the results of surveys, it was concluded that the Bislig Area had the highest potential for mineral deposits.

In Phase III, detailed geological and geophysical surveys with geochemical method were carried out in the Bislig Area by four (4) parties, and, based upon the results, diamond drilling was conducted at five (5) promising sites.

And finally, a copper dissemination of high grade has been found.

The outline of the geological survey carried out over three years is shown in Table 1.

Table 1. Exploration program employed in Eastern Mindanao Project

Phase I Feb. ~ Jun. 1972	**Selection of promising areas (3,000Km^2)** Reconnaisonce geological & geochemical (stream sediment) surveys
	↓
Phase II Jan. ~ Apr. 1973	**Selection of more promising areas** Detailed geological & geochemical (stream sediment) surveys
	↓
	Selection of the most promising area (170Km^2) Detailed geological, geochemical (soil) and geophysical (IP method) surveys
	↓
Phase III Sep. 1973 ~ Feb. 1974	**Exploration for Cu ore** Detailed geological (with geochemical method) and geochemical (IP method) surveys drilling exploration

3. List of Members

The list of members engaged in the survey is shown in Table 2.

Table 2 List of Members

Phase I

JUAN E. PILAC	Bureau of Mines, Philippines	TŌRU MIURA	Metallic Minerals Exploration Agency of Japan
		YASUSHI KANBE	do
		MICHIHISA SHIMODA	Overseas Technical Cooperation Agency of Japan
		YUTAKA EDA	do
		TŌRU ŌTAGAKI	do
		AKIRA SATŌ	do
MAXIMO V. GARCIA	B.O.M.	HIROSHI FUCHIMOTO	O.T.C.A.
WENCESLAO ARGAÑO	do	TERUYUKI TAKEDA	do
NARCISO BAUTISTA	do	TAKASHI ONO	do
IRENEO OSCILADA	do	DATSUO ARAI	do
EMIL T. AVILA, Jr.	do	HARUHIKO HIRAYAMA	do
MARIO TORRES	do	KAZUHARU UMETSU	do
DONNO CUSTODIO	do	JUNICHI KŌNO	do
JOSE N. ALMASCO	do	YASUYOSHI UEKI	do
ALBERTO ISSAC, Jr.	do	MASAKAZU KAWAI	do
ELIGIO Z. ARIATE	do	KŌJI NAGASHIMA	do
BERNICITO BALLESTEROS	do	MASAO HORI	do
PAUFILO MONTERO	do	TAKASHI KATANO	do
BENJAMIN PINGOL	do	TATSUO NIIMURA	do
		KEIICHI KUMITA	do
		SHUSUI URAI	do
		MANABU YAMAGUCHI	do
		MASAHIRO HASE	do
		HIDETOSHI TAKAOKA	do
		TETSUO TAKAGI	do
		KAZUHIRO TAKAHASHI	do

Phase II

JUAN E. PILAC	Bureau of Mines, Philippines	HIROSHI FUCHIMOTO	Overseas Technical Cooperation Agency of Japan
		KYOICHI KOYAMA	Metal Mining Agency of Japan
		MAGOICHI ADACHI	do
		KAICHIRO SHIMIZU	O.T.C.A.
(Geological team)			
MAXIMO V. GARCIA	B.O.M.	TERUYUKI YAKEDA	O.T.C.A.
WENCESLAO ARGAÑO	do	HARUHIKO HIRAYAMA	do
NALCISO BAUTISTA	do	YASUKICHI UEKI	do
IRENEO OSCILLADA	do	YOSHINOBU WATAYA	do
ALBERTO ISSAC, Jr.	do	KATSUO ARAI	do
DONNO CUSTODIO	do	TAKEOMI MIYOSHI	do
BEN ALEGADO	do	RYOICHI SUZUKI	do
MARIO TORRES	do	SHUSUI URAI	do
ROLANDO DESTACAMENTO	do	TATSUO NIIMURA	do
		IKUHIRO HAYASHI	do
		TOKICHIRO TANI	do
		KEIJI NAKANO	do
		HIDETOSHI TAKAOKA	do
		NORIO NAGASAKI	do
(Geophysical team)			
CESAL V. RAMOS	B.O.M.	ASAHI HATTORI	do
MARCELINO APELO	do	ITSURO OGAWA	do
CAROL S. SAMONTE	do	OSAMU KUSAKA	do
BERNICITO BALLESTEROS	do	KATSUMI ŌYANAGI	do
ELIGIO Z. ARIATE	do	HITOSHI ITŌ	do
		TOSHIAKI FUJIMOTO	do
		TOMIO TANAKA	do
		NAOYOSHI TAKAHASHI	do
		JUNICHI SATŌ	do
		SABURŌ TACHIKAWA	do

Phose III

JUAN E. PILAC	Bureau of Mines, Philippines	KANAE NIWA	Metal Mining Agency of Japan
		REISUKE SHIGA	do
		MICHIHISA SHIMODA	Overseas Technical Cooperation Agency of Japan
		YUTAKA EDA	do
(Geological team)			
MAXIMO V. GARCIA	B.O.M.	HIROSHI FUCHIMOTO	O.T.C.A.
EMIL T. AVILA, Jr.	do	TERUYUKI TAKEDA	do
BERNICITO BALLESTEROS	do	IKUHIRO HAYASHI	do
ALBERTO ISSAC, Jr.	do	KEIJI NAKANO	do
JOSE N. ALMASCO	do		
(Geophysical team)			
CESAR V. RAMOS	B.O.M.	ASAHI HATTORI	O.T.C.A.
MARIO TORRES	do	OSAMU KUSAKA	do
ELIGIO Z. ARIATE	do	TOSHIAKI FUJIMOTO	do
		TOMIO TANAKA	do
		SABURO TACHIKAWA	do
(Drilling team)			
CESAR LUCERO	B.O.M.	AKIO KATO	O.T.C.A.
RUSTICO BAYON	do	UTAJI SUZUKI	do
		TAKEO AKIMOTO	do
		MINORU NOMURA	do
		YUKIO TAKAHASHI	do
		SAKAE HIRONO	do
(Transportation team)			
TEOFILO FRONDA	B.O.M.		
ROLANDO DESTACAMENTO	do		

4. Location

The survey area lies in the eastern part of the Mindanao Island and about 50Km north of Davao city. It covers an area totaling about 11,000Km^2 encircled by the following lines:

in the north	the latitude 8°15' North
in the south	the latitude 7°30' North
in the west	the longitude 125°15' East
in the east	the coastal line of east Mindanao

This area extends over six provinces, that is, Agusan del Sur, Surigao del Sur, Davas del Norte, Davao Oriental, Bukidnon and Cotabato.

5. Transportation

The regular air-survice is available between Manila and Davao, Cagayan de Oro or Bislig. Besides, in Malaybalay and Bagganga there are private air fields for small airplanes. The national road from Davao to Buttuan passes through the center of the survey area in N-S direction. A network of the logging road is available on the east side of this national road except the southern mountain ara. On the west side, however, there are scarcely any roads, obstructed by the rugged topography, and it is imposible for a jeep to pass through. As no roads connect the Eastern and Western Areas, there is no other way than to take the national road via Cagayan de Ore or Kabacan proceeding to the Western Area from the Eastern Area. It takes more than one full day by car in either way.

6. Topography

Controlled by the geological structure, the topography of N-S ~ NNW-SSE direction predominates in the Mindanao Island. From the topographical feature, the survey area can be roughly divided into following units from the east to the west.

1. Eastern Mountain Area
2. Central Lowland Area
3. Western Mountain Area

The Eastern Mountain Area, a part of the Diwata Mountains, shows generally a steep topography. Especially, in the southern part with an average elevation of 1,000 to 1,500m, some of the peaks attain over 2,500m. The Bislig Area in the northern side, where drilling exploration was carried out, is a gentle hill with an elevation of 300m.

The Central Lowland Area extends from the Butuan Bay at the north to almost the Davao Gulf at the south with an elevation of 100 to 200m. Most of the drainage system in this area belongs to the Agusan River. This area is a big subsiding zone, where a thick pile of sediments transported by those rivers flowing down from the eastern or the western mountain area is accumlated. The Philippine Fault, traversing the Philippine Islands, passes through the east side of the Lowland Area.

The Western Mountain Area is a part of the central range which extends the entire length of Mindanao and has an average elevation of 1,000 to 1,200m. This area shows rugged topography and is characterized by deeply dissected narrow valley with steep cliffs. On the western wing of this mountain area, there is a big geological, structural line and two big rivers, that is, the Davao and the Pulangi Rivers are flowing along this line.

7. Climate

The area belongs to the climate of tropical-rain-forest-type, but there is a great difference in the precipitation and the temperature between the mountainous area and the plain. The annual mean temperature is $28^{\circ}C$ and the annual mean precipitation amounts to about 2,000mm. In the mountainous area, the weather is unsettled, and it drizzles frequently. Therefore, for this area there is no so-called dry or rainy season, but it is rather dry from March to April in the Eastern Area and from January to March in the Western Area. As typhoons are born in this area and develop on the way to the north, the damage caused by rain is more serious than that caused by wind.

8. Vegetation

Almost all the mountainous area is covered by a jungle of tropical-rain-forest type large trees such as lauan, apitong and tangile grown luxuriantly, so that it is gloomy even in the daytime. In the Bislig Area, where logging works are actively undertaken, a systematic afforestation after logging has been carried out. Mangrove trees grow partially along the coast and mouths of rivers.

PART II GEOPHYSICAL SURVEY

1. General Remarks

As mentioned before, the survey area can be divided into the following three units from the geological as well as topographical features.

The Eastern and Western Areas are occupied widely by the volcanic rocks ranging from Cretaceous to Paleogene periods. These rocks are weakly metamorphosed and are often designated as metavolcanics or metasediments. They are overlain by the clastic rocks which are younger than Paleocene. And furthermore, the Quaternary volcanic rocks cover them in the Western Area.

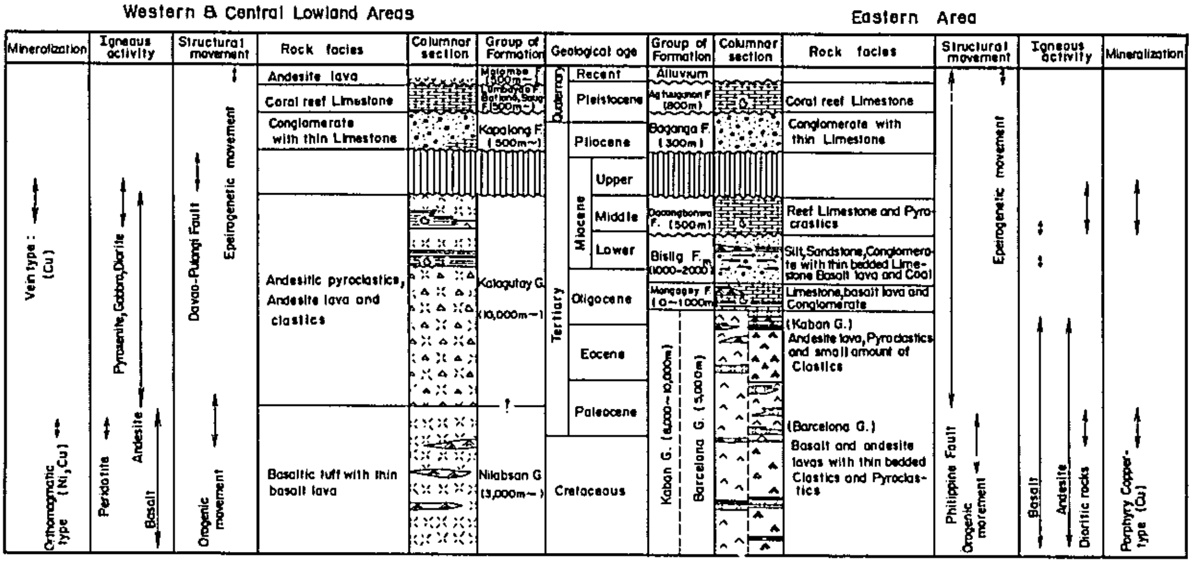
Small-scale intrusive bodies of quartz diorite are in the Eastern Area and a composite body of diorite, gabbro and pyroxenite and a large-scale peridotite dyke, passing through the survey area with N-S direction, in the Western Area.

The Central Lowland Area consisting of Quaternary clastic rocks shows a gentle topography.

It is very difficult to correlate the geology of the Eastern and Western Areas because of the Central Lowland Area extending about 40Km in width. However, many animal fossils are included in the younger sedimentary rocks than Paleogene, so that the correlation can be made as shown in Table II-1.

The K-Ar method was employed in chronologizing the igneous rocks, such as, lava and intrusive rock.

Table II-1 Generalized stratigraphic section in the Project Area



2. Geology

2-1 Eastern Area

The Eastern Area consists of the Barcelona group, the Kaban group, the Mangagoy formation, the Bislig formation, the Dacongbonwa formation, the Baganga formation, and and the Agtuuganon formation in ascending order.

2-1-1 Barcelona Group

This group is distributed in the northeastern part of the survey area, extending along the east coast from Sanco point to San Roque via Lingig in the belt-shape of 7 to 8 Km in width. It consists of 3 formations, that is, basaltic formation relatively rich in clastic rocks, andesitic formation with pyroclastic rocks and basaltic formation with pyroclastic and clastic rocks at the top. Most of them are sub-aerial and subaqueous lava flows. Pillow and columnar structures are developed in the basalte lavas and autobrecciated or columnar structures in the andesite lavas.

Under the microscope, the basalt is augite basalt and plagioclase phenocrysts are in a matrix chiefly composed of acicular plagioclase, acicular augite and glass. The andesite has phenocrysts of augite and plagioclase in a matrix of plagioclase microlite and glass showing felty or trachytic texture. In the andesite, phenocrysts of hornblende, biotite and quartz can be seen in some places.

As there are some similarities in the chemical compositions, mineral assemblage, texture, etc. of volcanic rocks in this group, they are considered to have been formed by the continuous, igneous activities. And this group has undergone burial metamorphism ranging from high temperature-zeolite facies to prehnite-pumpellyite-metagreywacke facies.

2-1-2 Kaban Group

The Kaban group is distributed along the east side of the Philippine Fault with 5 to 20Km in width and about 50Km in N-S direction. It is chiefly composed of andesitic volcanic rocks intercalating a few clastic rocks. It has been formed by the igneous activities with 3 cycles, that is, the first cycle characterized by the volcanic activities changing hornblende andesite to basalt and followed by the sedimentation of sandstone, mudstone and limestone, the second cycle beginning with andesitic volcanic effusions, and ending with basaltic ones in the subaquous environment, with explosion in the early stage and, followed by the sedimentation of tuffaceous sandstone, mudstone and tuff, in the later stage, and the third and last cycle characterized by the explosive, andesitic volcanic activities. These volcanic activities progressed from the south to the north unlike those of the Barcelona basaltic rocks.

The relations between the Kaban and the Barcelona groups are uncertain because the area between them are covered by the younger sedimentary rocks. But they appear to have been formed in the different sedimentary basins by the volcanic activities of the same period.

2-1-3 Mangagoy Formation

The Mangagoy formation is distributed in a belt-shape from barrio Mangagoy to the upper reaches of the Lingig River, on the west side of the Barcelona group. The upper part of this formation consists of volcanic conglomerate, siltstone and mudstone, and the upper part, a thick limestone. The formation is rich in larger foraminiferas and using these, it was clarified to have been formed in middle~late Oligocene.

The Mangagoy formation overlies the Barcelona group comformably: therefore, it is believed that the uppermost member of the latter group had deposited in middle Oligocene.

2-1-4 Bislig Formation

The Bislig formation is exposed widely along the tributaries of the Bislig River and at the headwaters of the Panusugon and the Cateel Rivers. This formation consists of alternatated beds of conglomerate, sandstone, siltstone and mudstone. Conglomerate is deposited in the lower horizone and trends to change to sandstone and siltstone, becoming fine gradually in grain size towards the upper horizon. The Bislig formation overlies the Mangagoy formation conformably.

In the vicinity of the Bislig River, volcanic rocks are relatively few but not only andesitic agglomerate and lapilli tuff but also basalt lava flows are intercalated in limestone.

This formation is believed to have taken place in middle Miocene and deposited in a shallow sea environment.

2-1-5 Dacongbonwa Formation

The Dacongbonwa Formation is distributed in the drainage basin of the Cateel River. It consists of christalline limestone with andesitic pyroclastic rocks and overlies the Bislig formation unconformably. It was formed in early ~ middle Miocene.

2-1-6 Baganga Formation

The Baganga formation is typically exposed in the drainage basin of the Baganga and Mahanob Rivers. The most common rock type in the formation is dark-yellow tuffaceous sandstone which is poorly sorted and loosely consolidated, with occasional siltstone.

Although no fossil can be found in the formation, the Baganga formation is correlated with the Kapalong formation of pliocene to Pleistocene in the Western Area from the rock facies and the sequence.

2-1-7 Agtuuganon Formation

The Agtuuganon formation occupies the high peaks in the central part. It consists of coral reef limestone and overlies the Dacongbonwa formation conformably with its maximum thickness being 700m.

2-1-8 Intrusive Rocks

The intrusive rocks in the Eastern Area may be described as follows.

(1) Gabbro

Small-scaled dikes of gabbro are exposed in the mineralized zone located in the upper reaches of the Taon River. They are considered to have intruded along the fissures, trending NNE ~ NE and NNW, caused by faulting. They are the last intrusive rocks in the survey area and cut the dacite and the quartz diorite. Included always in these rocks are not only plagioclase, augite and olivine but also biotite. Little alteration can be recognized.

The gabbro exposed near barrio Denipas facing the Bislig Bay does not contain olivine and biotite crystals. Microscopically Fe-saponite occurs like in the basalt group as a secondary mineral, it might have made an intrusion in an early stage.

(2) Dolerite

The dolerite dykes intrude into the Barcelone group, the Kaban group and the Bislig formation. Most of the dikes in the Barcelona group intrude along faults. Having undergone the burial metamorphism, they are considered to have intruded in the same period as the Barcelona basaltic activities.

In the dolerite cutting the Bislig formation, metamorphic minerals such as pumpellyite do not occur unlike the dolerite mentioned above. Its age seems to be late Miocene.

(3) Dacite

The dacite is exposed in the upper reaches of the Taon River. It intrudes along faults and partially occurs as lava flow. Not only large phenocrysts of plagioclase but also hornblende, biotite and quartz are characteristically included. Owing to strong montmorillonitization, its texture is unclear even under the microscope. The montmorillonitization is probably caused by hydrothermal alteration related to the dacite intrusion and has little relation with the mineralization.

(4) Diorite Porphyry

The diorite porphyry dykes intrude into the Kaban group. Phenocrysts of large plagioclase crystals (maximum 1cm in length) and augite are characteristic of these rocks. Sericite, chilorite, zeolite, calcite and clay minerals are produced as secondary minerals.

(5) Dioritic Rocks

The dioritic rocks can be lithologically classified into granodiorite and quartz diorite.

The granodiorite is exposed near Manbalili municipality located at the northern end of the national road running from Davao to Surigao. It is gray colored and holocrystalline, and alters the adjacent andesite thermally. Its main constituents are plagioclase, quartz, potash-feldspar, hornblende and biotite with accessory magnetite and apatite. It is affected by weak pyrite dissemination but no chalcopyrite can be seen.

The quartz diorite bodies are exposed in the upper reaches of the Agusan and Taon Rivers.

The former quartz diorite is exposed at the southern end of the survey area as a platy dike with 5~10m in width. It suffers remarkably from pyritization. In the upper reaches of the Agusan River, although outside of the survey area, there are some known porphyry copper type mineralized zones and exploration work has been underway in several places.

The above-mentioned pyrite dissemination shows the northern limit of the mineralized zones and no other dioritic rocks crop out from this place to the Manbalili municipality.

The absolute age of the intrusive body is 60 x 10^6 years (late Miocene) by K-Ar method.

The latter quartz diorite, in the upper reaches of the Taon River, intrudes into the Barcelona basaltic rocks, with 700m in width, extending 3Km in NE direction. It intrudes along the major fault passing along the Taon River.

In the eastern side of this rock, geochemical and geophysical anomalies were detected and drilling exploration was carried out.

The age of intrusion will probably be late Miocene from the surrounding geology. The K-Ar ages on this rock are 129 x 10^6 years (late Cretaceous), 454 x 10^6 years (late Ordovician) and 499 x 10^6 years (early Ordovician). All of them are much older than thought. In the case of that Ar in the hydrothermal solution or gas was trapped in the sample during the alteration time, the K-Ar age is measured older than true age. As the period of quartz diorite intrustion is very important in clarifying the nature of the mineralization, further study will be desirable.

2-2 Western Area

The Western Area consists of the Nilabsan group, Kalagutay group, the Kaplaong formation, the Lumbayao formation and the Malambo formation in ascending order.

2-2-1 Nilabsan Group

The Nilabsan group, the lowest section in this area, is typically exposed along the Nilabsan River flowing down on the west side of the Davao River. It is also distributed widely on the east side of the Pantaron Ranges.

The group has been formed by augite-andesitic basaltic volcanic activity. It consists mostly of pyroclastic rocks accompanying a very few clastic rocks. The thin beds of reddish brown, andesitic fine tuff are characteristically included in this group.

The Nilabsan group is intruded by peridotite and is displaced by the Davao-Pulangi Fault. Therefore, it is hard to estimate the true thickness of the said group, but it attains probably more than 20,000m in thickness. Nevertherless, it has monotonous rock facies from the lower to the upper. The repetition of fine sedimentary rock and poorly sorted tuff suggests that the sedimentary basin, as a whole, had continued sinking with rhythmical uplift and subsidence movements.

Although no paleontological evidences were obtained in the surveys, the age of the Nilabsan group is considered to be Cretaceous～Paleocene from the study of serpentine (Hess H.H. 1955).

2-2-2 Kalagutay Group

The Kalagutay group is distributed only in the west side of the large-scall peridotite dyke overlying the Nilabsan group conformably. It consists mainly of andesitic pyroclastics with subordinate clastic rocks and volcanic rocks.

The main differences between the above groups are as follows:

1. The volcanic rocks of the Kalagutay group is more acidic than the Nilabsan groups.

2. Chips of chromite, chrysotile and antigorite, which were probably derived from peridotite, are contained in the pyroclastic rocks of the Kalagutay group.

3. No reddish brown tuff beds is seen in the Kalagutay group.

The foregoing suggest that the two groups differ in not only the igneous activity but the sedimentary environment as well.

The Kalagutay group has limestone of late Oligocene ~ early Miocene and mudstone of middle Miocene at the top. Therefore, the age of this group is Oligocene middle Miocene. The thickness attains 10,000m.

2-2-3 Kapalong Formation

The Kapalong formation is distributed in the eastern side of the Davao-Pulangi fault. It is exposed typically along the Kapalong, Maguimon and Lasang Rivers. It is Molasse consisting of conglomerate, sandstone and siltsone. Pebbles of the conglomerate are chiefly composed of peridotite with a few pyroclastic rocks of the two groups.

This formation, assumed to have taken place in Pliocene ~ Pleistocene, overlies the older group unconformably.

2-2-4 Lumbayao Formation

The Lumbayao formation consists of coral reef limestone with conglomelate, sandstone and shale at the bottom. It is observed at the top of the mountains about 400~ 900 meters high and overlies the Kapalong formation and the Kalagutay group unconformably.

2-2-5 Malambo Formation

The Malambo formation is composed of hornblende andesite lava, being distributed at an elevation higher than 1,000m. The geological age is probably the end of Pleistocene.

2-2-6 Intrusive Rocks

(1) Peridotite, Gabbro

The peridotite forms the Pantaron Ranges dividing Bukidnon and Davao Provinces and is 2 ~ 5Km in width stretching in N-S direction. It is yellowish dark green, compact rock consisting of olivine, chino-pyroxene and a few chromite. In the headwaters of the Balahayo River, amphibole schist, forming probably the basement rock of this area, is found in the peridotite body as xenolith. The gabbro with large crystals of diallage is accompanied by this peridotite. Both of them seem to be closely related each other genetically.

According to Hess H.H., the age of the peridotite intrusion is Cretaceous ~ Paleocene.

(2) Pyroxene, Gabbro, Diorite

The igneous composite body composed of pyroxenite, gabbro and diorite measuring 5Km in width and 15Km in length crops out in the upper reaches of the Nilabsan, Locawon and Tigua Rivers. Their mineral assemblages resemble each other that is, all rocks contain primary biotite, augite, plagioclease, apatite, magnetite, etc.

Mutual relation among these rocks suggests intrusions took place in the order of pyroxenite, gabbro and diorite but they are probably comagmatic.

This composite body has intruded into mudstone and sandstone of middle Miocene belonging to the Kalagutay group. The absolute age of gabbro is 1.1×10^6 years (late Miocene) by K-Ar method.

In the upper reaches of the Tigua River, a mineralized zone was found: therefore, geochemical and geophysical surveys were carried out in Phase II.

2-3 Central Lowland Area

In the Central Lowland Area, thick continental sediments of Pleistocene ~ Recent have accumulated. Geological survey was not carried out on this area because of low potential for ore deposite.

Most of the area seems to have been covered by siltstone and sandstone, which crop out horizontally along the road between Tagum municipality and Saug camp. Although they are temporarily called "Saug formation", details are not known.

The coral reef limestone forming a plateau near the Umayan River is Pleistocene and is correlated with the Batiano formation near barrio Batiano in the Baganga district, the Agutuuganon formation and the Lumbayao formation in the West.

The vast alluvial plain formed by the Agusan and Libuganon Rivers is about 35Km wide from the east to the west. This alluvium and the Saug formation make it difficult to clarify the geologic structure and correlation between the Eastern and Western Areas.

2-4 Geological Structure and Geological History

2-4-1 Geological Structure

In the survey area, the major structural trend is N-S or NNE-SSE direction. From the structual point of view, the area can be divided into the following three (3) areas.

(1) Eastern Mountain Area

In the Barcelona group exposed along the east coast, the folding structures trending NE-SW are remarkable. They are made more prominent by the faults trending NNE-SSW. It is believed that the quartz diorite in the upper reaches of the Taon River has intruded along the faults.

The Kaban group adjoining to the Philippine Fault forms a monoclinal structure dipping northward in the southern and central regions, but forms a dome struructure in the upper reaches of the Bahayan River. It is said that the Philippine Fault is the left lateral, active fault having been formed in early Tertiary. Some dioritic masses, located close to the fault, seem to have intruded into the weak zone caused by faulting.

(2) Central Lowland Area

The Central Lowland Area has a large-scale synclinal structure embracing the Tertiary system of N-S trend. Although it is considered as a subsiding area, the Cenozoic sediments are rather thin judging from the existing geological map.

(3) Western Mountainous Area

The Western Mountainous Area consists of eugeosynclinal sedimentary rocks, accompanied by a lot of pyroclastic rocks which were formed by the Cretaceous ~ late Miocene igneous activities. As a whole, the area forms a geosyncline and is intruded by a large-scale peridotite dyke at the anticlinal axis.

In this area, N-S system structures are prominent. Especially in the Nilabsan group (the oldest group), there are developed anticlinal and synclinal structures in a small scale. On the contrary, the Kalagutay group dips westward monoclinally. The composite body consisting of pyroxinite, gabbro and diorite makes intrusion as sheet.

The fault passing along the Davao and Pulangi Rivers, is of such a large scale streching to Gingog in the north and to the Apo Volcano in the south that it traverses the Mindanao Island almost entirely.

3-4-2 Geological History

The basement rocks in the survey area are presumed as consisting chiefly, of the metamorphic rocks of Pre-Jurasic. At the end of Jurasic, the sedimentary basin was probably formed by the orogenic movements. Marine transgression began in middle

Cretaceous. In the Western Area, the sedimentary basin, as a whole, continued to sink with rhythmical uplift and subsidence movements. Consequently, a thick pile of andesitic, pyroclastic rocks and clastic rocks were accumulated. In the Eastern Area, basaltic and andesitic, volcanic activities were vigorous, causing lavas and pyroclastics to flow out in different basins. As these activities occurred always in a hallow sea environment, typical pillow and columnar structures developed in the lava flows.

At the end of Cretaceous period, uplifting occurred in the Western Area accompanied by the peridotite intrusion, and the crystalline schist of the basement rock in this area was probably exposed. Shortly thereafter, the Philippine Fault started to move, followed by the intrusion of dioritic rocks.

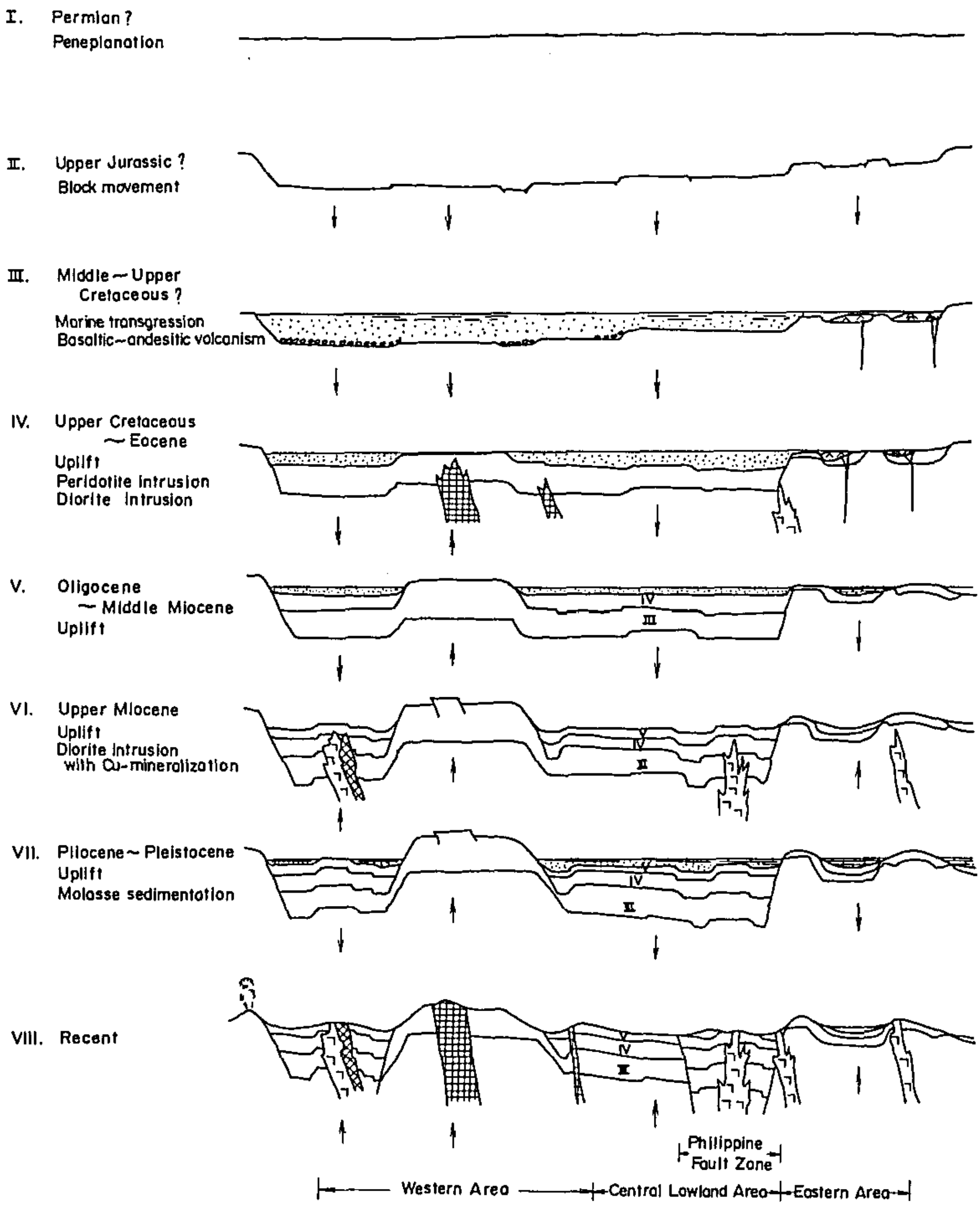
In the Eastern Area, the Mangagoy and Bislig formations deposited in middle Oligocene to middle Miocene in a shallow sea environment. In the Western Area, the Kalagutay group mainly composed of andesitic, pyroclastic rocks deposited in the same environment. Since the abovementioned peridotite was exposed above the sea level at that time, a few rock fragments of the peridotite were supplied to this group. In late Miocene, diorite intruded into the Bislig and Tagbiga Areas and accompanied by prophyry copper type and vein type mineralizations.

Thereafter a sudden upliting occurred in the peridotite zone in the Western Area. Consequently, Molasse type sediments deposited along the eastern and southern rims of the uplifting zone. The Davao and Pulangi Faults were probably formed during this period.

In Pleistocene, a thick pile of limestone deposited in some places. Thereafter, the Central Lowland Area appeared above the sea level after marine retrograssion, and thereupon, thick Recent continental sediments deposited.

The history described above is schematically summerized in Fig I-1.

Figure II-1 Schematic sections showing geologic development of the survey area



3. Economic Geology

Main deposits in Mindanao are Ni, Cr, and Fe deposits in the dioritic rocks. Some mines are now operating and others exploring. As far as near the survey area, in the upper reaches of the Agusan River, the Masara Mine once produced crude ores and drilling explorations are conducted at the Sabena and the Manat Mines near the Masara Mine. Drillings are also carried out at the Jupiter Mine in Malaybalay, Bukidnon province.

Therefore, from the geological point of view, the potentiality of Ni and Cu deposits in the survey area can be expected. According to records, only the Surigao Mine (Au, Ag) in the upper reaches of the Taon River and Soriano Mine (Ba) in the upper reaches of the Agamitan River were in operation before.

The mineralized zones which were clarified by the survey are as follows.

3-1 Eastern Area

3-1-1 Bislig-Lingig Area

The basalt in the upper reaches of the Taon River is intruded by quartz diorite trending NE, accompanying porphyry copper type mineralization. Drilling exploration was conducted in this Area under Phase III, as having the highest potential for ore deposits in the survey area.

In the northern part of the mineralized zone, rock exposure is very limited because of gentle slope and many gossan boulders distributed on the hill. The boulders consist of chalcopyrite, sphecularite, pyrite and quartz. The host rock is affected by strong chloritization.

In the central part, the disseminated zone, with such mineral assemblage as chalcopyrite-molybdenite-pyrite, is found in the eastern side of the main body of quartz diorite or in the dyke of the same rock. Metal contents are Cu 0.1 ~ 0.3%, Mo 0.02 ~ 0.05%. Rock alteration is very weak; epidorization and chloritization are microscopically observed.

The southern part is occupied by montmorillonitized dacite. The Silver Bell, the Lepanto and the Surigao Mines are located in this area. In the Surigao Mine area, high grade ores, composed of chalcopyrite, galena, sphalerite and pyrite, are explored by inclined shaft. Contents of stockpile are Cu 0.85%, Pb 17.6% and Zn 28.9%.

From the synthetic studies based on the results of geological, geochemical and geophysical surveys, the Cu dissemination in the central part was believed to suggest the most promising potential for ore deposits; therefore, drilling exploration was conducted.

3-1-2 Bahayan-Mamunga Area

In the Kaban group adjoining to the Philippine Fault, pyrite disseminated zone accompanying argillization and silicification was disclosed. It extends over 14Km in N-S direction with 1Km in width. Although copper content is very low, judging from the rock alteration and the geological structure, a shallow igneous intrusion (perhaps diorite?) accompanying ore deposits can be expected.

3-2 Western Area

3-2-1 Tagbiga Area

The Tagbia mineralized zone at the headwaters of the Tigua River, was discovered by tracing the geochemical anomalies. The Cu mineralization is observed along joints developed in the pyroxinite-diorite composite body or in the sheared zone as vein. The direction of veins mainly shows two systems; NW-SE direction with pyrite-clay veins (width 0.20 ~ 0.50m, Au 6g/t, Cu 0.5%) and NNE-SSW direction with chalcopyrite-pyrite veins (width 0.10 ~ 0.20m, Au 6 ~ 15g/t Cu 12 ~ 18%). But the veins do not continue for long distances and not all of them contain molybdenum. This Cu mineralization is probably not a porphyry copper type.

On the strength of the result of geochemical survey (soil sampling), geophysical survey (IP method) was conducted.

3-2-2 Pantaron Ranges Area

The mineralized zone in the upper reaches of the Naumnam River consists of pyrite networks. The host rock composed of dolerite and sandstone is cut by magnetite bearing epidote veinlets and is affected by strong chloritization. This mineralization is probably related with diorite. Cu content is low.

A few floated ore samples was taken at the Naunam River near Harapitan municipality. They are composed of troilite (FeS), pentlandite and chalcopyrite (Cu 0.07%, Ni 0.28%) and cut peridotite as stringer. Unfortunately, thier source were not found.

3-3 Mineralization Age

The absolute age of diorite in the upper reaches of the Agusan River is 60 x 60^6 years (lete Paleocene) and that in the upper reaches of the Sita River (the same diorite body as the Tagbigas) is 20 x 10^6 years (early Miocene --- middle to late Miocene from fossils). On the other hand, the age of quartz diorite in the porphyry copper zone was measured as early Cretaceous or early late Ordovician. As this age is contrary to the field evidences, some amount of Ar must probably have been trapped by the consituent minerals of the rock during the alteration, and hence K-Ar age was measured much older than true age. From geological point, it looks most reasonable to identify the age of quartz diorite intrusion as late Miocene.

Therefore, it can be concluded that dioritic activities occurred twice, that is, in late Paleocene and late Miocene, and in both cases, accompanied Cu mineralization.

PART III DRILLING EXPLORATION

1. General Remarks

Geochemical survey method by stream sediment is commomly used for selecting effectively the promising area of mineral resources from the large area. In this project, geochemical survey was also carried out with geological survey. The Central Lowland Area, which has a low potential for mineral deposits, was omitted from the geochemical as well as geological surveys.

In Phase I, geochemical samples of stream sediment were collected so as to cover the whole area, and were analyzed for three elements, Cu, Zn and Ni. By the careful interpretation, two Cu anomalous zones, one in Taon River of the Eastern Area, the other in the Tagbiga River of the Western Area, were revealed.

In Phase II, geochemical detailed survey for Cu by stream sediment was conducted on both areas to define the anomalous zones. Besides, diorite intrusive bodies accompanying Cu mineralization were disclosed. As no mineralizations or geochemical anomalies were found in other places, soil sampling and spot test for Cu were carried out on the both areas in order to establish the geophysical survey lines.

In Phase III, geochemical survey by soil sampling and field test for Cu were conducted in order to trace the extension of mineralized zone in the upper reaches of the Taon River. As a result, they showed that the zone does not extend toward south and proved very useful to select drill sites.

2. Field Operations and Interpretation of the Results

Geochemical surveys were carried out mainly by stream sediment in Phase I, by stream sediment and soil sampling in Phase II and by soil sampling in Phase III.

The field operations, analytical techniqe and interpretation of the results are as follows.

2-1 Field Operations

Samples of stream sediment were taken along the routes of geological survey. The sampling intervals were, as a rule, every 1Km in a long river with one sample taken from each stream.

In Phase I, two samples of stream sediment, -80 -100mesh and -100 -200mesh fractions, were collected at one point in order to check the variation of metal content in grain size. Soil samples were also taken at the meeting for comparing the metal contents in the soils with those of the top from where stream sediments could hardly be collected.

The Bislig and Tagbiga areas with the potential of mineral deposits were covered by ridge and spur soil-sampling pattern. Soil was turned up about 20cm in depth with hammer, and yellow soil samples below humus (B-horizon) were collected. Additional soil samples were also taken along the geophysical survey lines, at every 25 50m intervals in Bislig and 100m in Tagbiga, in order to use these data for drilling plan.

The total number of samples thus collected are as follows:

	Stream Sediment	Soil	Total
Phase I	5,173^{pcs} (0.76 pcs/Km^2)	515^{pcs}	5,688^{pcs}
Phase II	2,445 (0.815 pcs/Km^2)	1,668 (37 pcs/Km^2)	4,113
Phase III	—	435 (87 pcs/Km^2)	435

2-2 Analytical Technique

Field test was used for Cu and Ni. In Phase II, samples of stream sediments (-80-mesh fractions) were analyzed semi-quantitatively for Cu by spot test using rubeanic acid and colorimetrically for Ni using dimethlglyoxime. The former method was effective for defining mineralized zone but the latter method, not effective.

In Phase III, α - α' biquinoline method was used for analyzing Cu in order to eliminate the differences of Cu contents between total and cold-extractable Cu. The samples of -80mesh fractions were used in Phase II as well.

In the laboratory, all samples were analyzed by emission spectrometry, atomic absorption spectrometry, colorimetry, and X-ray fluorescence.

The emission spectrometry was used to decide the effective elements for pathfinder of ore deposits. About one-tenth of all samples of Phase I were selected at random and were analyzed for 10 elements, viz., Cu, Zn, Pb, Mo, Ni, Co, Ti, Sn, Cr, Ag.

The atomic absorption spectrometry was used for Ag, Cu, Pb, Zn, Ni and Co, the colorimetry for Mo, and the X-ray fluorescence for Ba.

2-3 Treatment of the results

14,898 geochemical results were accumulated in Phase I and 19,120 results in Phase II. A large amount of these data were treated by the graphycal method (Lepeltier C. 1060) to determine the mean background and threshold values.

As the Phase I was for a reconnaissance survey, the area was not subdivided from geological point.

Therefore, geochemical data of the stream sediments were roughly divided into 4 groups. That is, the Eastern and Western Areas. Each group was split into two small groups, one for the Cretaceous area, which was affected by mineralization, and the other the Tertiary area. (Some part of "Cretaceous rocks" was proved to belong to middle Miocene by the Phase II survey).

After determination of the mean background (b) and the threshold (t) values interpreted from the subdivided data using the said method, the geochemical anomalies were divided into three ranks, that is, (t-10%)~t, t~2t and 2~, as, shown on the 1:250,000 map.

The man background and threshold values of 3 elements in each area are shown in Table III-1.

Table III-1 Mean background and threshold values

data on – 100 mesh fractions (ppm)

	Geological Age	Number of Samples	Cu		Zn		Ni	
			b	t	b	t	b	t
Eastern Area	Cretaceous	757	75	185	98	190	14	20
	Tertiary	433	49	135	89	213	17	31
Western Area	Cretaceous	803	52	113	56	108	78	135
	Tertiary	463	48	92	62	90	92	580

b: mean background value t: threshold value

In Phase II, geological survey was carried out only on the so-called Cretaceous Area. Consequently, geology bacame much clearer. Data was grouped in every igneous body or lithological unit; I Bislig Area composed of basaltic rocks, II Kaban Area composed of andesitic rocks, III Pantaron Area composed of peridotite, IV-a Tagbiga Area composed of pyroxene-diorite composit body, and IV-b Tigua Area composed of andesitic, pyroclastic rocks.

In the detailed survey area of I and II, local mean background and threshold values were calculated in addition to the above regional values. In order to draw assay contour lines, three point's moving average method was employed.

The regional and local mean background and threshold values are shown in Tables III-2 and III-3.

Table III-2 Regional mean background and threshold values of stream sediment samples

(ppm)

		Number of Samples	Ag		Cu		Zn		Mo		Ni		Co		Characteristic rocks
			b	t	b	t	b	t	b	t	b	t	b	t	
Eastern Area	I	449	1.7	3.5	88	270	110	380	0.68	3.2	-	-	-	-	Basalt, Quartz diorite
	II	1,046	1.3	3.6	75	170	82	160	0.52	1.5	-	-	-	-	Andesite
Western Area	III	552	-	-	40	58	50	76	-	-	330	1,200	33	70	Peridotite
	IV -a	157	-	-	80	220	35	80	-	-	12	17	13	18	Pyroxenite, Dionite
	IV -b	678	-	-	36	60	55	90	-	-	30	150	18	25	Pyroclastic rocks

Remarks b: mean back ground value
t: threshold value

Table III-3 Local mean background and threshold values of soil samples

	Number of Samples	Au		Cu		Zn		Mo		Ni		Co	
		b	t	b	t	b	t	b	t	b	t	b	t
Bislig Area	829	0.9	1.8	110	550	30	215	1.0	10.0	-	-	-	-
Tagbiga Area	394	-	-	105	420	50	105	-	-	36	70	53	120

b: mean back ground value
t: threshold value

3. Summary of Survey Results

3-1 Results of Phase I Survey

In the Eastern Area, the anomalous zone, extending more than 5Km in length, occurs in the upper reaches of the Taon River, where Cu contents are much greater than the threshold value.

The highest value of Cu is 637ppm and the mean 193ppm. (As the quartz diorite had not been reported by that time, it may be said that the Taon River mineralization was discovered by this geochemical survey).

The diorite area distributed along the Philippine Fault in small-scale, was located on the extension of the already known mineralized zone, and was expected as having good Cu-mineralization. No geochemical anomalies were, however, detected in both northern and southern areas.

In the Western Area, a somewhat concentrated Cu anomaly (150 ~ 200ppm) occurs at the headwaters of the Tagbiga River, where Cu contents are 3 ~ 4 times over the threshold value. In the area where peridotite is distributed, high contents of Ni (800 ~ 1500ppm) are obtained. But Ni contents of the peridotite are about 0.2% and in addition, the topography is not suitable for laterite; therefore, it may be difficult to expect good Ni deposits.

In the Tertiary area, concentrated, geochemical anomalies are not detected. The contents are generally low.

From the foregoing facts, an area composed of the Cretaceous volcanic rocks on the eastern and the western sides of the Pantaron Ranges totaling 3,000Km^2 was selected for further detailed surveys.

3-3 Results of Phase II Survey

Regional geochemical stream sediment survey and local geochemical soil survey were conducted in Phase II.

3-2-1 Stream Sediment Survey

At the headwaters of the Taon River in the Eastern Area, 3 elements of Cu, Zn and Mo exceed the threshold values by far. Here, the highest values are Cu 739ppm, Zn 1.138ppm and Mo 10.2ppm. The anomalous zone concides well with the mineralized zone of porphyry copper type, which has been made clear by the following surveys.

In the upper reaches of the Auguan River, 300ppm ~ 500ppm of relatively high Cu contents were shown in stream sediments. This may be due to the Sabena or the Masara Mine where drilling work is being conducted. The geochemical anomalous zone extends only towards outside of the survey area; therefore, the follow-up works were not carried out on this zone.

In the Western Area, remarkable Cu anomalies with 200 ~ 400ppm were recognized in the composite body of pyroxenite and diorite in the headwaters of the Tagbiga River. Rubeanic acid field test also indicated high copper concentration.

A Cu anomalous zone accompanying Zn was also obtained in the drainage on the west side of the lower reaches of the Bodonawan River. Cu contents ranging 200 ~ 325ppm are equivalent to 3 ~ 5 times of the regional mean background value. Numerically speaking, these contents are not so high but are concentrated.

From the results of geological and geochemical stream-sediment surveys, the Bislig and Tagbiga Areas were selected for further detailed surveys.

3-2-2-1 Bislig Area

(1) Porphyry Copper Area (Fig III-1)

In this area, outcrops of mineralized rock and floats of gossan are found everywhere, and a fair strong Cu reaction of rubeanic method was recognized.

Each element in the soil samples taken along the geophysical lines is distributed as follows:

Cu ------ The remarkable anomalous zone occurs along the eastern rim of main quartz diorite body, showing 300 ~ 500ppm over the area 400m wide and 1, 300m long.

Mo ------ The anomaly overlaps the copper anomaly. Besides, weak indication is also found in the central part of quartz diorite body.

Zn & Ag -- Both elements tend to concentrate on the outside of Cu-Mo zone, and seen to show a geochemical zonning. But thier contents are low for a mineralized zone.

(2) Silver Bell Mine Area

Comparing the mean background values of Ag, Cu, Mo and Zn with those of the Porphyry Copper Area, Cu is about a half of the latter, and Ag, Zn and Mo almost approximate. In the threshold values, only Ag approximates; on the other hand, other elements less than a half.

As each element does not tend to concentrate, it has been concluded that the mineralization is not so strong.

(3) Lepanto Mine Area

Pyrite and barite are disseminated in shale of this area. Therefore, geochemical

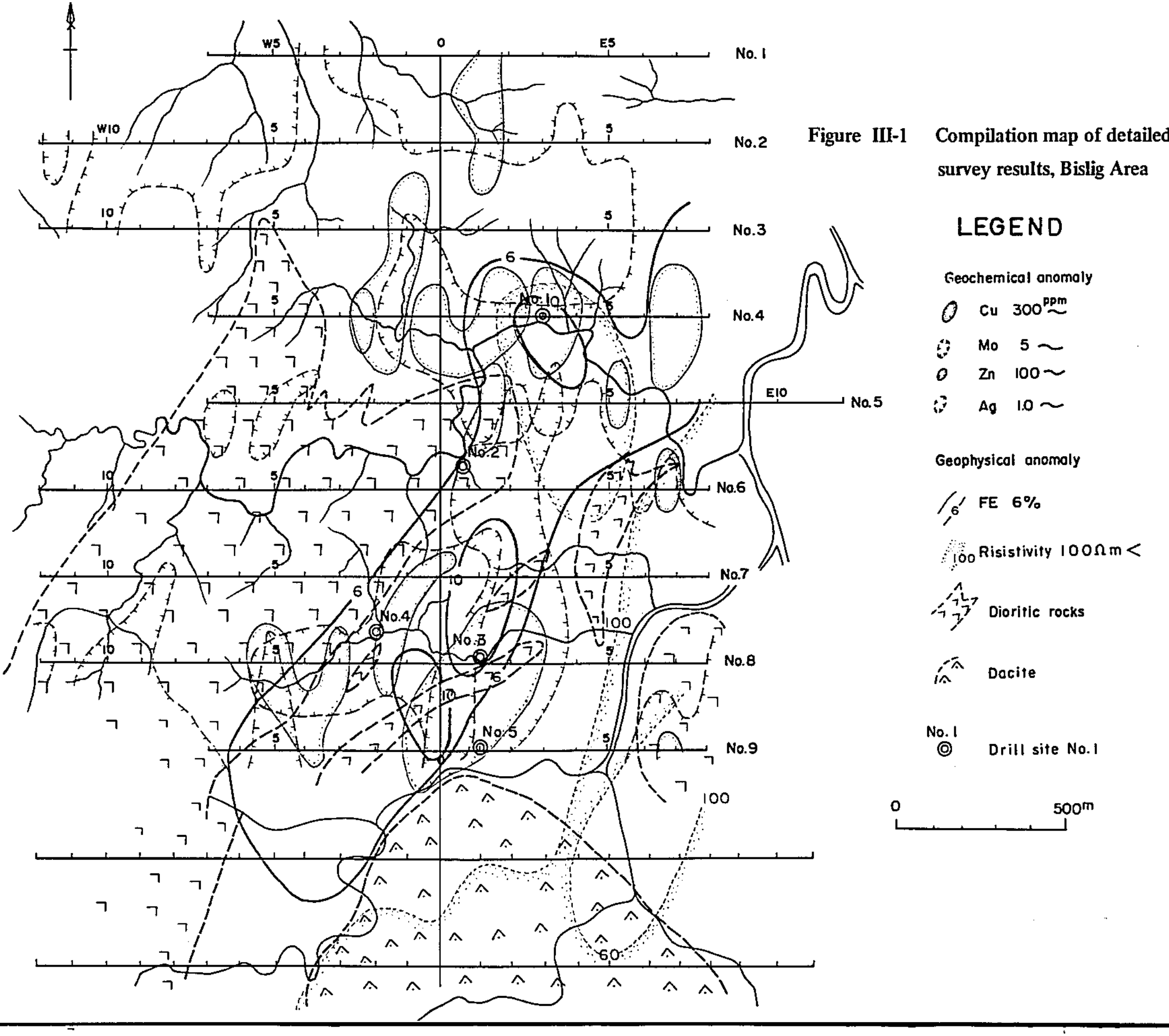


Figure III-1 Compilation map of detailed survey results, Bislig Area soil survey was conducted for Ag, pb, Zn and Ba, in anticipation of the sedimentary ore deposits.

The results did not show high anomalies in respect to the said 4 elements, and Cu was not detected by rubeanic acid test on these samples.

3-2-2-2 Tagbia Area (Fig III-2)

A Cu anomalous area is located in the upper reaches of the Tigua River and the anomaly occurs in pyroxenite and diorite intruding into pyroxenite.

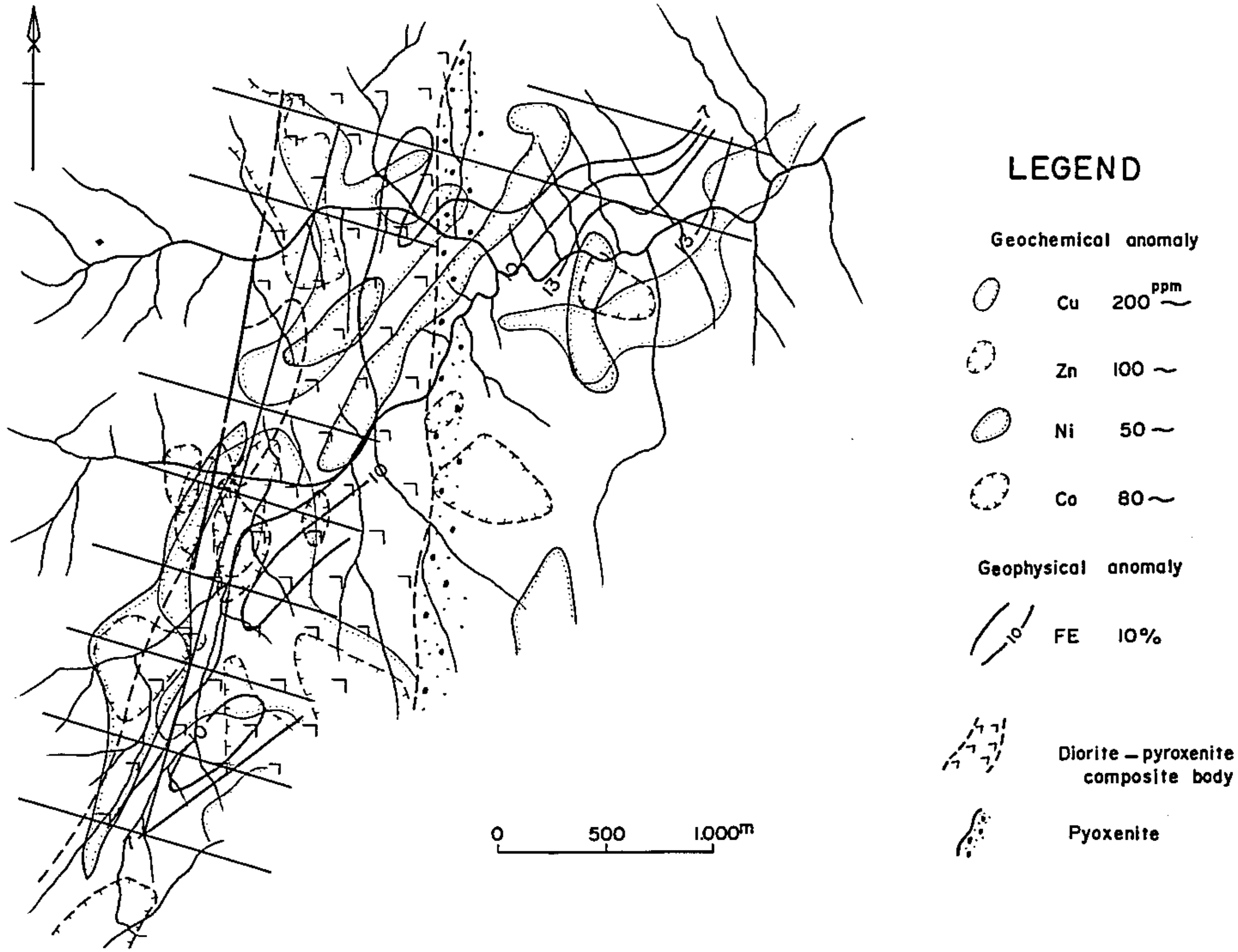
Cu ------ Anomalies occur widely along the western contact of the composite body, showing 200 ~ 400ppm. IP-survey, therefore, covered them. The Cu anomalies, located in the northeast part of the detailed survey area, show better concentration than the anomalies along the western contact. But both stream sediment and soil samples were weak in reaction of rebeanic acid test, and hence geophysical survey was not carried out.

Zn ------ Anomalies correspond well to those of Cu.

Ni & Co -- These anomalies extend narrowly in the western part adjacent to the western copper anomalies of the composite body. Another anomaly is found in the eastern part of pyroxenite but in both cases, the contents are 1/10 ~ 1/20 times those in peridotite zone.

As stated above, a clear concentration of the 4 elements exists in the same western margin of pyroxenite-diorite composite body.

Figure III-2 Compilation map of detailed survey results, Tagbiga Area



3-3 Results of Phase III Survey

Geochemical soil survey was conducted along the geophysical survey lines in the large-scale altered zone located in the southern side of the Taon mineralized zone. The results indicate that the Cu anomalous zone, extending along the eastern boundary of main quartz diorite body, diminishes suddenly in this area, and that the potential of massive ore deposits is very low in the Surigao and Silver Bell Mine Areas because of the narrow Cu anomalies of vein type. Besides, no Cu anomalies were found in the central argillized zone.

Consequently, from the results of geological, geochemical and geophysical surveys, it has been concluded that any further exploration work on this area would be of less importance.

PART IV GEOPHYSICAL SURVEY

1. Abstract

According to the results of Phase I geological and geochemical surveys and Phase II detailed geological surveys, the eastern area, Bislig and the western area, Tagbiga were selected as high potential areas for mineral resources.

Geological surveys were adopted starting from Phase II survey. The objectives of the geophysical investigations as described in this report are to find out electrical property, distribution and scale of the mineralized zone, to discuss the possibility of finding ore deposits and to select the best drilling sites by applying electrical survey (Induced Polarization Method) in above-mentioned areas.

As IP method indicates a remarkable anomaly for the porphyry copper type deposits and its surrounding mineralized zone which are expected to be found in those areas, IP method has made remarkable development of finding mineralization in tropical jungles where outcrops are hard to find.

In Phase II geophysical survey, survey lines were planned from the information of the outcrops of copper, the distribution of geochemical anomalies and geological standpoints in the eastern area, Bislig and in the western area, Tagbiga.

Moreover, additional IP lines were also run based on the results of the geophysical survey, so the length of IP lines in the eastern area was 18.4Km while in the western area 16.7Km, making a total length of 35.1Km.

Results of these surveys indicate IP anomalous zones in both areas.

In the eastern area, remarkable anomalous zones were detected in the center of the survey area, accompanied by a low resistivity zone due to hydrothermal alteration.

Togather with the results of geochemical anomalies, a few drilling points were selected in this area.

The relations between geology and electrical property have been made clear.

In the western area, Tagbiga, since this broad survey of IP covering an area 3, 300m long from the north to the south and varying in width from 1, 200m-2, 600m from the east to the west was well planned, and taking into consideration the results of geological and geochemical surveys, we could get significant information on mineralized zone from well defined IP anomalies.

Some of these anomalies seem to be due to primary magnetite in pyroxenite.

Despite the fact that copper anomaly was weak in the geochemical survey, the strong FE anomalous zone described in the IP survey report is recommended as an area to be surveyed hereafter as it might be the halo of a porphyry copper deposit.

In Phase III geophysical survey over the Bislig area, IP survey was conducted over the area of some 6Km^2, where the anomalous zone was expected to extend to the south of the area of Phase II survey.

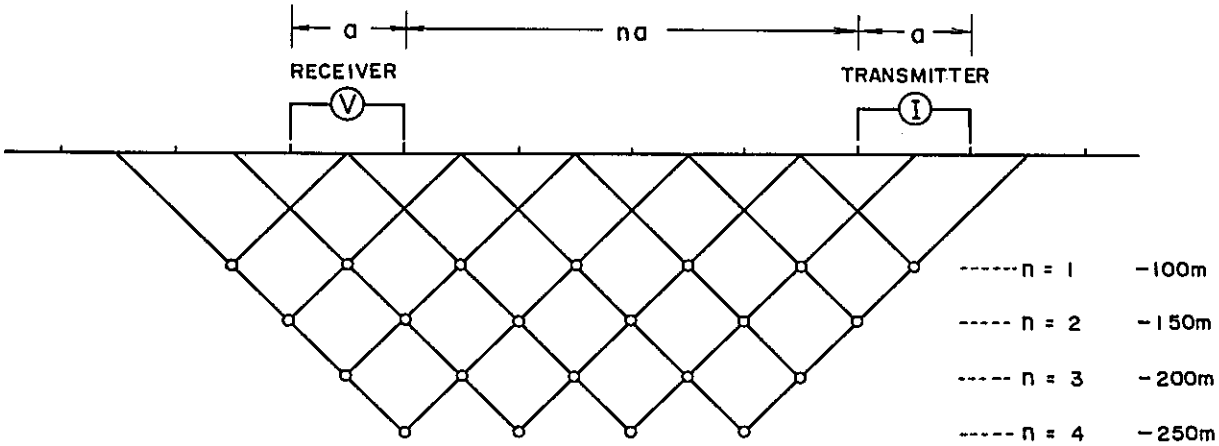
As a result of this survey, remarkable anomalous zone of 300 - 400m length was recognized toward the southwest, but the anomalous source was considered mainly due to pyrite in basalt and no anomaly was detected in the southern part of this area.

2. Method of Survey

Electrical method of IP was adopted in both Phase II and Phase III activities.

IP adopted in these Phases is variable frequency method using dipole-dipole electrode configuration with the electrode distance a=100m and the separation factor n=1, 2, 3 and 4.

Figure IV-1 Method used in plotting dipole-dipole IP results



The surveyed depth is 200 ~ 250m. Ten survey lines were run in Bislig in Phase II survey and the total length was 18.4Km at the line interval of 250m, and in Tagbiga total length of 11 survey lines was 16.7Km at the line interval of 400m.

In Phase III work in Bislig, total length of 9 survey lines was 22.0Km at the line interval of 300m.

Instruments used in those surveys are as follows;

Bislig area

Phase II

IP Transmitter	P660 made by McPHAR Co., CANADA
	Maximum output 5A, 700V
	Generator 3.5KW, 400HZ, 110V

IP Receiver	P660 made by McPHAR Co., CANADA Fullscale 100 microvolt

Phase III

IP Transmitter	Model 506 made by CHIBA Electronic Loboratory, JAPAN Maximum output power 2.5A, 800V Engine generator model 421 made by Briggs-Stratton Co,, USA 2.0Kw, 400HZ, 115V
IP Receiver	Model YDC-441 and YMO-605 made by YOKOHAMA Electronic Laboratory, JAPAN Fullscale 10 microvolt

Tagbiga area

Phase II

IP Transmitter	Model 506 made by CHIBA Electronic Loboratory, JAPAN Maximum output power 2.5A, 800V Engine generator Model MK-2, made by McCollough Co., USA. 2.0KW, 400HZ, 115V
IP Receiver	Model YMO-421 made by YOKOHAMA Electronic Laboratory, JAPAN Fullscale 10 Microvolt

Because of thick vegetation covering the area with very steep topography at certain parts, the compass and tape traverse survey was conducted.

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

3. Outline of Survey Results

3-1 Survey Results of Phase II

3-1-1 The eastern area

A remarkable anomalous zone extending to the northeast was detected in the middle of the surveyed area, and it agrees well with the distribution of basalt.

The width of this anomalous zone of NE trending was about 400m and the length was 1500m and the FE anomaly conforms mainly with the pyritized zone from the surface to the depth.

Dioritic rocks in southwestern part of the surveyed area have high resistivity ranging from 500-1,000 ΩM.

From this property the distribution of dioritic rocks was well interpreted at the surface as well as in depth.

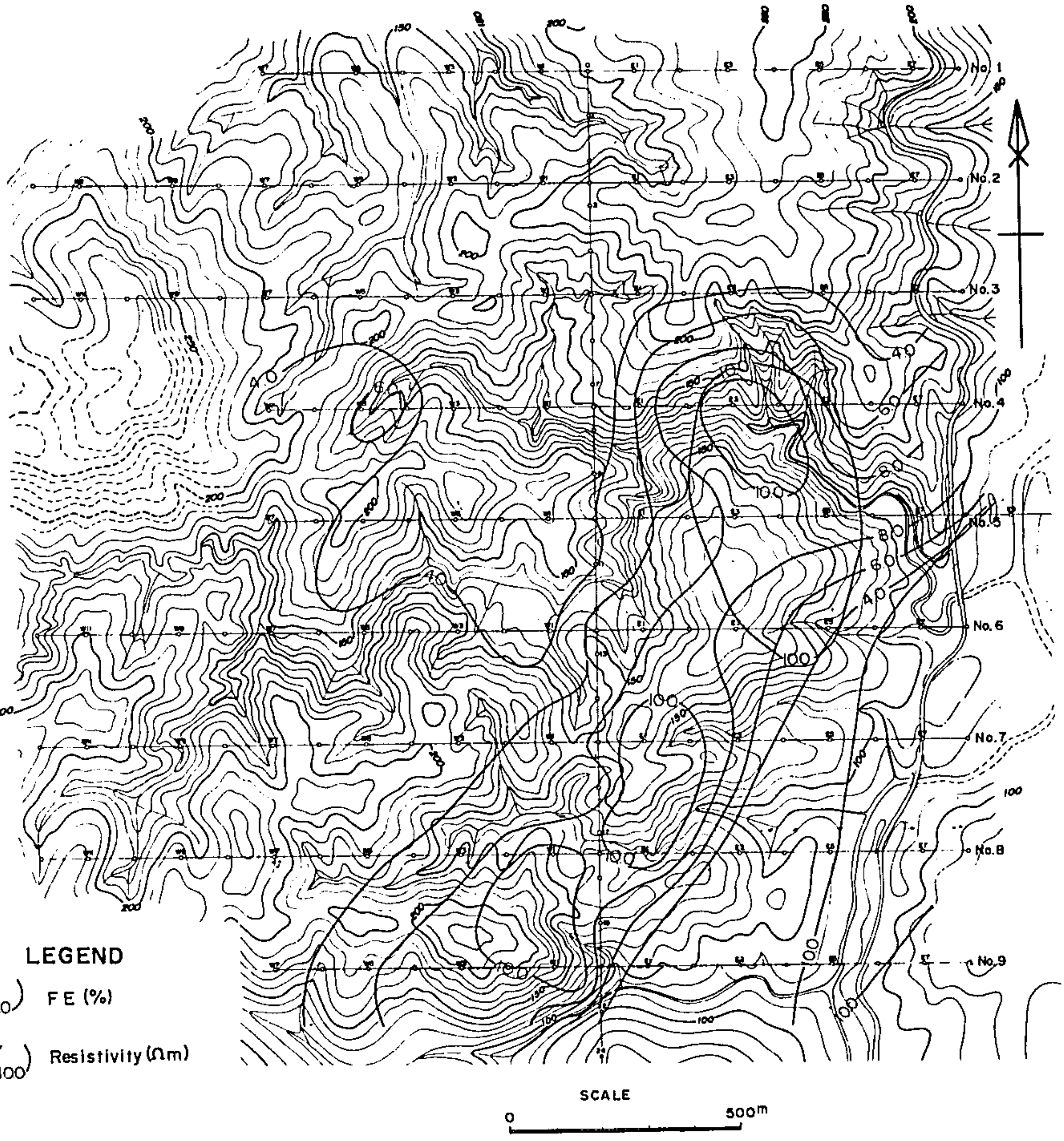
Basalt showed low resistivity from 100 to 250 ΩM, and less than 1000 ΩM in the hydtothermally altered zone which coincides with a high FE zone.

The ore deposit which is expected in this area lies probably at the interface between basalt and diorite. From 6 to 8% FE anomaly is considered to be the most promising zone of copper deposit extending to the southwestern part of point E-1 of line No.6, point 0 to W-1 of line No.7 and point W-2 of line No.8.

In this zone, point E-1 of line No.6 was recommended as an interesting drilling site.

As a future plan, an additional IP survey is necessary to study further the distribution of the well defined anomaly observed on survey lines No.8 and No.9 which might be considered extending to the southwest of this area.

Figure IV-2 IP results of the Bislig Area (Phase II)



3-1-2 Western area

Remarkable anomalous zone of NNE trending was detected in the eastern part of the surveyed area.

The anomaly was detected on point 20 of line A and extend to point 36 to 53 on line B, and detected strongly all over on line D, extending to point 36 to 53 on line B and point 16 to 21 on line A. Although there is lack of information about this anomalous zone in the area between line C and line E, which are 700 meters apart, the area surrounded by 7% FE contour almost agrees with the distribution of mineralized zone. This anomalous zone was observed only in the pyroxenite and the composite body of pyroxenite and diorite in the eastern portion of the surveyed area. No anomaly was detected in the sedimentary rocks in the western portion of the area.

The strong and deep anomaly observed in the eastern part of line B and the whole part of line D is considered to be due to fresh magnetite grains in pyroxenite or mineralization of diorite intrusive at depths.

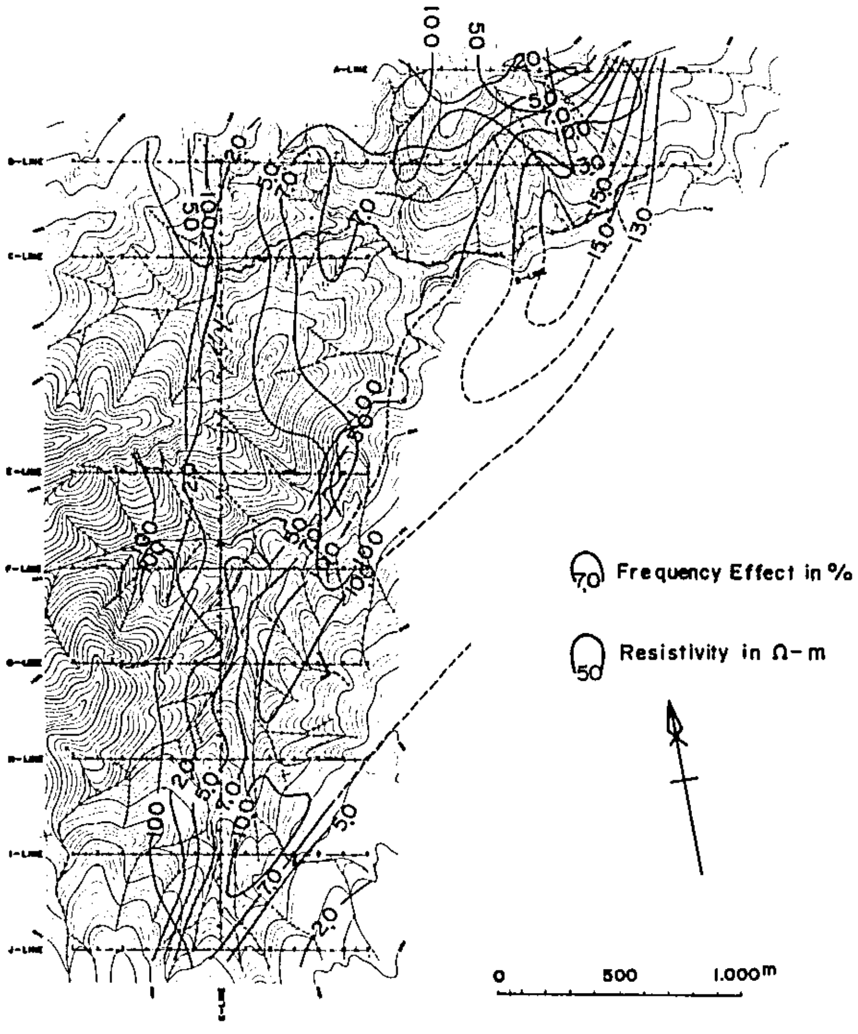
Having partially low resistivity, the area near point 20 of line D appears most interesting as shown by the result of the geophysical survey.

Although topographical elevations vary considerably and the results of the apparent resistivity is influenced much by the topographic irregurality, the low resistivity sedimentary rocks and andesite (around 60Ωm) are well distinguished from the high resistivity pyroxyenite and composite body of pyroxenite and diorite. (around 150Ωm).

Furthermore, investigation of the gap between the anomalous zones striking NE-SW, that is east of line E and F and to the south of line D, and the northeastern extension of this area would be desirable.

According to the results of the geophysical survey, point 20 of line D shows the most consistent IP anomaly. This point is recommended as the most prospective drilling site.

Figure IV-3 IP results of the Tagbiga Area (Phase II)



Point 16 of line H, where a comparatively broad N-S extension of IP anomaly is expected, might be the secondary proposal site of drilling.

In the future surveys, application of the magnetic observation as well as the self potential method (SP) is desirable as a complementary survey to the IP method, since the IP anomaly detected in the survey is considered to be due mainly to fresh magnetite.

Magnetic measurement could be very effective in the identification of ore and the determination of the distribution of igneous rocks.

3-2 Survey Results of Phase III

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

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

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

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

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

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

Figure IV-4 IP values from in-situ & laboratory measurement

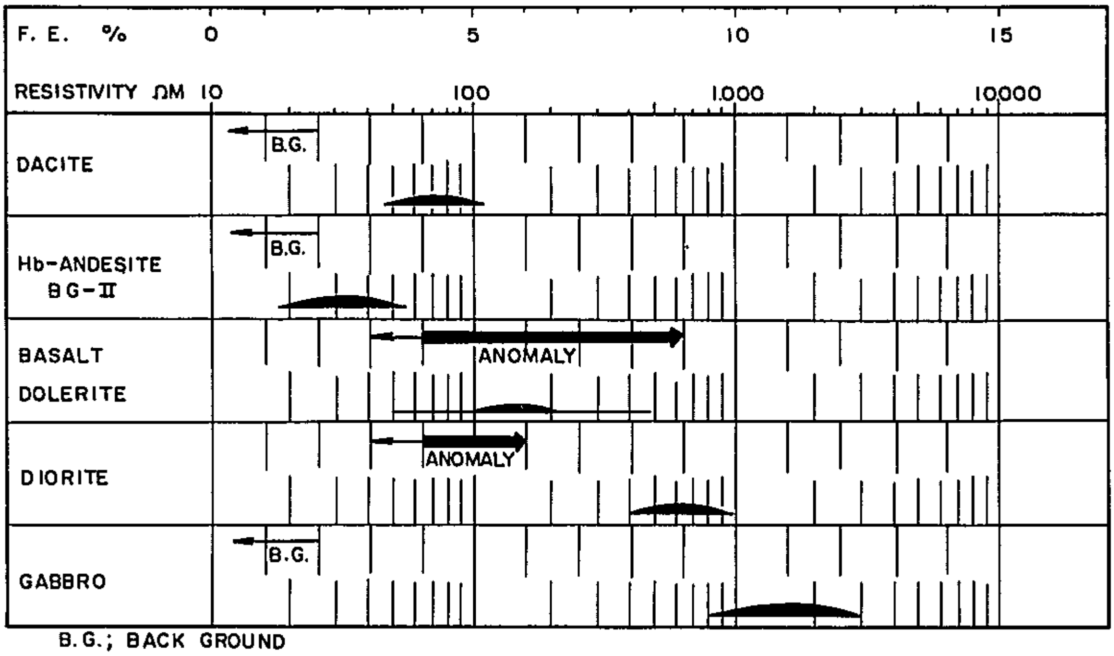
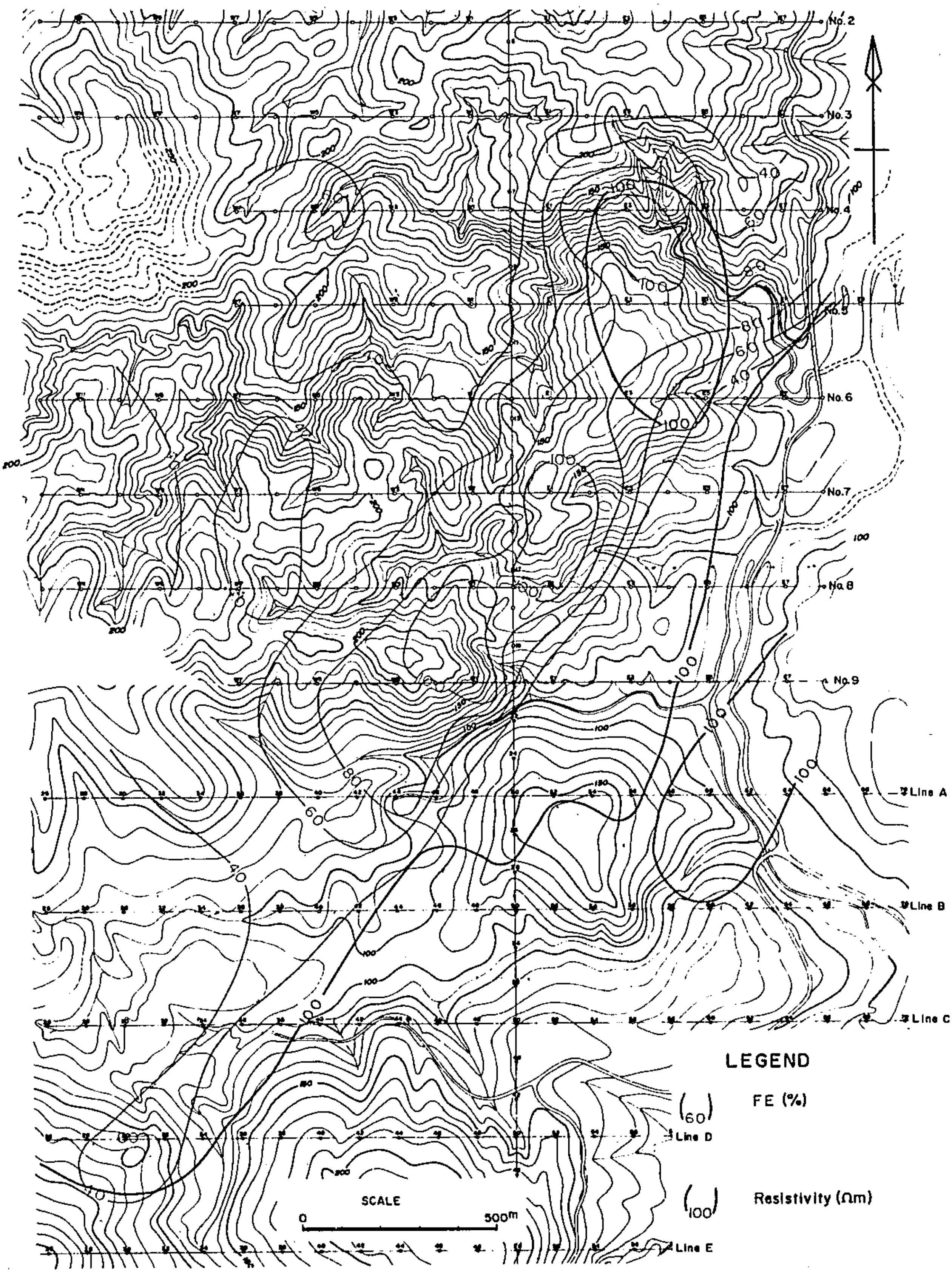


Figure IV-5 General IP map of the Bislig Area (Phase II, III)



4. Future Problems

As mentioned in the section of survey results of Phase II in the eastern area, drilling sites were selected judging from the distribution of FE anomaly, which is, according to the results of drilling exploration, due mainly to pyrite.

FE anomaly detected at the point E3 on line No. 4 is considered to have been caused by the shallow mineralization of pyrite and a good mineralized zone of chalcopyrite was hit at the depth of 250m of DDH No. 1 at this point.

Resistivity results shown in Figure IV-2 indicates low resistivity of less than 100Ωm for the basalt south of point E3 on line 4 extending to point E4 on line 5 and E4 on line 6. The zone of low resistivity, which is inferred to be due to the argilization with rich porosity and of the remarkable FE anomaly, appears to have high potential as target for exploration in the future.

In order to get further imformation on IP and to make general interpretation easy, geochemical survey and other geophysical methods, such as magnetic exploration, electro-magnetic exploration and so on are recommended.

In case of drilling exploration, use of geophysical logging such as electrical log and radioactive log is recommended to obtain information on in-situ physical property of the underground; by setting current electrodes in the drill hole, supplementary exploration around the hole can also be carried out. This method might have proved helpful in defining the expansion of mineralized zone around DDH No. 1.

PART V DRILLING EXPLORATION

1. General Remarks

Five (5) holes were drilled in the upper reaches of the Taon River for the purpose of clarifying the nature of mineralized zone disclosed by Phase I and II surveys. The drill sites were selected not only from the distribution of geochemical anomalies overlapping geophysical anomalies but from the geological points of view. Each hole drilled was vertical for a depth of 250m. Drilling length totaled 1253.10m.

The work was conducted on three shifts. Two (2) sets of drilling machines were alternately used adopting the wire-line process.

No. 1 hole, the first one from the north, intersected the dissemination of porphyry copper type deposits. In this zone, propylitic alteration and quartz-sericite alteration are remarkable. Cu contents increase from the point of the contact between quartz diorite and basalt at the depth of 200m.

The mean copper contents are shown below:

depth m	width m	Cu %
100 ~ 250	150	0.397
224 ~ 250	26	1.006
248 ~ 250	2	4.93

Analyses of drilling cores of every 2m length show that the copper tends to increase toward depth. The other four (4) holes show low grade Cu with very weak propylitic alteration.

2. Details on each Hole drilled

DDH-No. 1 (Depth: 250.00m)

This hole encounters dolerite ~ basalt after a 13.40m thickness of overburden. Then quartz diorite occurs from 197.50m depth to the bottom. From 166m to 217m in depth is a sheared zone where core recovery is about 48%.

Propylitic alteration shown by the mineral assemblage of epidote-calcite is remarkable from the surface to 200m in depth; silification can be observed with propylitic alteration from 100m to 170m in depth. Below 200m in depth silicification is too strong to distinguish quartz diorite from other rocks.

Pyrite is disseminated in the whole drill hole section. Chalcopyrite is also observed below 100m depth, showing 0.40 ~ 0.50% in mean content of Cu. The amount of chalcopyrite increases toward depth. The network at 248 ~ 250m depth shows 4.93% in Cu content. The mean Cu grade for a length of 26m from 224 to 250m in depth is 1.006%. But each content of Au, Ag, Mo and Zn is very low.

DDH-No. 2 (Depth: 250.60m)

After 11.00m thickness of overburden, quartz diorite extends to the bottom. It is intruded by small-scale diorite porphyry dikes at respective depths of 76m, 125m, 136m and 153m. Alteration is generally weak. A part of plagioclase is altered to sericite and kaolinite and mafic minerals to epidote and chlorite.

Filmy pyrite disseminations are found along parallel joints developed in both rocks. The density of the films is about 1/4 compared with that of DDH-No. 1.

Chemical assays show Cu 0.16%, from 16 to 20m in depth and the rest, less than 0.1% Cu and very low in Mo content.

DDH-No. 3 (Depth: 250.50m)

After 9.00m thickness of overburden, the hole is throughout in basalt. The basalt is intruded by small-scale dykes; diorite porphyry at 60m, dolerite at 110m, 120m and 130m respectively and quartz diorite at 200m in depth. The basalt is generally affected by weak chloritization which does not become strong toward depth.

Most of the mineralizations are pyrite disseminations along joints which are comparatively concentrated from the surface to 80m in depth. Although the highest Cu content was detected around above-mentioned joints by the geochemical survey, only one or two chalcopyrite stringers accompanied by pyrite are observed at several meters intervals. Below 100m depth, mineralization is almost absent. The highest Cu value is 0.99% at 12 ~ 14m in depth but the rest are low contents of less than 0.1% of Cu.

DDH-No. 4 (Depth: 251.20m)

Below overbureden of 7.50m in thickness, basalt ~ diorite extends up to 96m in depth and then quartz diorite to the bottom. Joints are poorly developed as compared with other holes and pyrite dissemination is also weak. Very weak epidote-chlorite alteration is generally observed and silicification occurs partly near the contact between basalt and quartz diorite. Chemical assays show very low Cu content except 0.96% Cu at 126 ~ 128m in depth. By this drill hole, it has been made clear that the main body of quartz diorite inclines toward east.

DDH-No. 5

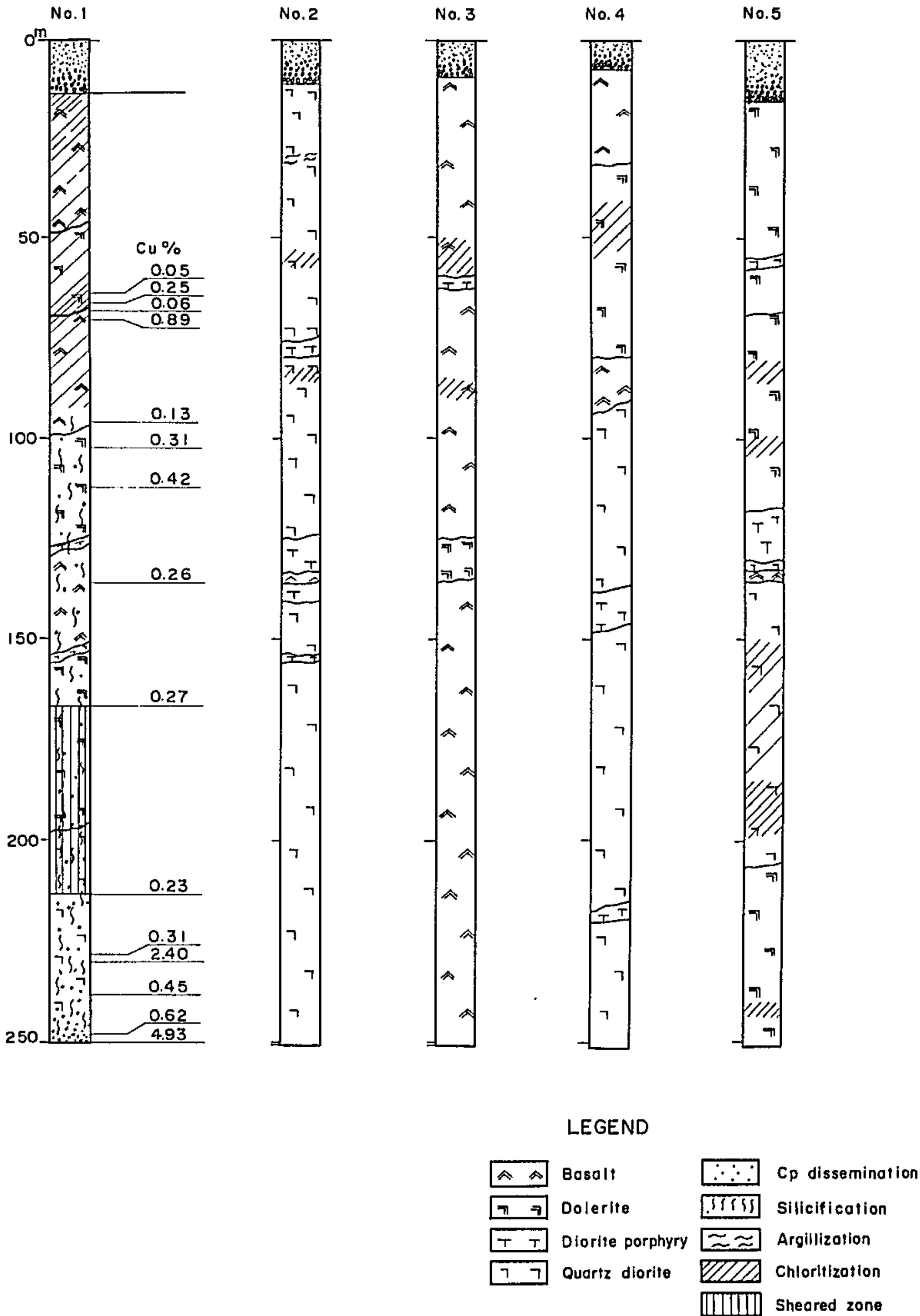
After 15.20m thickness of overburden, dolerite extends to 69m in depth, quartz diorite to 207m in depth and then dolerite to the bottom. Alteration is propyritic and its intensity is the same as in DDH-No. 3 or No. 4.

The 10m thickness after overburden is disseminated by pyrite with chalcopyrite, and local copper disseminations can be observed at 40 ~ 54m and 67 ~ 80m in depth. Some chemical assays are shown below:

depth m	width m	Cu %	Mo %
15.20 ~ 34	18.80	0.34	0.001
52 ~ 54	2	0.69	0.043
68 ~ 70	2	0.69	0.001
230 ~ 234	2	0.34	0.001

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

Figure V-1 Compilation of core-logs



PART VI CONCLUSION

The systematic surveys were carried out in Eastern Mindanao from 1972 to 1974. The comclusions obtained by the surveys are as follows:

1. The drilling conducted in the upper reaches of the Taon River intersected the dissemination of porpyry copper type deposits. The copper content of 150m thickness from 100m to 250m in depth is 0.397%; 26m thickness of better part from 224m to 250m in depth, 1.006%. And the copper shows signs of increasing towards depth. Judging from the results of the surveys, this mineralization is believed to be local. As the rock alteration is very strong, however, it is desirable to carry out the follow-up drilling for defining the scale and nature of mineralization.

2. The geological surveys have classified so-called "Metavolcanics" and "Metasediments" of Cretaceous to Paleogene, distributing widely in the survey area. They have also clarified the ages of their deposition and their sedimentary environments. The stratigraphy established in this area will play an important role in geological survey on the surrounding area.

3. It has been proved in this project that geochemical survey for copper by stream sediment was very effective for selecting the most promising area of mineral resourses and that geochemical survey for copper by soil sampling and geophysical survey (IP method) were also helpful for defining a mineralized zone. The survey method employed in this project is believed to fit other new projects as Mindanao Project.

PL. 1

GEOLOGICAL SURVEY

OF

EASTERN MINDANAO

GEOLOGICAL MAP

Scale 1 : 250,000

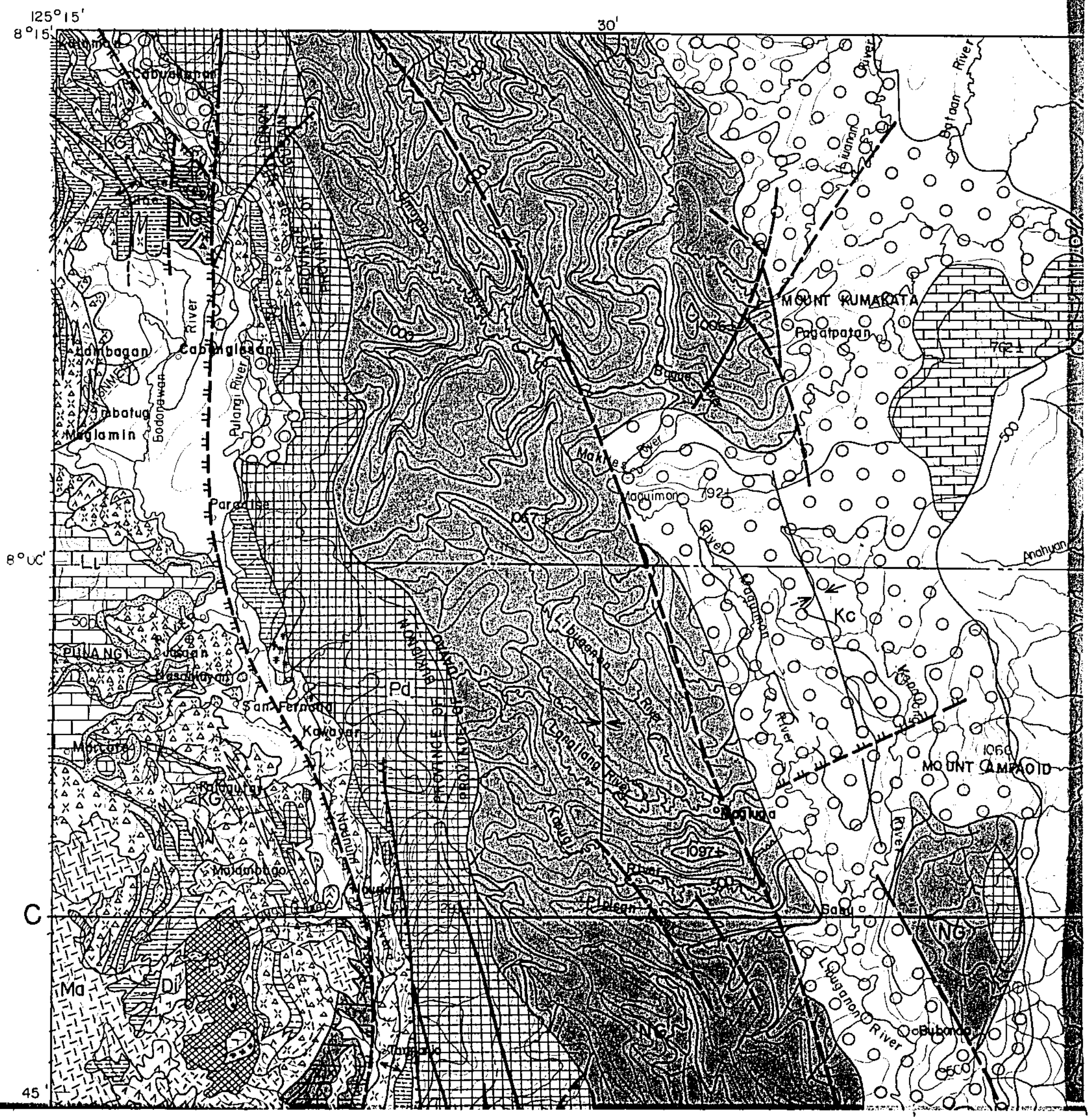
0 20 km

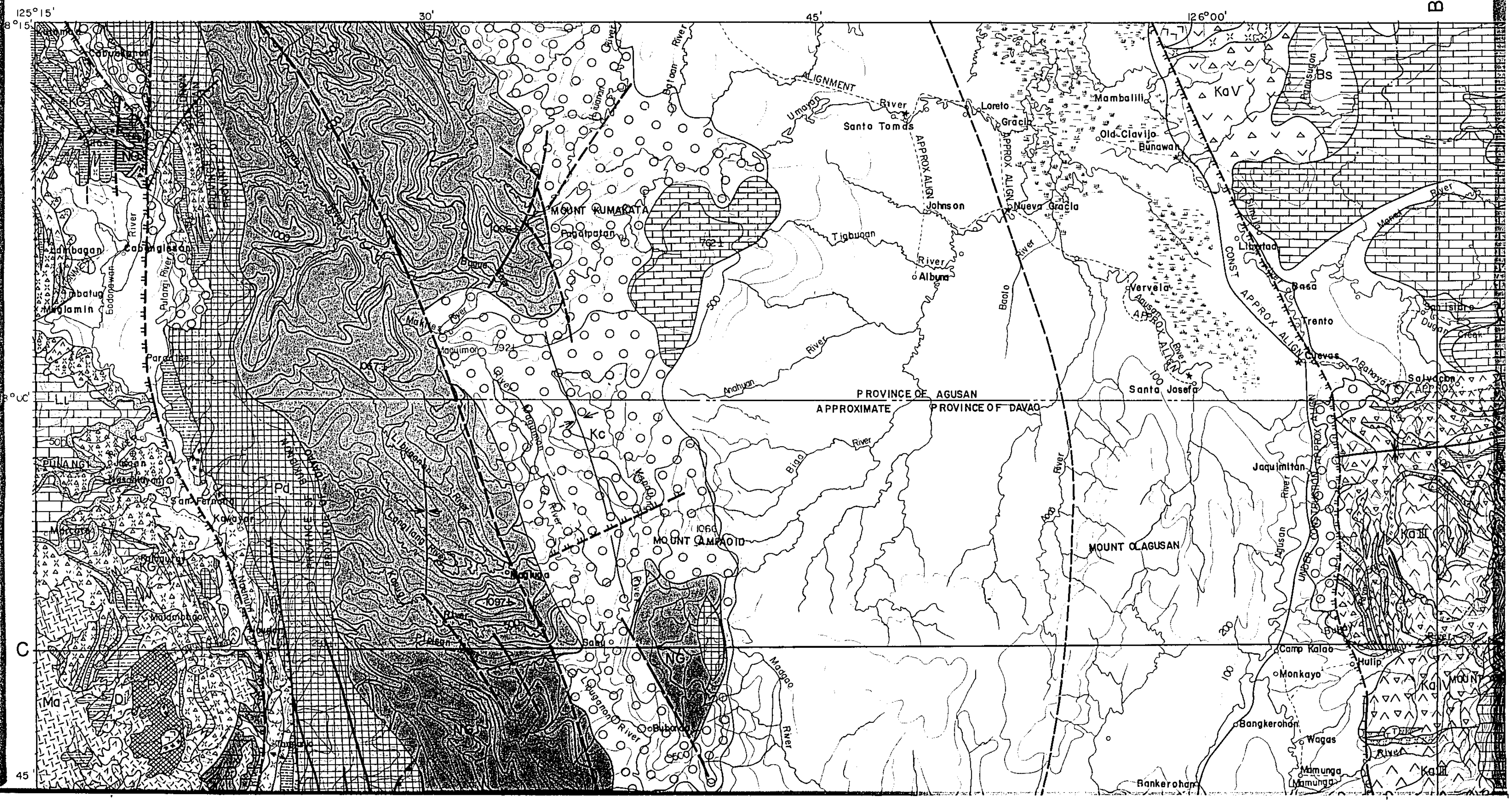
METAL MINING AGENCY

OVERSEAS TECHNICAL COOPERATION AGENCY

JULY 1974

Prepared by Bishimetal Exploration Co., Ltd.





125°15'
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126°00'
B
8°15'
8°00'
45'
C
MOUNT KUMARATA
Pagatpatan
MOUNT AMPAOID
MOUNT CLAGUSAN
PROVINCE OF AGUSAN
APPROXIMATE
PROVINCE OF DAVAO
ALIGNMENT
APPROX ALIGN
CONST APPROX ALIGN
UNDER CONSTRUCTION APPROX ALIGN
Santo Tomas
Loreto
Gracia
Mambalili
Old Clavijo
Bunawan
Johnson
Nueva Gracia
Tigbuoan
River
Albuna
Libertad
Basa
Trento
Vervela
Cuevas
Santa Josefa
Salvacion
San Isidro
Jaquimitan
Camp Kalao
Monkayo
Bangkerohan
Wagas
Mamunga
Hulip
Umayan
Baolo
Agusan
Anahuan
Biao
Batoan
Manat
Dugan
Creek
Lambagan
Cabanglasan
Imbatug
Maglamin
Paradise
Pulangi
San Fernando
Kawayan
Maramag
Maluko
Magugpo
Magdao
Bubaran
Saba
Makalas
Maquimon
Kapalong
Libuganon
Lopagan
Pd
Kc
NG
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792
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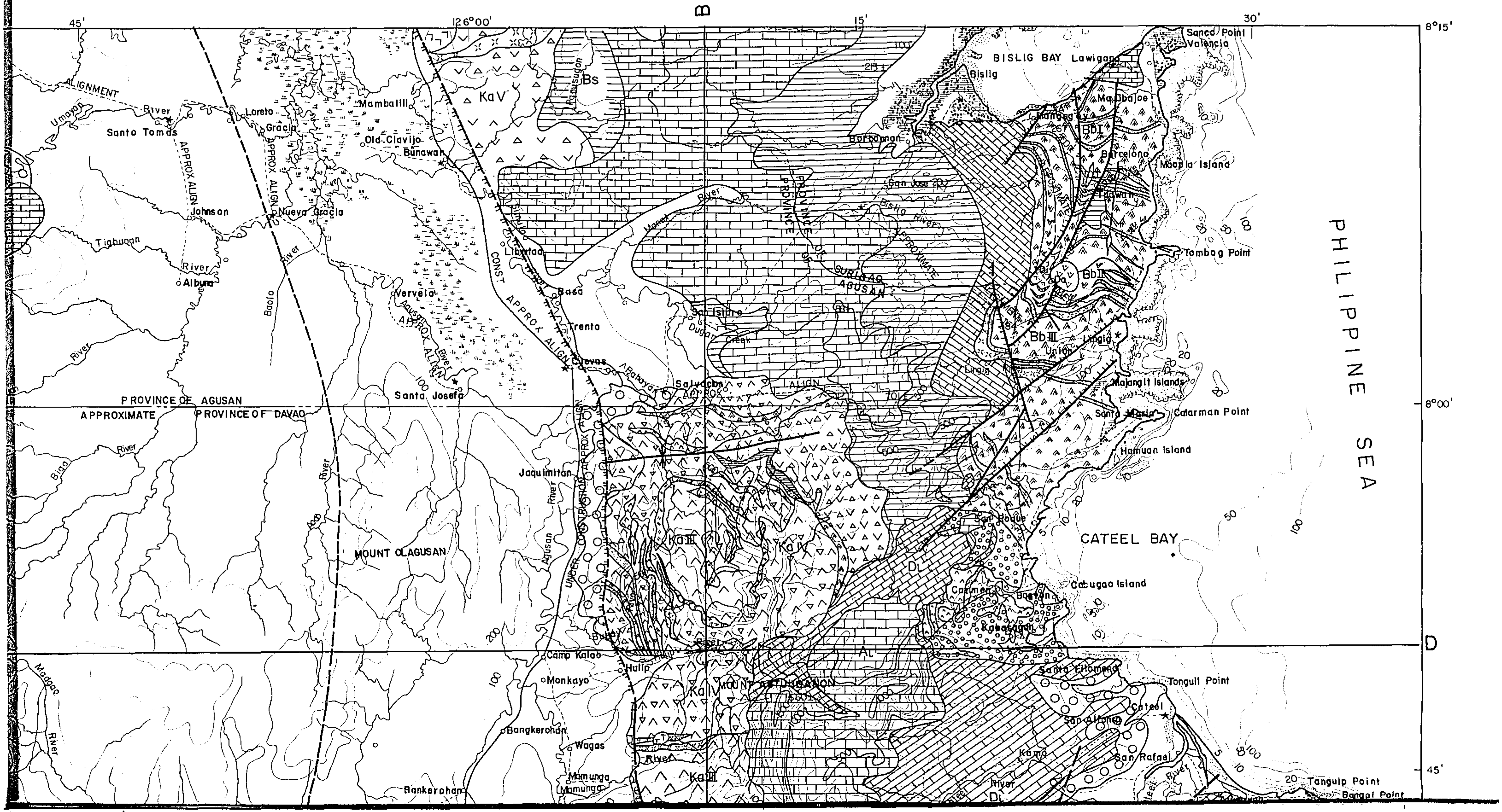

PHILIPPINE SEA
BISLIG BAY
CATEEL BAY
Bislig
Lawigan
Sanco Point
Valencia
Mangagoy
Barcelona
Maopla Island
Tombog Point
Lingig
Majanglt Islands
Catarman Point
Santa Maria
Hamuan Island
San Roque
Cabugao Island
Carmen
Boston
Kabasagan
Santa Filomena
Tonguil Point
Cateel
San Alfonso
San Rafael
Tanguip Point
Bangal Point
PROVINCE OF AGUSAN
PROVINCE OF DAVAO
PROVINCE OF SURIGAO
APPROXIMATE
MOUNT CLAGUSAN
Santo Tomas
Johnson
Albuna
Loreto
Gracia
Nueva Gracia
Mamballi
Old Clavijo
Bunawan
Libertad
Vervela
Santa Josefa
Basa
Trento
Salvacion
San Isidro
San Jose
Barbanan
Jaquimitan
Camp Kalao
Monkayo
Hulip
Bangkerohan
Wagas
Mamunga
Rankerohan
MOUNT AGTUGANON
CONST APPROX ALIGN
UNDER CONSTRUCTION APPROX ALIGN
ALIGNMENT
KaV
KaIII
KaIV
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Di
Al
45'
126°00'
15'
30'
8°15'
8°00'
45'
B
D

Scale 1 : 250,000

0 20 km

METAL MINING AGENCY

OVERSEAS TECHNICAL COOPERATION AGENCY

JULY 1974

Prepared by Bishimetal Exploration Co., Ltd.

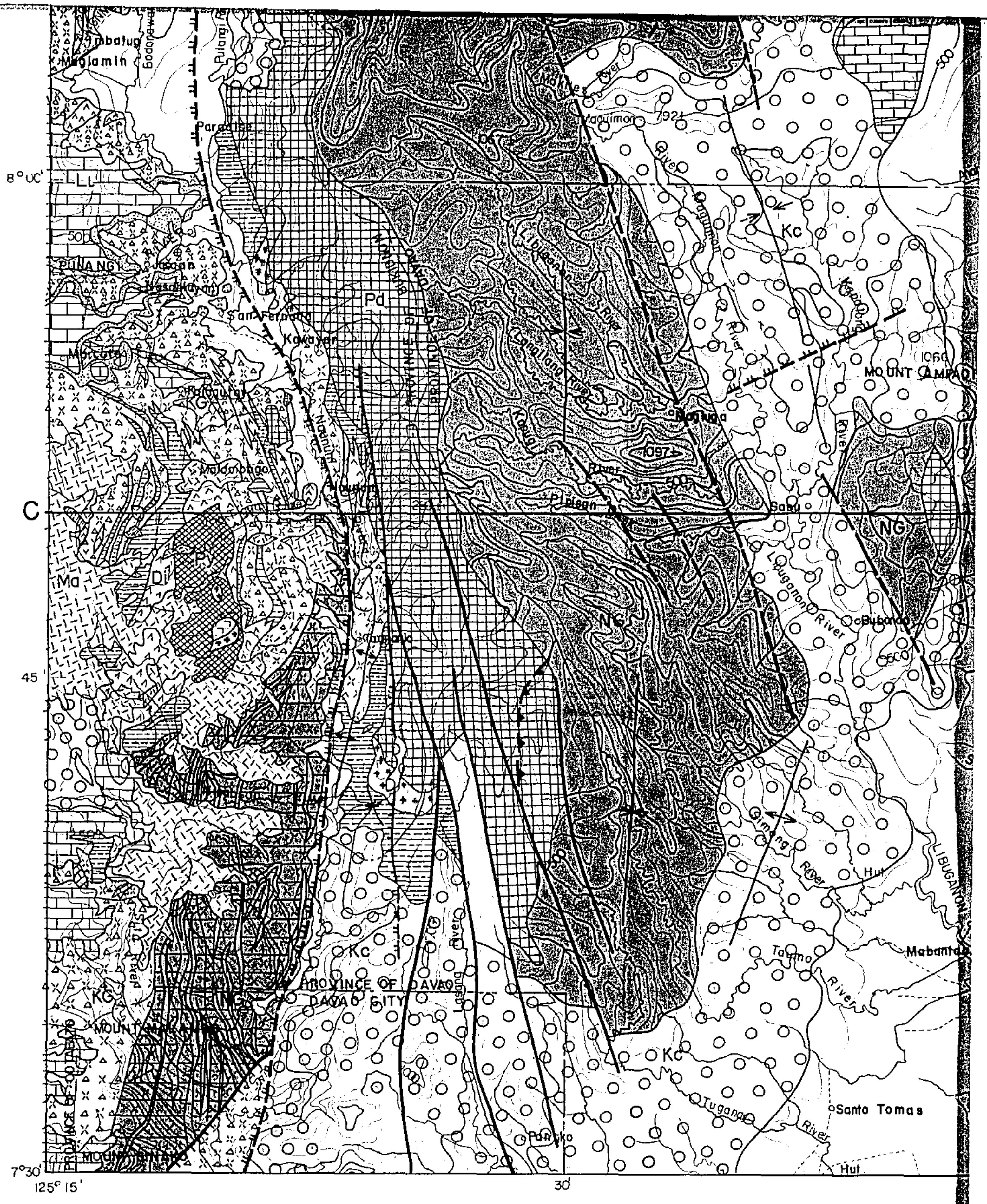
LEGEND

(Eastern Area)

Quaternary	Recent Alluvium			
	Pleistocene	Agtuuganon F.	Al	Limestone
		Kapalong F.	Kc	Conglomerate & Sandstone
Tertiary	Pliocene			
	M.Miocene Dacongbonwa F.		Dl	Limestone with Tuff
	E.Miocene Bislig F.		Bs	Siltstone, Sandstone & Conglomerate with thin bedded Limestone & Basalt lava
	Oligocene Mangagoy F.		Ml	Limestone
			Mt	Conglomerate
	Kaban G.	V Form.	KaV	Altered andesite & Pyroclastics
		IV Form.	KaIV	Augite-andesite & Pyroclastics
		III Form.	KaIII	Altered andesite
Cretaceous		II Form.	KaII	Glassy andesite
		I Form	KaI	Hornblende andesite

Barcelona G.	III Form.	BbIII	Basalt lava with Pyroclastics
	II Form.	BbII	Andesite lava with Pyroclastics
	I Form.	BbI	Basalt lava with Clastics

(Western Area)



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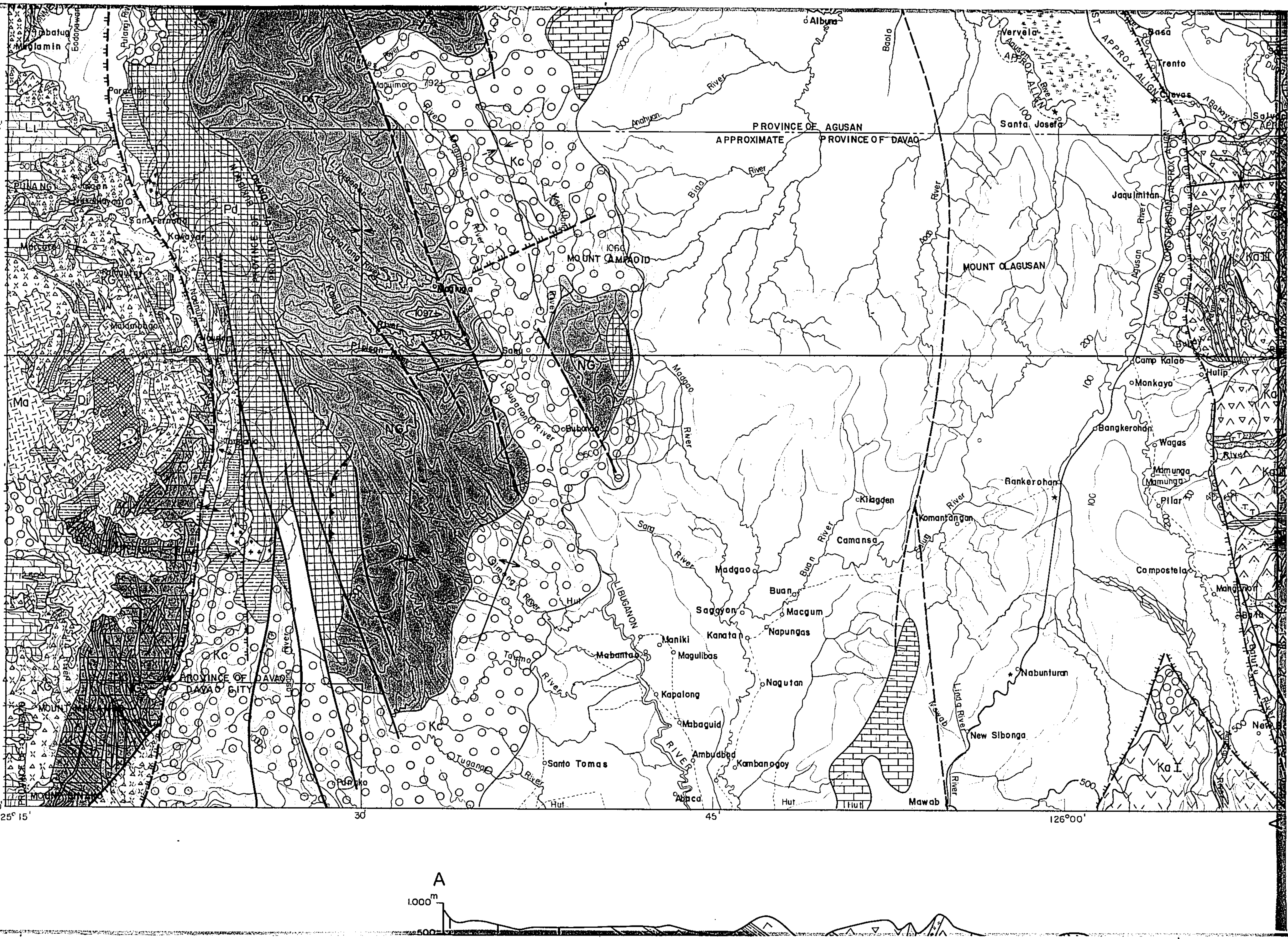

PROVINCE OF AGUSAN
APPROXIMATE
PROVINCE OF DAVAO
PROVINCE OF DAVAO
DAVAO CITY
MOUNT AMPAOID
MOUNT CLAGUSAN
LIBUGANON RIVER
Albuna
Vervela
Santa Josefa
Basa
Trento
Paradise
San Fernando
Kawayan
Jaquimitan
Camp Kalao
Monkayo
Bangkerohan
Wagas
Mamunga
Pilar
Compostela
Kilagden
Komantangan
Camansa
Madgao
Buan
Macgum
Saggyon
Kanatan
Napungas
Maniki
Mabantao
Magulibas
Nagutan
Kapalong
Mabaguid
Ambudbod
Kambanogoy
Abaca
Santo Tomas
Nabunturan
New Sibonga
Mawab
Bubondo
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8°00'
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125°15'
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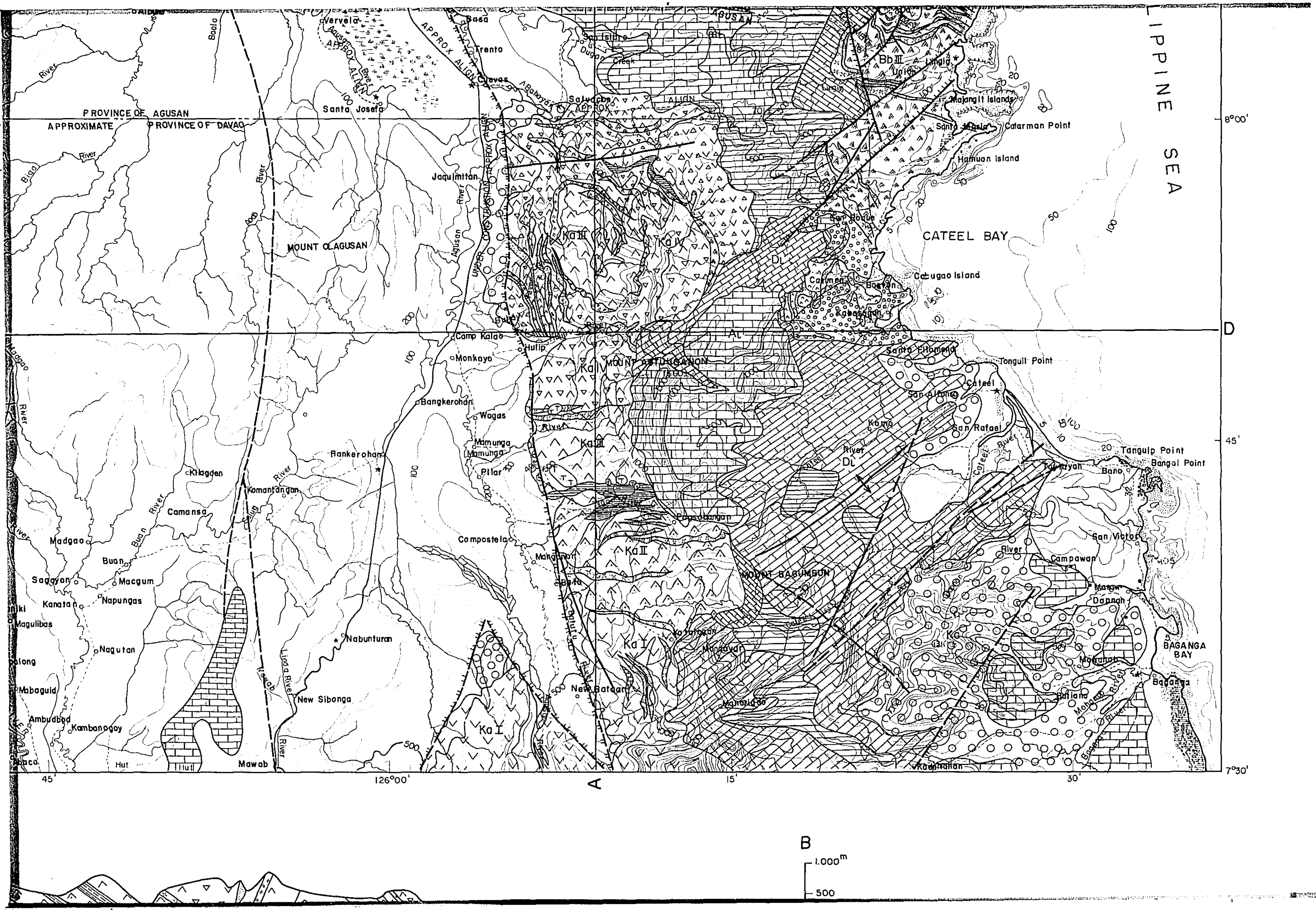

LIPPINE SEA
CATEEL BAY
BAGANGA BAY
PROVINCE OF AGUSAN
APPROXIMATE
PROVINCE OF DAVAO
MOUNT CLAGUSAN
MOUNT BAGUMBUN
APPROX ALIGN
Santa Josefa
Trento
Salvacion
Jaquimitan
Camp Kalao
Monkayo
Bangkerohan
Wagas
Mamunga
Pilar
Komantangan
Camansa
Madgao
Buan
Macgum
Saggyon
Kanatan
Napungas
Magulibas
Nagutan
Mabaguid
Ambudbod
Kambanogoy
Nabunturan
New Sibonga
Compostela
New Bataan
Mawab
Hut
Agusan River
Buan River
Linda River
Santa Filomena
Cateel
San Alfonso
San Rafael
Kabasagan
Carmen
Boston
San Roque
Cabugao Island
Hamuan Island
Catarman Point
Santa Maria
Majanglt Islands
Lingig
Tonguil Point
Tanguip Point
Bangal Point
Bano
San Victor
Campawan
Dapnan
Baganga
Mahanob
Kapnitahan
Cateel River
Baganga River
Mahanob River
Ka I
Ka II
Ka III
DL
AL
Bb III
8°00'
45'
7°30'
126°00'
15'
30'
A
B
D
1.000m
500

LEGEND

(Eastern Area)

Quaternary	Recent Alluvium			
	Pleistocene	Agtuuganon F.	Al	Limestone
Tertiary	Pliocene	Kapalong F.	Kc	Conglomerate & Sandstone
	M.Miocene	Dacongbonwa F.	Dt	Limestone with Tuff
	E.Miocene	Bislig F.	Bs	Siltstone, Sandstone & Conglomerate with thin bedded Limestone & Basalt lava
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			Mt	Conglomerate
Cretaceous	Kaban G.	V Form.	KaV	Altered andesite & Pyroclastics
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		I Form	KaI	Hornblende andesite
	Barcelona G.	III Form.	BbIII	Basalt lava with Pyroclastics
		II Form.	BbII	Andesite lava with Pyroclastics
		I Form.	BbI	Basalt lava with Clastics

(Western Area)

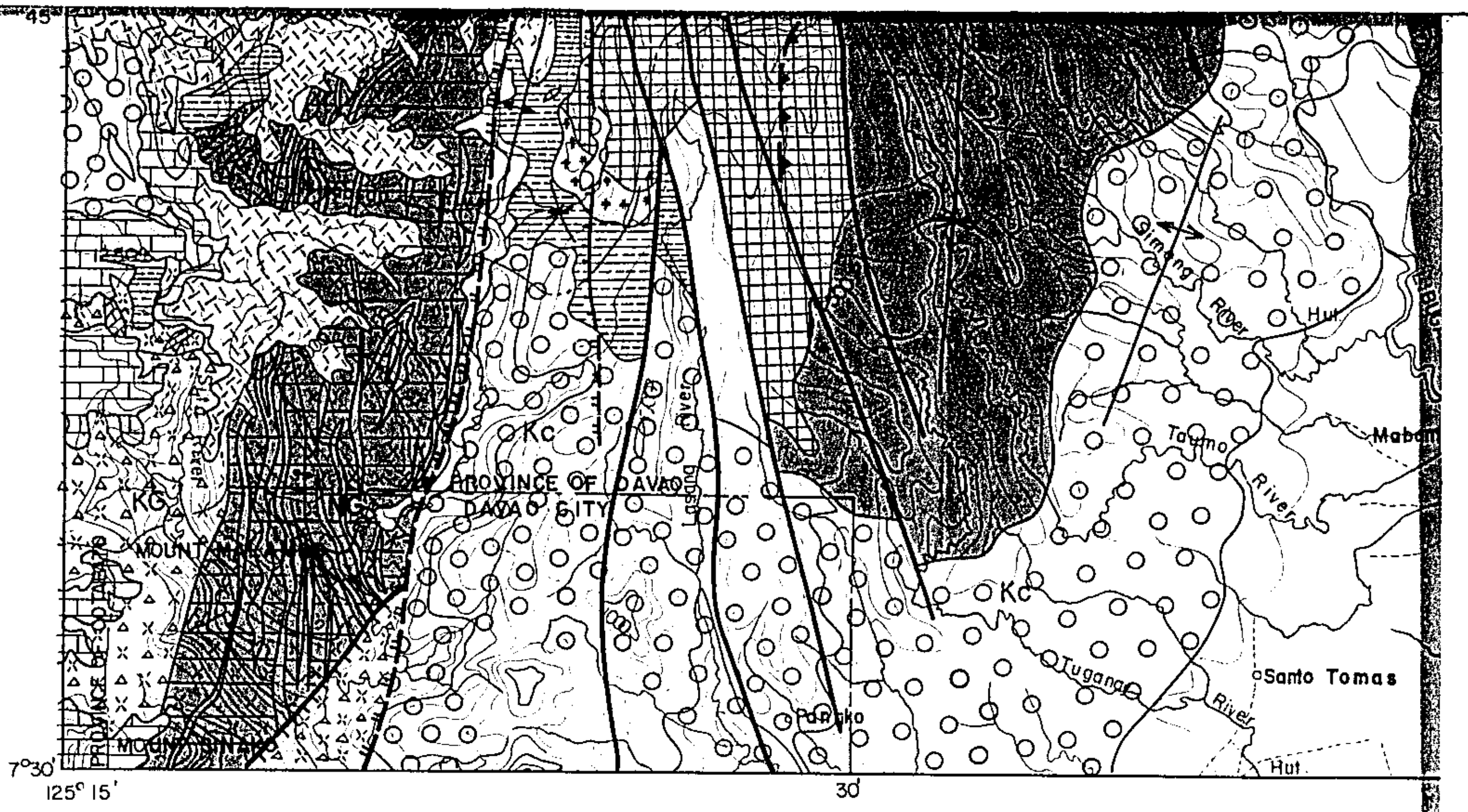
Quaternary	Recent Alluvium			
	Pleistocene	Malambo F.	Ma	Hornblende andesite
		Lumbayo F.	Ll	Limestone
			Ls	Limy sandstone & Limy mudstone
Tertiary	Pliocene	Kapalong F.	Kc	Conglomerate & Sandstone
		Kalagutay G.	KG	Mudstone, Sandstone, Tuff & Andesite
Cretaceous		Nilabsan G.	NG	Mudstone, Sandstone, Tuff, Andesite & Basalt lavas

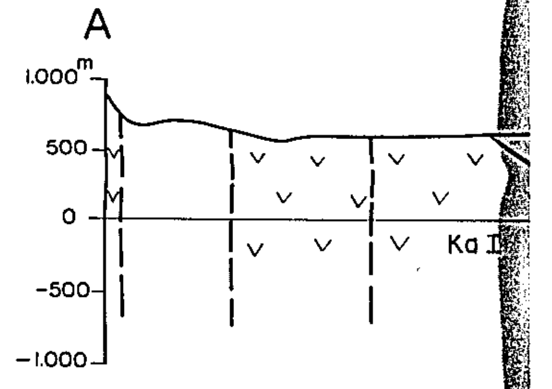
(Intrusive rocks)

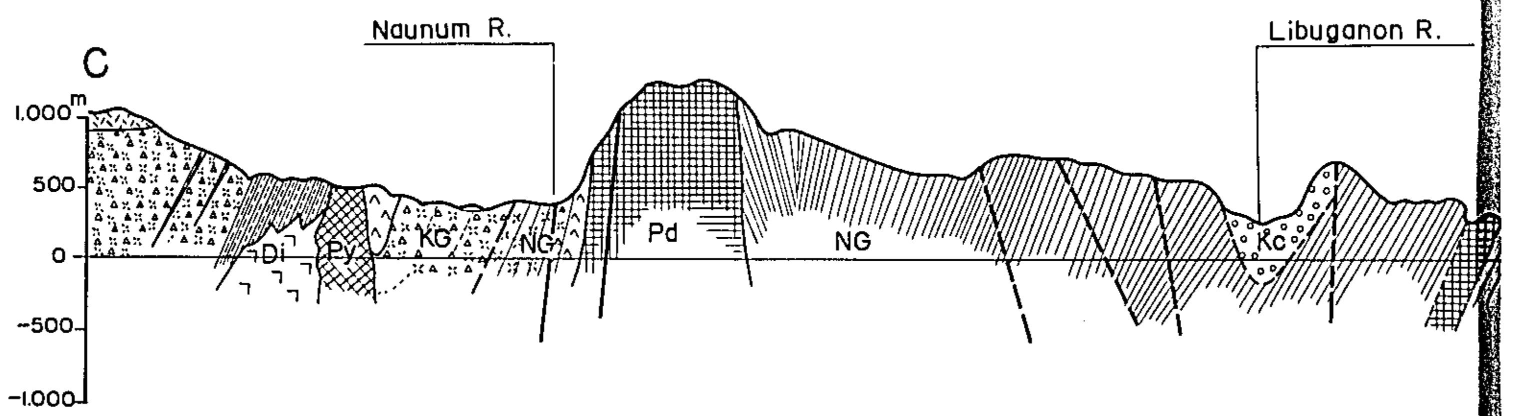
Di	Diorite
Gb	Gabbro
Py	Pyroxenite
Pd	Peridotite

(Others)

- Mudstone
- Mudstone & Sandstone
- Sandstone
- Limestone
- Pumiceous tuff
- Tuff ~ Tuff breccia
- Red tuff
- Andesite
- Basalt







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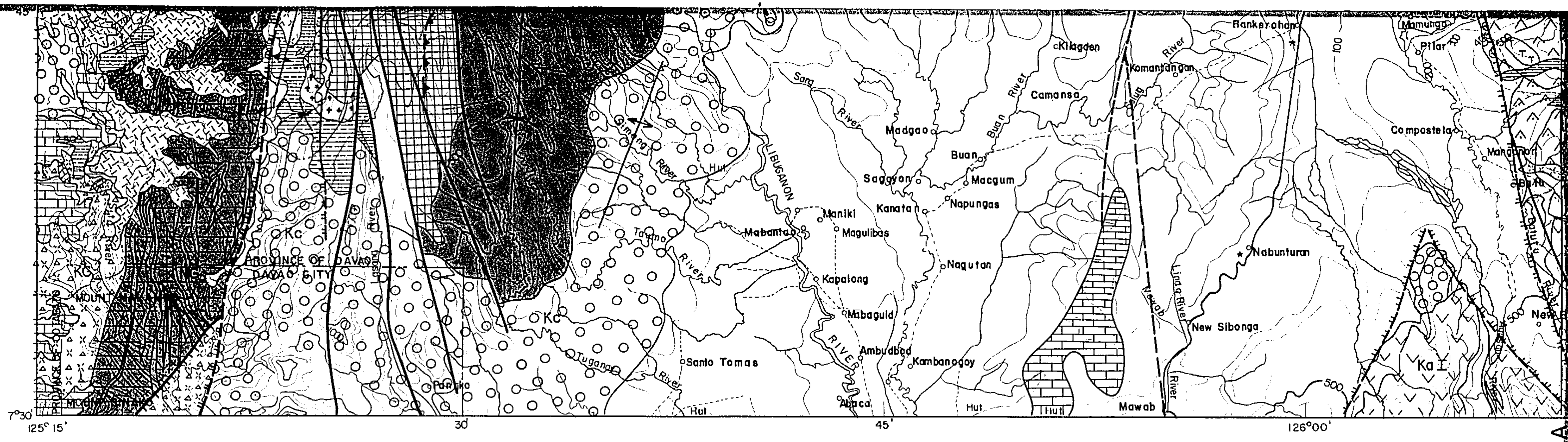

Kc
KG
PROVINCE OF DAVAO
DAVAO CITY
MOUNT
Gimong River
Hut
Taymo River
Tuganay River
Panabo
Santo Tomas
LIBUGANON RIVER
Maniki
Mabantao
Magulibas
Kapalong
Mabaguid
Ambudbod
Abaca
Kambanogoy
Sang River
Madgao
Saggyon
Buan
Buan River
Macgum
Kanatan
Napungas
Nagutan
Kilagden
Camansa
Komantangan
Hut
Mawab
Mawab River
Linda River
New Sibonga
Nabunturan
Rankerohan
Mamunga
Pilar
Compostela
Mangonon
New Bataan
Ka I
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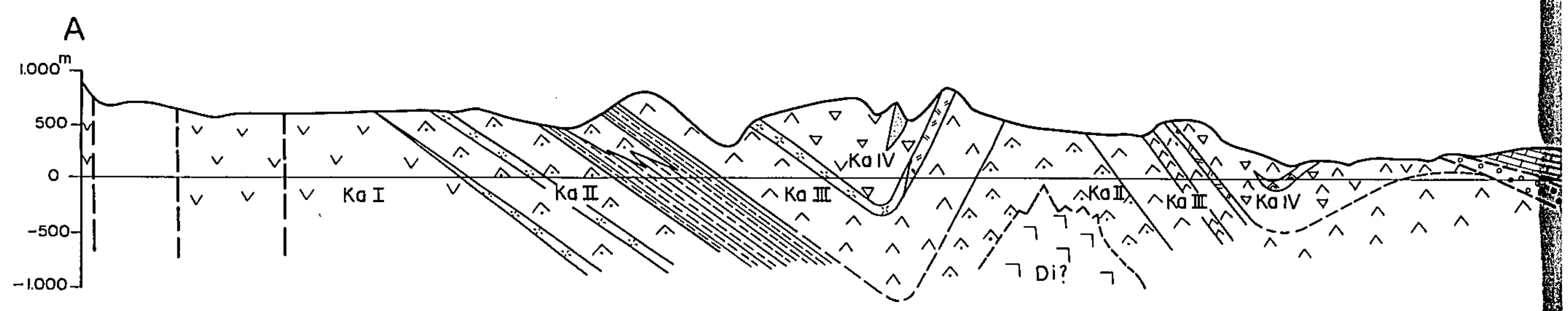
7°30'
125° 15'
30'
45'
126°00'



A
1.000 m
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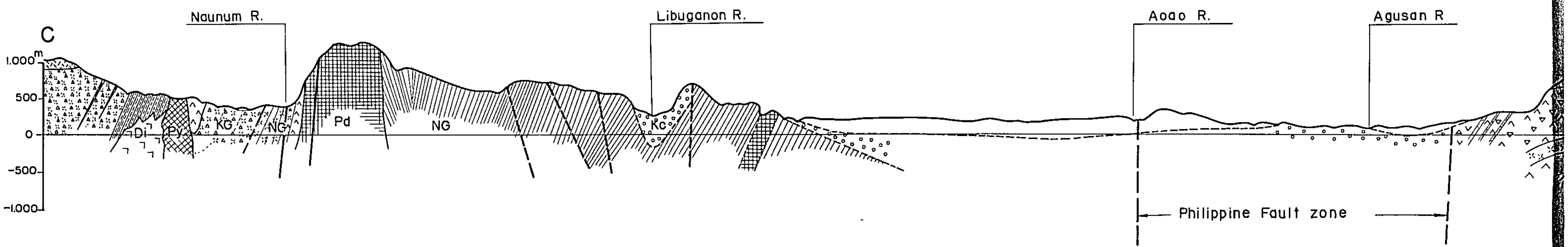
-500
-1.000
Ka I
Ka II
Ka III
Ka IV
Ka II
Ka III
Ka IV
Di?



C
1.000 m
500
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Naunum R.
Libuganon R.
Aoao R.
Agusan R
Di
PY
KG
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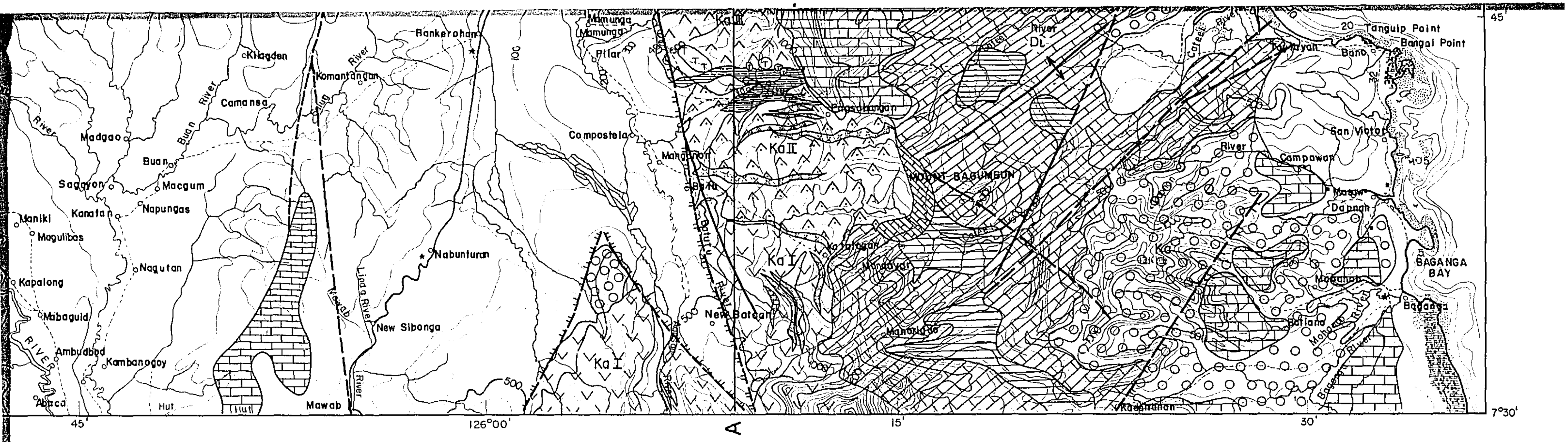
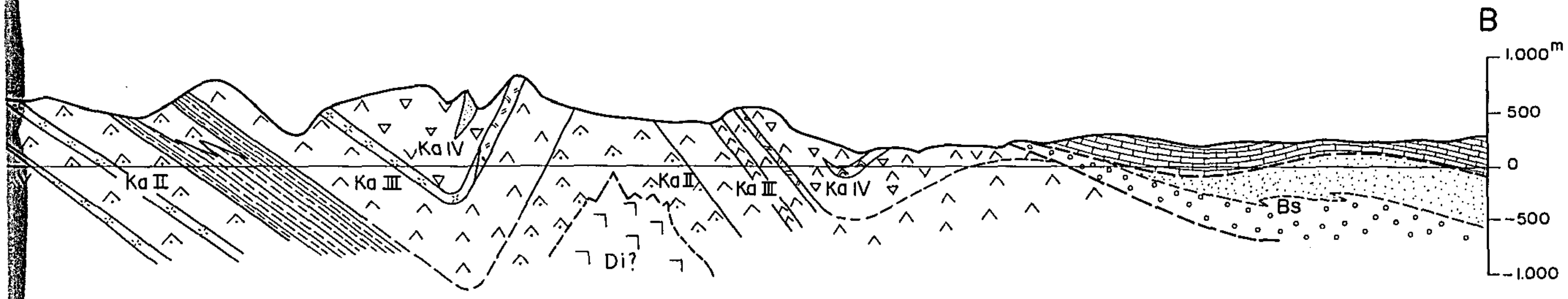
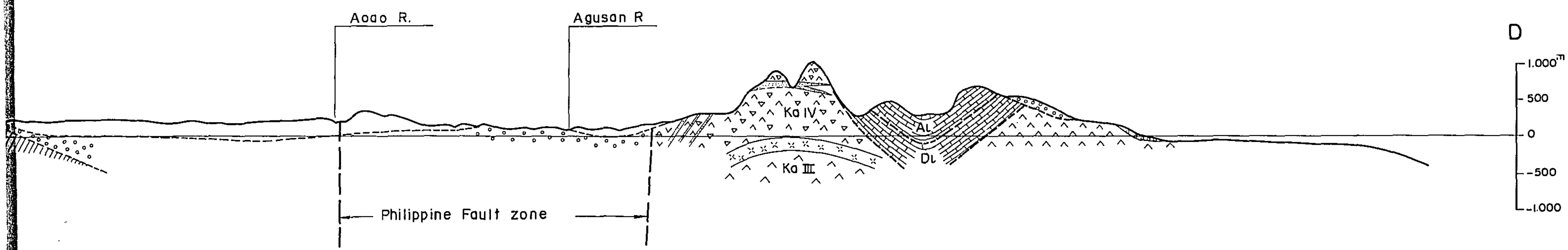
Philippine Fault zone



45'
126°00'
15'
30'
7°30'
A
Kilagden
Komantangan
Bankerohan
Mamunga
Pilar
Camansa
Madgao
Buan
Saggyon
Macgum
Maniki
Kanatan
Napungas
Magulibas
Nagutan
Nabunturan
Kapalong
Mabaguld
Ambudbod
Kambanogoy
Abaca
Mawab
New Sibonga
Compostela
New Bataan
Ka I
Ka II
Ka III
Ka
Di
MOUNT BAGUMBUN
San Victor
Campawan
Tangulp Point
Bangal Point
BAGANGA BAY
Baganga
Bano
Hut



B
1.000m
500
0
-500
-1.000
Ka II
Ka III
Ka IV
Di?
Bs



Aoao R.
Agusan R
D
1.000m
500
0
-500
-1.000
Ka IV
Ka III
Al
Di
Philippine Fault zone

PL. 2

GEOLOGICAL SURVEY

OF

EASTERN MINDANAO

GEOCHEMICAL ANOMALIES OF STREAM SEDIMENTS

Scale 1 : 250,000

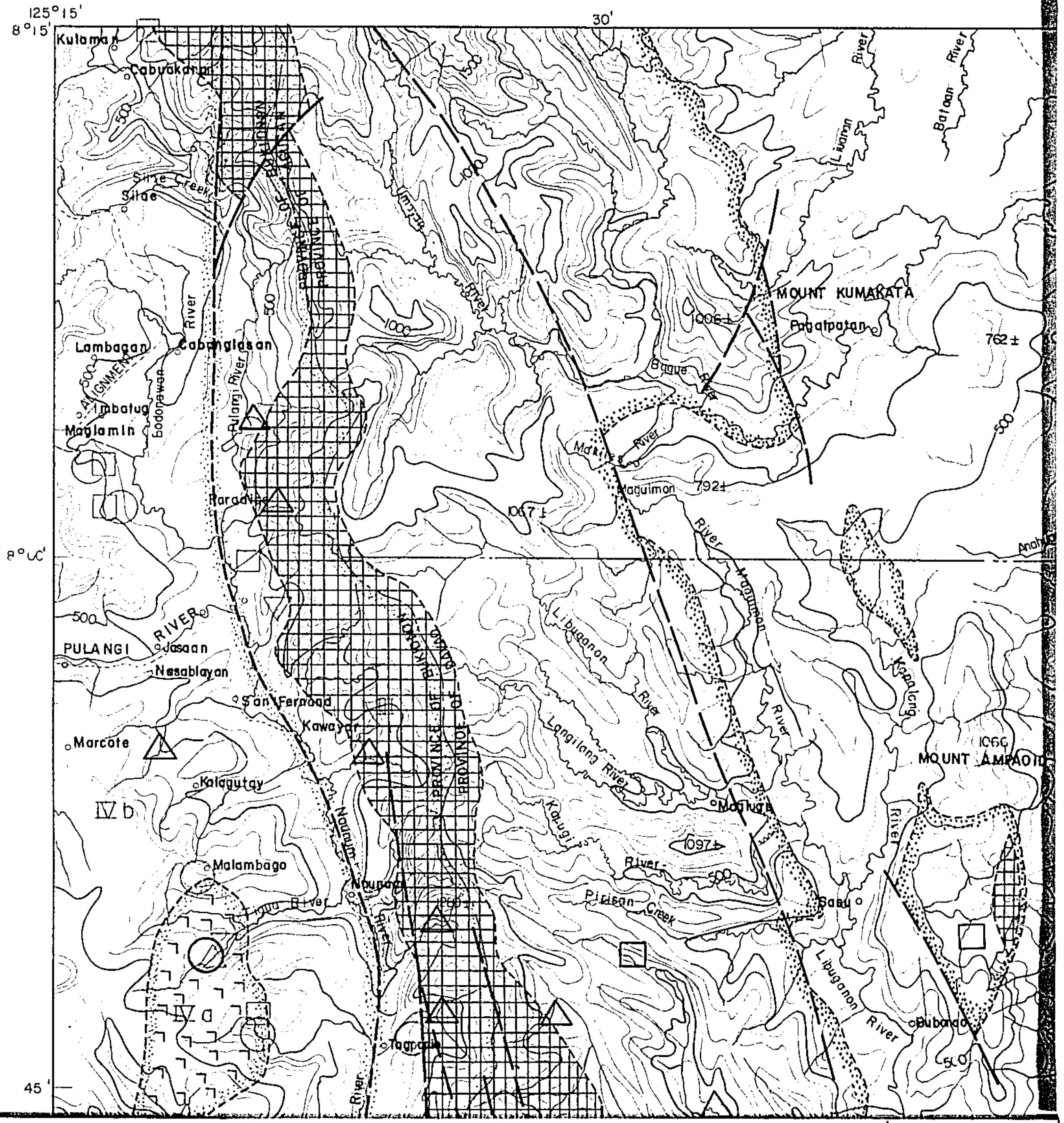
0 5 10 15 20km

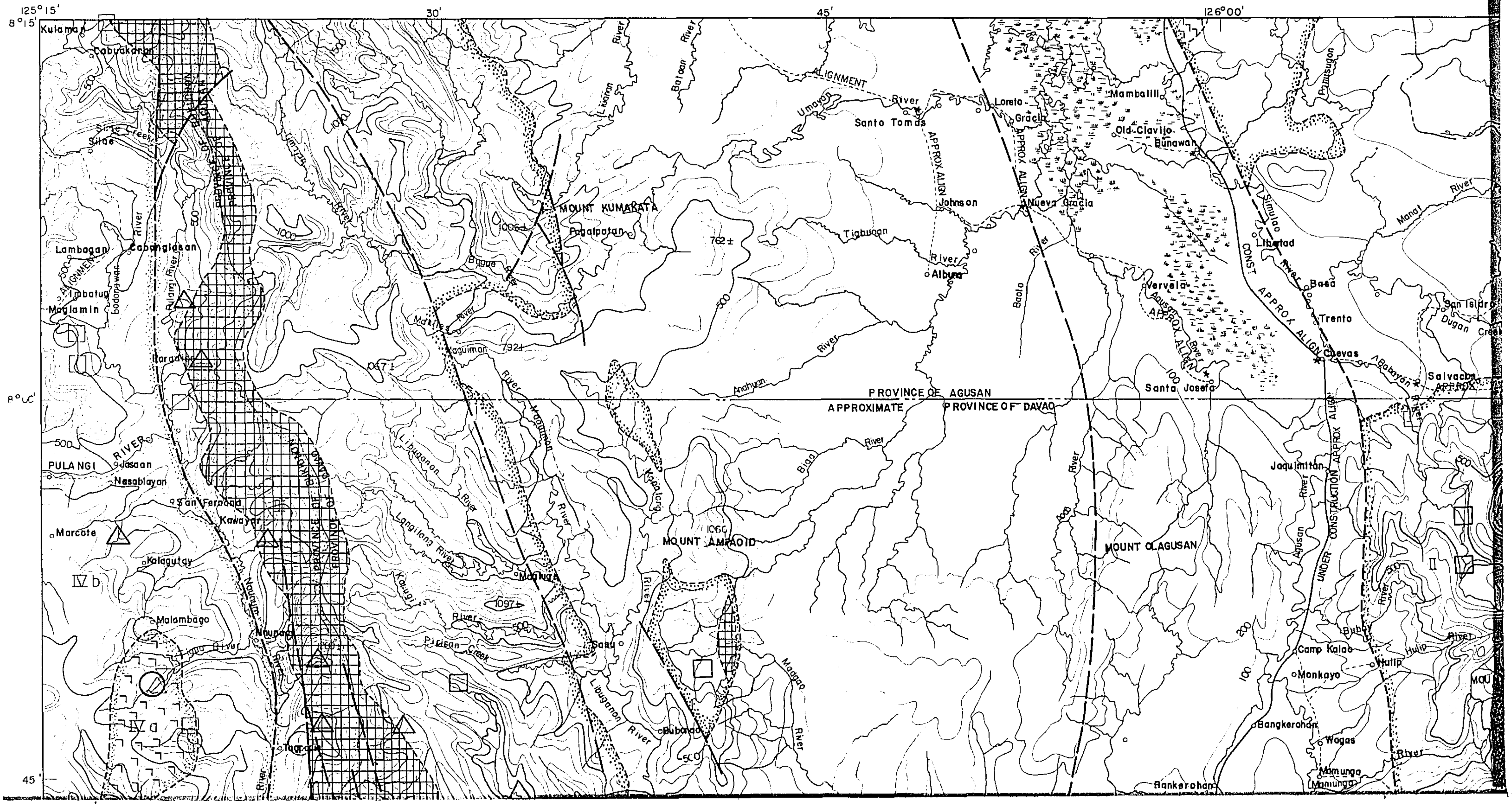
METAL MINING AGENCY

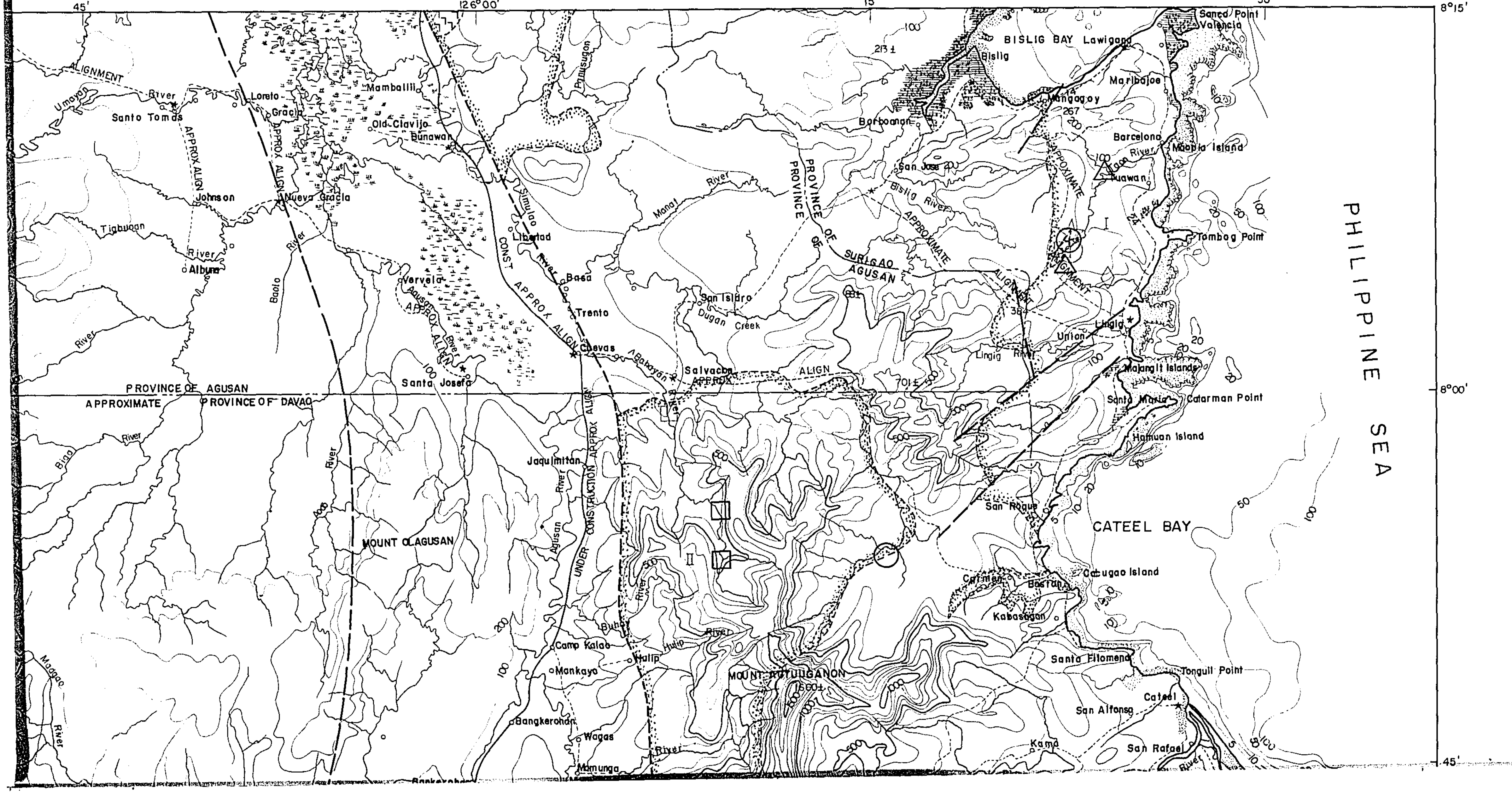
OVERSEAS TECHNICAL COOPERATION AGENCY

JULY 1974

Prepared by Bishimetal Exploration Co., Ltd.




125°15'
30'
45'
126°00'
8°15'
8°00'
45'
Kulaman
Cabuakanan
Sirac Creek
Silae
Lambagan
Cabangiasan
Imbatug
Maglamin
Paradise
PULANGI RIVER
Jasaan
Nasablayan
San Fernand
Kawayan
Marcote
Kalagutay
IV b
Malambago
Naunago
Tigua River
IV a
Tagpalu
MOUNT KUMAKATA
Pagatpatan
1006±
1067±
762±
792±
Maguimon
Bugue River
Libuganon River
Langilang River
1097±
Pirisan Creek
Saau
Bubonao
Libuganon River
MOUNT AMPAOID
1060
Magaa River
Batoan River
Umayan River
ALIGNMENT
Santo Tomas
APPROX ALIGN
Johnson
Tiabuaan River
Albura
Anahuan River
Biaa River
PROVINCE OF AGUSAN
APPROXIMATE
PROVINCE OF DAVAO
Loreto
Gracia
Nueva Gracia
Mambalili
Old Clavijo
Bunawan
Baolo River
Vervela
Agusan River
Santa Josefa
MOUNT OLAGUSAN
Liberlad
Basa
Trento
Cuevas
CONST APPROX ALIGN
UNDER CONSTRUCTION APPROX ALIGN
Simulao River
Manat River
San Isidro
Dugan Creek
Babayan River
Salvacion
Jaquimitan
Agusan River
Camp Kalao
Monkayo
Hulip
Bangkerohan
Wagas
Mamunga
Bankerohan
II



45'
126°00'
15'
30'
8°15'
8°00'
45'
PHILIPPINE SEA
BISLIG BAY
Lawigan
Sanco Point
Valencia
Bislig
Mangagoy
Maribojoc
Barcelona
Mapla Island
Tuawan
Tombog Point
Lingig
Union
Lingig River
Barboanan
San Jose
Bislig River
PROVINCE OF SURIGAO
PROVINCE OF AGUSAN
APPROXIMATE ALIGNMENT
San Isidro
Dugan Creek
Manat River
Mamballi
Old Clavijo
Bunawan
Loreto
Gracia
Santo Tomas
Umayan River
Johnson
Nueva Gracia
Tigbuoan
Albuna
River
Baolo River
Vervela
Libertad
Basa
Trento
Cuevas
Babayan River
Salvacion
Santa Josefa
CONST APPROX ALIGN
APPROX ALIGN
PROVINCE OF AGUSAN
APPROXIMATE
PROVINCE OF DAVAO
UNDER CONSTRUCTION APPROX ALIGN
Jaquimitan
Agusan River
MOUNT CLAGUSAN
Majanglt Islands
Santa Maria
Catarman Point
Hamuan Island
San Roque
CATEEL BAY
Cabugao Island
Carmen
Bostan
Kabasagan
Santa Filomena
Tongull Point
Cateel
San Alfonso
Kamo
San Rafael
Buhay
Camp Kalao
Hulip
Mankayo
Bangkerohan
Wagas
Mamunga
MOUNT AGTUUGANON
1560±
Magaao River
Biraa River
I
II

Scale 1 : 250,000

0 5 10 15 20km

METAL MINING AGENCY

OVERSEAS TECHNICAL COOPERATION AGENCY

JULY 1974

Prepared by Bishimetal Exploration Co., Ltd.

LEGEND

Major geochemical anomaly

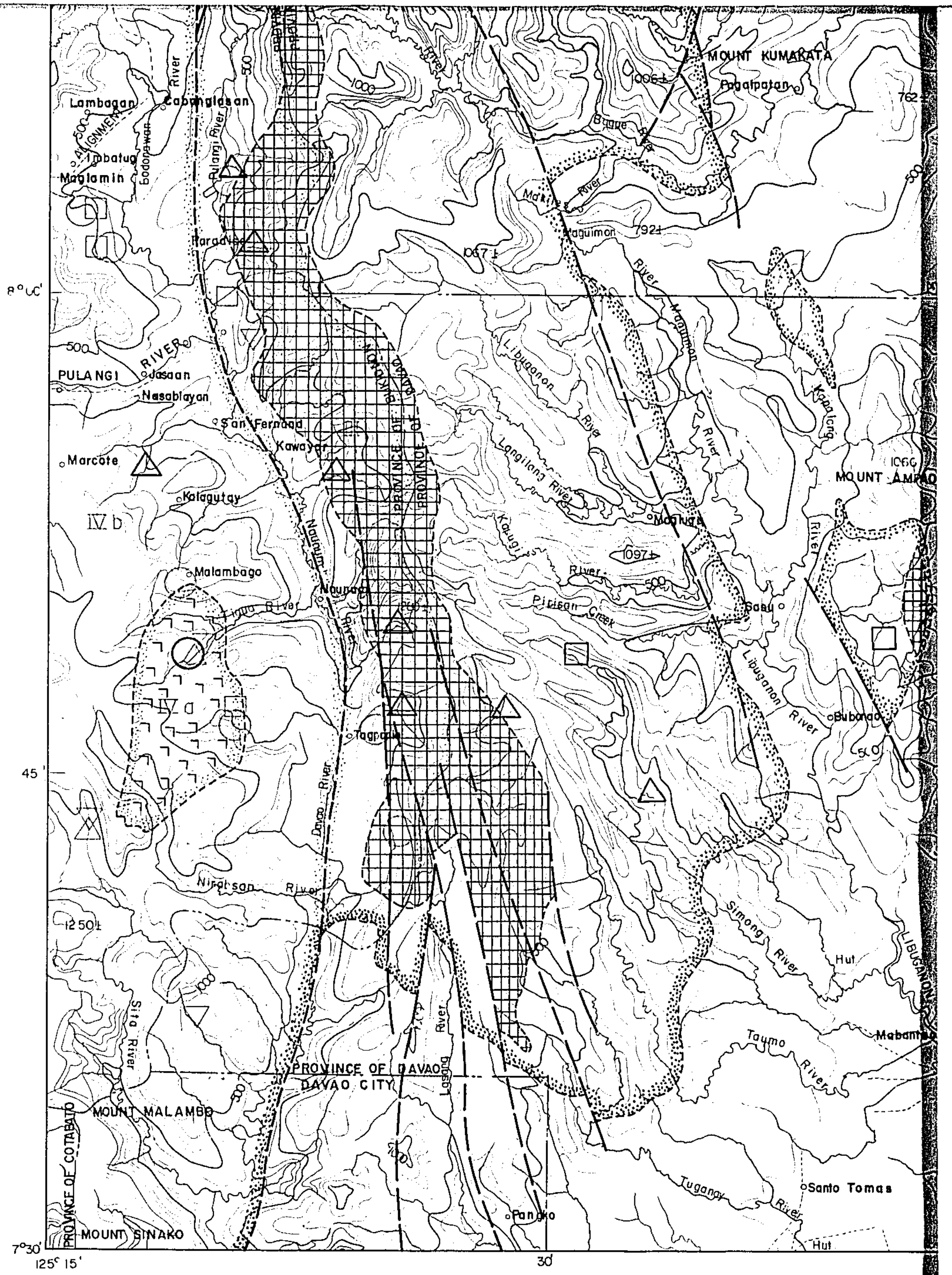
Phase I

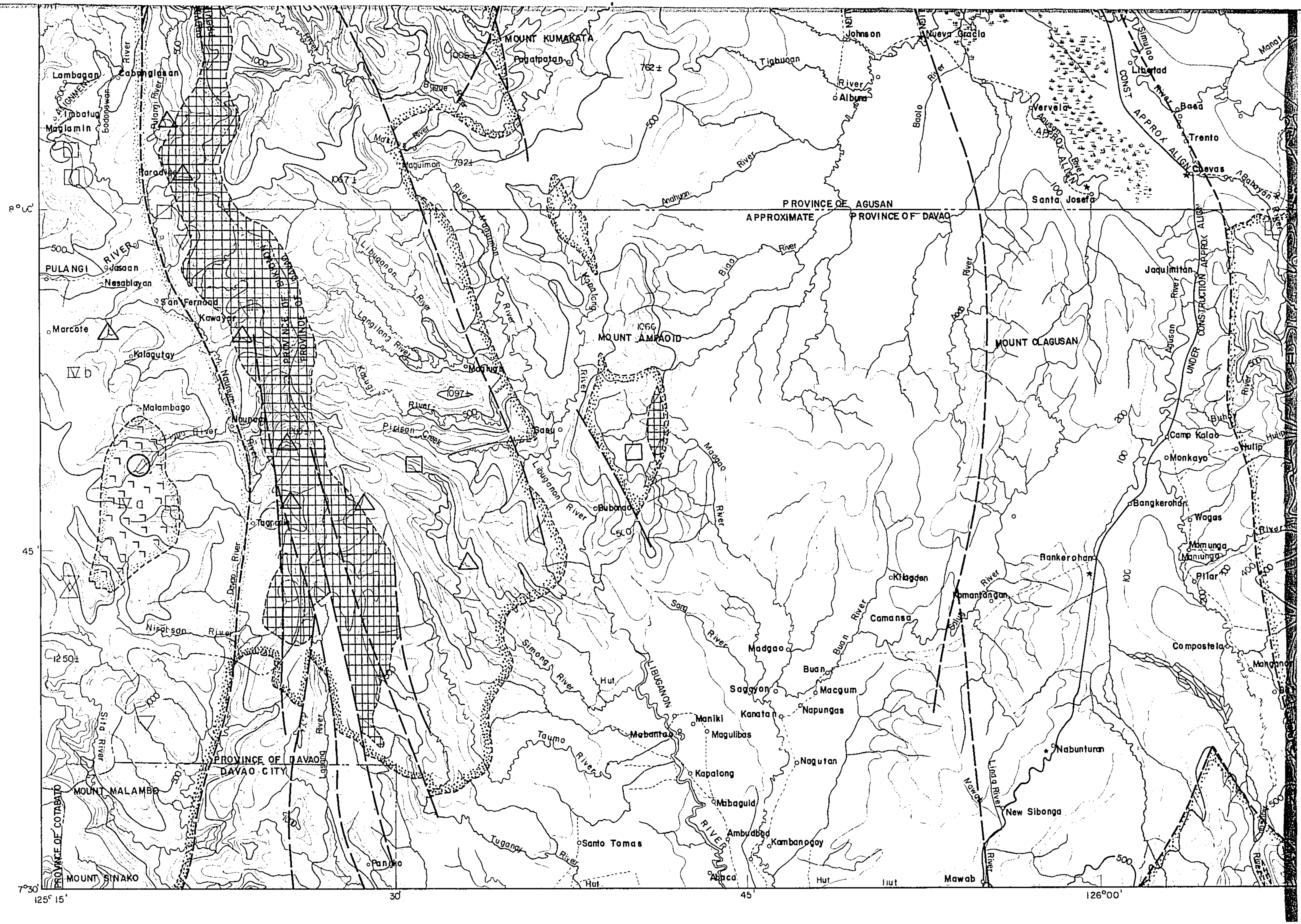
	Cu	Zn	Ni
>2t ----	○	□	△

Phase II

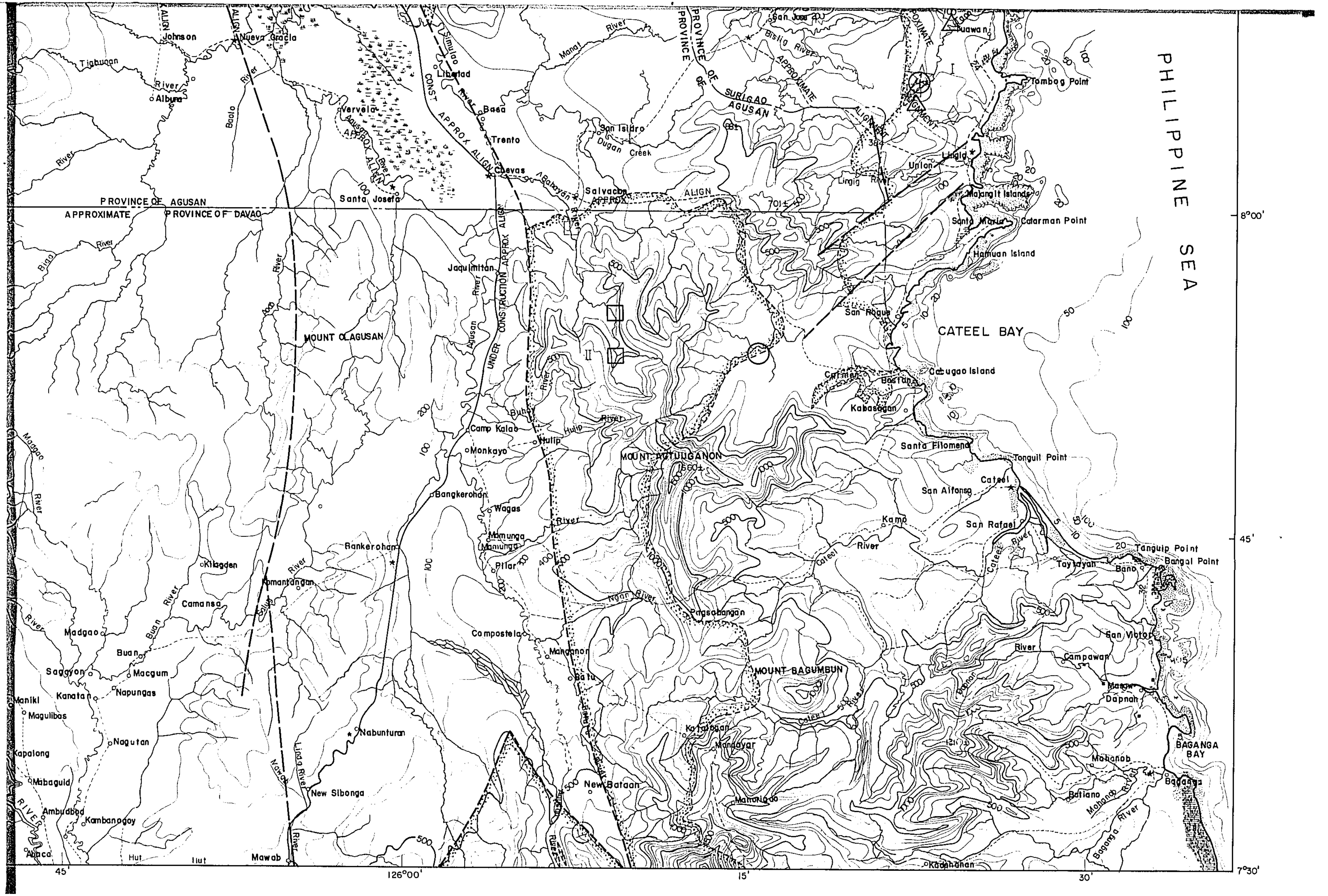
I, II, Na - Areas

	Cu	Zn	Ni	Co	Ag	Mo
>2t ----	○	□	△	▽	◇	☆





MOUNT KUMAKATA
Pagatpatan
Johnson
Nueva Gracia
Tigbuaan
Libertad
Lambagan
Cabanglasan
Pulangi River
Imbatug
Maglamin
Albura
River
Baolo
Vervela
Basa
Trento
Cuevas
Babayon
Agusan River
Santa Josefa
CONST APPROX ALIGN
APPROX ALIGN
Maguimon
Baguo
Anahuan
Taradias
PROVINCE OF AGUSAN
APPROXIMATE
PROVINCE OF DAVAO
PULANGI RIVER
Jasaan
Nesablayan
San Fernando
Kawayan
Marcote
Kalagutay
IV b
IV a
Malambago
Naupoon
Tagpolo
Libuganon River
Langilang River
Kaugi
Pirisan Creek
Biao
Kapalong
MOUNT AMPAOID
MOUNT CLAGUSAN
Jaquimitan
UNDER CONSTRUCTION APPROX ALIGN
Camp Kalao
Hulip
Monkayo
Bangkerohan
Wagas
Mamunga
Pilar
Compostela
Mangango
Sasa
Madgao
Bubonao
Kilagden
Komantangan
Camansa
Sara River
Buan River
Madgao
Buan
Macgum
Saggyon
Napungas
Kanatan
Maniki
Mabantao
Magulibas
Simong River
Taumo River
LIBUGANON RIVER
Nagutan
Kapatong
Mabaguid
Ambudbod
Kambanogoy
Santo Tomas
Tuganay River
Abaca
Hut
Mawab
Liang River
New Sibonga
Nabunturan
Niratsan River
Davao River
Sila River
PROVINCE OF DAVAO
DAVAO CITY
PROVINCE OF COTABATO
MOUNT MALAMBO
MOUNT SINAKO
Panabo
Lasang River
1250±
1067±
1097±
1066
762±
792±
8°00'
45'
7°30'
125°15'
30'
45'
126°00'


PHILIPPINE SEA
CATEEL BAY
BAGANGA BAY
PROVINCE OF AGUSAN
PROVINCE OF DAVAO
PROVINCE OF SURIGAO
AGUSAN
APPROXIMATE
MOUNT CLAGUSAN
MOUNT BAGUMBUN
Johnson
Nueva Gracia
Albuna
Tigbuan
Libertad
Basa
Trento
Cuevas
Salvacion
Santa Josefa
San Isidro
Dugan Creek
San Jose
Puawan
Tombog Point
Lingig
Union
Majangit Islands
Santa Maria
Catarman Point
Hamuan Island
San Roque
Cabugao Island
Carmen
Bastana
Kabasagan
Santa Filomena
Tonguil Point
Cateel
San Alfonso
San Rafael
Kamo
Cateel River
Tanguip Point
Bangal Point
Taytayan
Bano
San Victor
Campawan
Dapnan
Mahanob
Baganga
Batiano
Baganga River
Kadahuhan
Jaquimitan
Camp Kalao
Monkayo
Hulip
Bangkerohan
Wagas
Mamunga
Pilar
Kilagden
Komantangan
Camansa
Compostela
Manganon
Batu
Pagsabangan
Katalogan
Mandayar
Maha Nado
New Bataan
Nabunturan
New Sibonga
Mawab
Madgao
Buan
Saggyon
Macgum
Kanatan
Napungas
Maniki
Magulibas
Nagutan
Kapalong
Mabaguid
Ambudbod
Kambanogoy
Abaca
UNDER CONSTRUCTION APPROX ALIGN
CONST APPROX ALIGN
I
II
8°00'
45'
7°30'
126°00'
15'
30'

LEGEND

Major geochemical anomaly

Phase I

	Cu	Zn	Ni
>2t ----	○	□	△

Phase II

I, II, Na - Areas

	Cu	Zn	Ni	Co	Ag	Mo
>2t ----	○	□	△	▽	◇	☆

III, IIIb - Areas

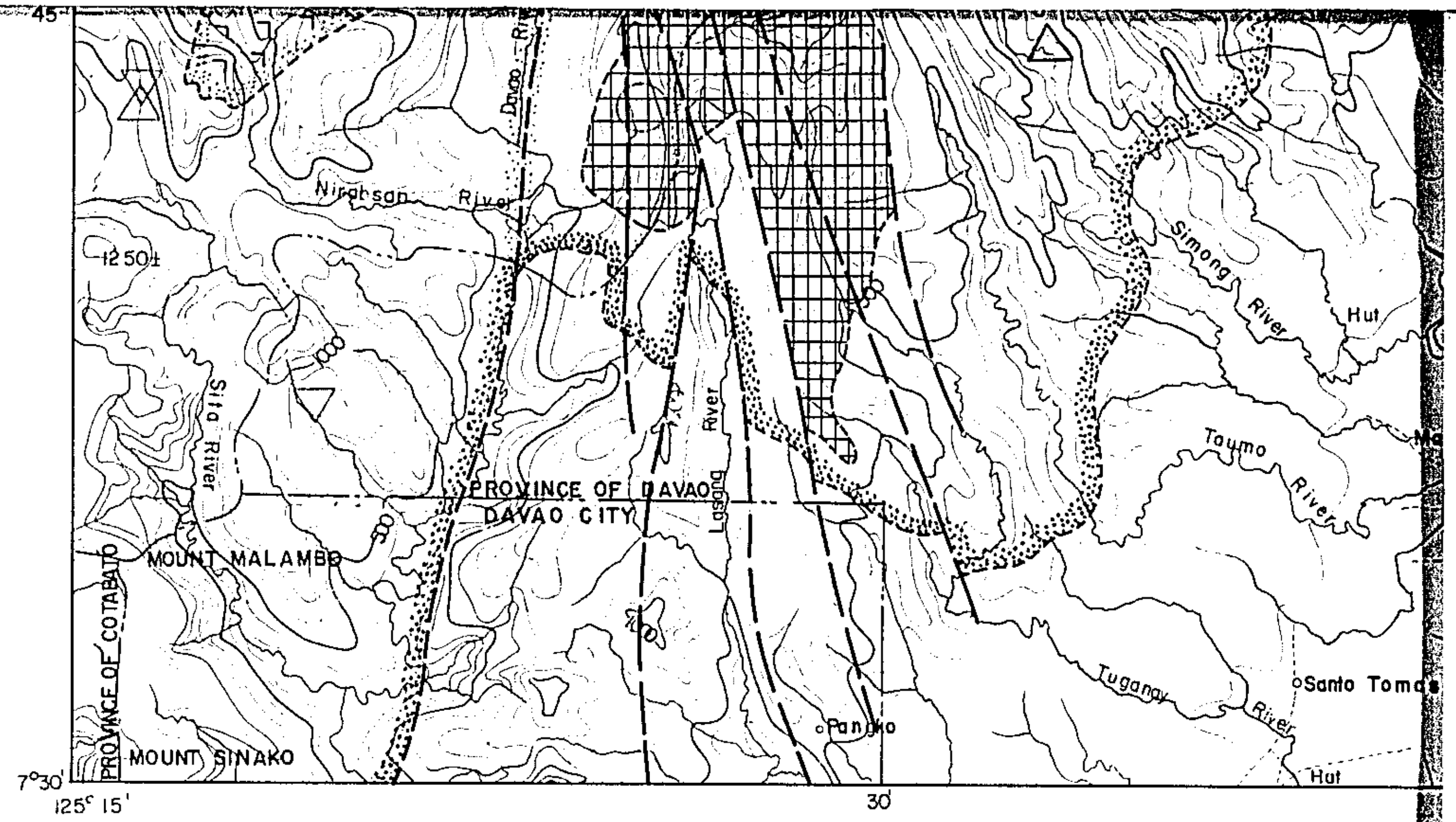
	Cu	Zn	Ni	Co
>4t ----	○	□	△	▽

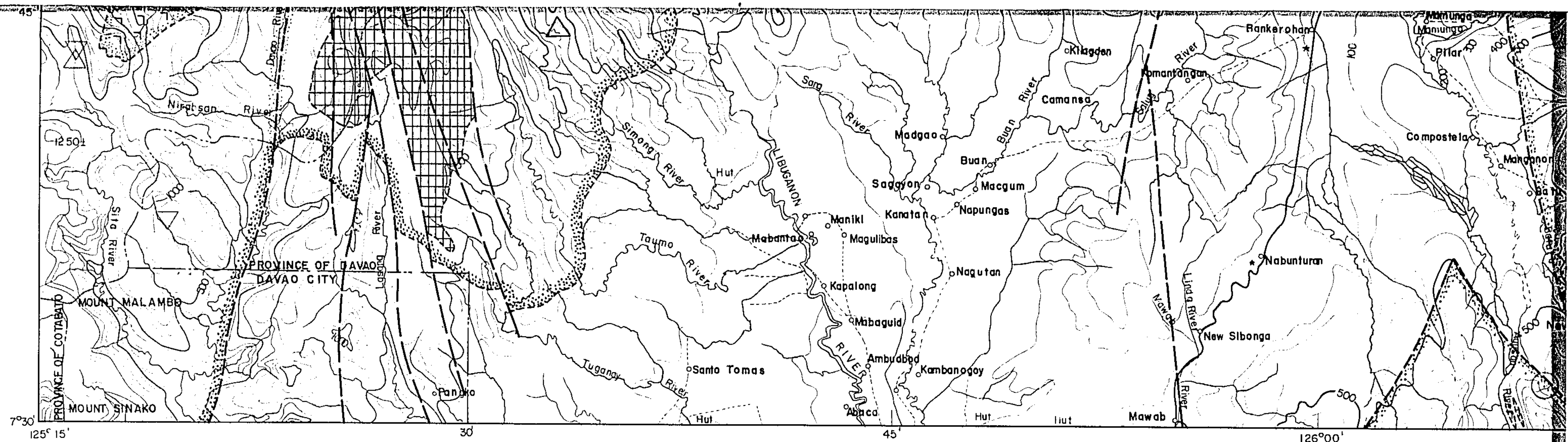
Cretaceous area (Phase I)

Lithological group (Phase II)

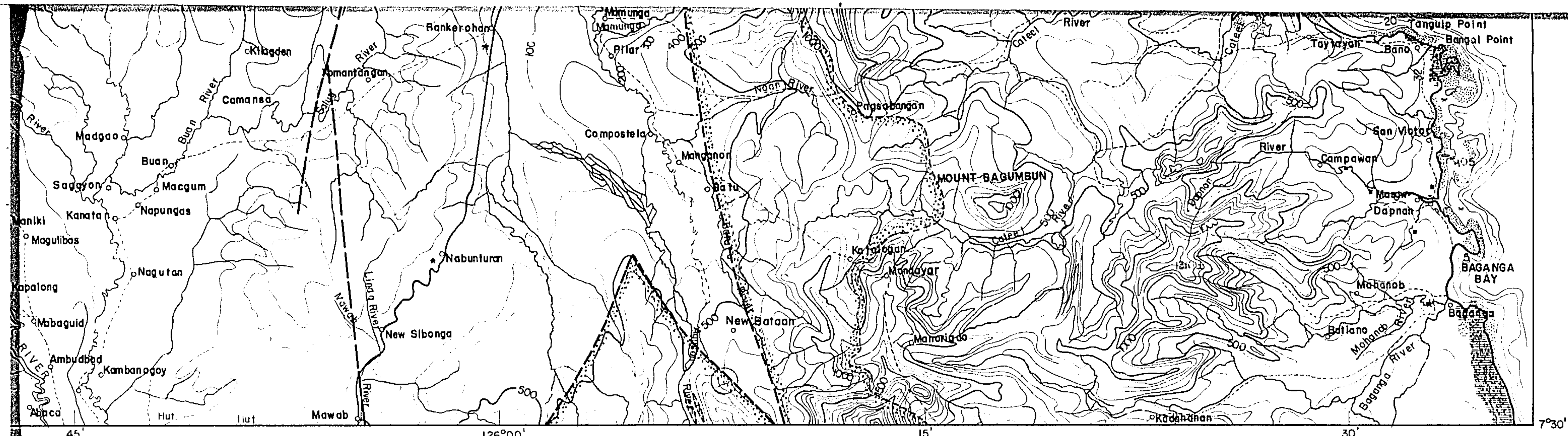
Diorite, Diorite-Pyroxenite,

Peridotite





PROVINCE OF DAVAO
DAVAO CITY
PROVINCE OF COTABATO
MOUNT MALAMBO
MOUNT SINAKO
Davao River
Siia River
Lasang River
Simong River
Taumo River
Tuganay River
LIBUGANON RIVER
Saro River
Buan River
Linda River
Mawab River
Hut
Santo Tomas
Maniki
Mabantao
Magulibas
Kapalong
Mabaguld
Ambudbod
Kambanogoy
Abaca
Saggyon
Kanatan
Napungas
Nagutan
Madgao
Buan
Macgum
Camansa
Kilagden
Comantangan
Rankerohan
Nabunturan
New Sibonga
Mawab
Compostela
Pilar
Panoko
7°30'
125° 15'
30'
45'
126°00'
500



Mamunga
Pilar
Bankerohan
Kiagdan
Tomantangan
Camansa
Buan River
River
Madgao
Buan
Saagyon
Macgum
Kanatan
Napungas
Maniki
Magulibas
Nabunturan
Nagutan
Kapalong
Mabaguid
Linda River
New Sibonga
Ambudbod
Kambanogoy
Abaca
Mawab
River
Compostela
Manganon
Batu
New Bataan
Ngan River
Pagsabangan
MOUNT BAGUMBUN
Katalogan
Mandayar
Cateel River
River
Campawan
San Victor
Taytayan
Bano
Tanguip Point
Bangal Point
Masaw
Dapnan
BAGANGA BAY
Mahanob
Batiano
Mahanob River
Baganga River
Baganga
Kadahuhan
500
1000
45'
126°00'
15'
30'
7°30'