REPORT

ON

THE COOPERATIVE MINERAL EXPLORATION

GEOLOGICAL ASSESSMENT OF CHROMITE, BASE METALS, PLATINUM AND RELATED PRECIOUS METAL OCCURRENCES

IN

SOUTH CENTRAL PALAWAN, THE REPUBLIC OF PHILIPPINES

PHASE I

SEPTEMBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PREFACE

In response to a request of the Government of the Republic of the Philippines, the Japanese Government decided to conduct a Mineral Exploration in the South Central Palawan Area and entrusted the survey to the Japan International Cooperation Agency(JICA) and the Metal Mining Agency of Japan(MMAJ).

The JICA and the MMAJ sent a survey team headed by Mr. Akio Shida from October 21, 1990 to December 9, 1990 and from January 30, 1991 to April 18, 1991.

The team exchanged views with the officials concerned of the Government of the Republic of the Philippines and conducted a field survey in the South Central Palawan Area. After the team returned to Japan, further studies were made and the present report has been prepared.

We hope that this report will serve for the development of the project and contribute to the promotion of friendly relations between our two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

July,1991

Kensuke Yanagiya

President

Japan International Cooperation Agency

Gen-ichi Fukuhara

President

Metal Mining Agency of Japan

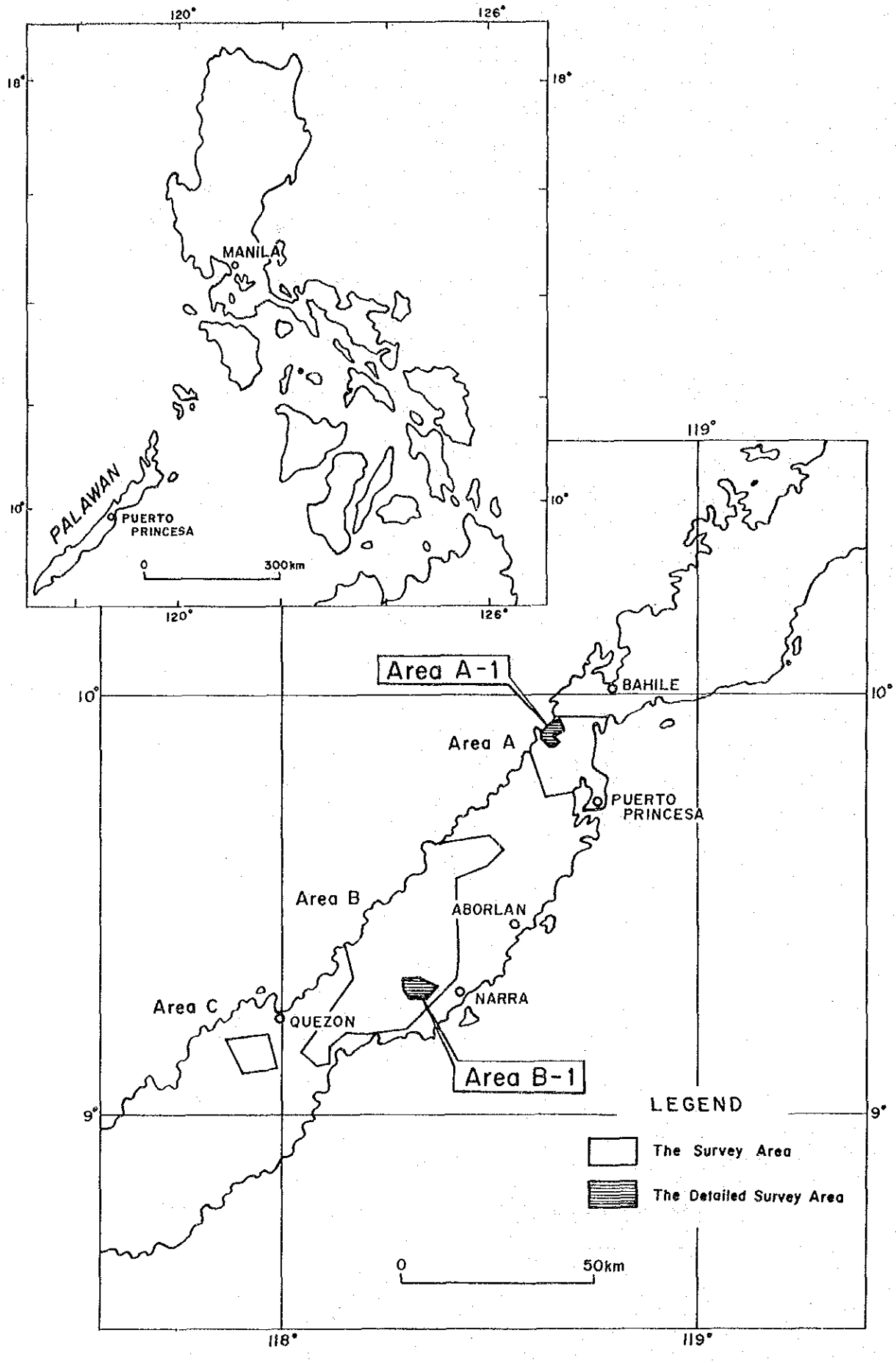

Fig. 1 Location map of the survey area

ABSTRACT

The survey was conducted as the Phase 1 of the cooperative mineral exploration project in the Palawan area, Philippines. The objective of this survey is to delineate the distribution of ore deposits by means of clarifying the geological setting of the area.

Palawan Island has been divided geologically into two areas, the Northern Palawan and the Southern Palawan, by the Sabang Fault cutting the central part of the island. Northern Palawan is underlain by Carboniferous and Permian sedimentary rocks and metamorphic rocks, while Southern Palawan is characterized mainly by an overthrust Palawan Ophiolite consisting of basalt, gabbro, and ultramafic rocks.

In this year's Phase 1 survey, geological and geochemical surveys were conducted in three areas, the A-area, B-area, and C-area in Southern Palawan. On the basis of the results of this survey, a further detailed survey was conducted in the area A-1 from the A-area and area B-1 from the B-area.

The A-area is underlain by the Mt. Beaufort Ultramafics consisting mainly of harzburgite, in which chrome and nickel mineral occurrences are contained. More than ten chromite mineral showings, and several laterite occurrences were identified in the west coast and Bacungan area. In the geochemical survey, at the first step, weight of heavy minerals obtained by panning a unit weight of soil was measured in sites to delineate promising areas for the chromite deposits. Seven elements (Ni, Cr, Fe, and Co as the group related to chromium, and Pt, Pd, and Au as the group related to precious metals) were analyzed. The result of the surveys leads to the delineation of three potential areas for the chromite deposits; the area to the north of Tagburos, the area from the north of Bacungan to the west coast, and the area from Malinao River to Tagminatay in the west coast.

Among them, the area from Malinao River to Tagminatay was picked up and named as area A-1 to conduct further detailed geological and geochemical surveys. This area is mainly underlain by harzburgite, in which dunite diapirs, containing chromite pods and disseminations, intruded in some places. The geological survey disclosed the pattern and distribution of the dunite intrusives and mineral occurrences. The principal chromite occurrences are in the San

Chromite area and Macasaet area in the southeastern part, the upper stream and lower stream areas of the Pananlagan River in the Central part, Tagkawayan area and Tagminatay area in the northern part. In the soil geochemical survey, the same seven elements as A-area were analyzed. The results show that the elements of the chrome group and precious metal group geochemically behave differently. The interpretation of the geochemical anomalies has revealed that two areas, the area containing the Pananlagan mineral showings and the area from the Tagkawayan mineral showings to Tagminatay, are of high potential for the chromite deposits.

The B-area is underlain by the Mt. Beaufort Ultramafics consisting mainly of harzburgite in the northern and central parts, and by the Sultan Peak Gabbro and Espina Basalt in the southern part. In the peridotites, dunite tectonite bodies are accompanied by chromite lenses, pods and disseminations. These mineral showings are in the vicinity of Berong, the nearby Moorsom Point, and in the surrounding area of Long Point --in the west coast; in the surrounding area of the Norsophil Mine, and in southwestern Malasgao River --in the east coast. The Norsophil Mine is presently in operation as a chromite mine. The dunite bodies in the basin of the Malinao River, west of Narra, are cumulate dunite generated by the differentiation of magma judging from the distribution and the existence of the transition zones. Chromite dissemination commonly exists in these dunite bodies. The EPMA studies show that these two types of dunites contain chromite of varying compositions. The chromium content of chromite from the cumulate dunite is lower than that in the tectonite dunite.

In the geochemical survey, at the first step, the weight of heavy minerals obtained by panning a unit weight of soil was measured in sites to delineate promising areas for chromite deposits as performed in the A-area. The interpretation of the assay results of the seven elements has revealed that the following five areas were promising for chromite occurrences; the upper stream area of Malasgao River, the surrounding area of Norsophil Mine, and the basin of Malinao River --in the east coast; the surrounding area of Long Point, and the Berong area --in the west coast.

Among these five areas, the basin of the Malinao River was selected and named as area B-1 to conduct further detailed geological and geochemical surveys. The area is underlain by

harzburgite, dunite, gabbro, and basalt. Chromite dissemination commonly occurs in the dunite bodies in the basin of the Malinao River and in the upper stream area of the Panacan River.

The soil geochemical survey assaying the seven elements has revealed that anomalies for chromium related elements overlapped in the northwestern portion of the B-1 area, which was accordingly judged as a promising area for chromite deposits.

The C-area is mainly underlain by harzburgite, which thrust over the gabbro and the basalt. Dunite bodies partly intruded the harzburgite. No mineralization occurs in the ultramafic rocks as well as in the basaltic rocks, which are distributed in a small area. In the geochemical survey, path-finder elements for copper such as Co, Pb, Zn, Au, As, Sb, and Hg were analyzed, because this area was judged as high potential area for Cyprus-type ore deposits from the existing data. However, no significant anomaly of these elements were detected, suggesting that the area was of less potential for these metals.

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PART I GENERAL REMARKS

Chapter 1 Introduction

1-1 Objective and progress of the survey

The RP-JAPAN Mineral Exploration Project has been conducted in the Republic of the Philippines since 1985 based on the Implementing Agreement between the Government of the Philippines through the Bureau of Mines and Geo-Sciences (BMG) and the Government of Japan through the Japan International Cooperation Agency (JICA), together with the Metal Mining Agency of Japan (MMAJ). The Implementing Agreement was signed on September 26, 1984, and the project was officially titled as the "Mineral Exploration- Mineral Deposits and Tectonics of Two Contrasting Geologic Environment".

In this RP-JAPAN project, the Province of Palawan, which administratively belongs to Region-IV, was divided into six areas for the convenience of survey.

The series of field surveys were conducted from January to February, 1986 in Palawan I (Taytay), Palawan II (Roxas), Palawan III (Puerto), and Palawan IV (Narra); and from February to March, 1987 in Palawan V (Busuanga) and Palawan VI (Quezon-Rio Tuba).

Prior to these surveys, a geological and geochemical survey program was conducted in 1985 by the United Nation's UNDP project in Central Palawan.

After evaluating the result of these surveys, a follow up semi-detailed geological and geochemical survey program was carried out from October to December, 1989 in three areas in Central Palawan; the Tinitian area in UNDP Project area, Central area in Palawan III (Puerto), and Victoria area in Palawan IV (Narra), as a part of the "Mineral Exploration - Mineral Deposits and Tectonics of Two Contrasting Geologic Environments in the Philippines".

Throughout 1989 - 1990, the investigation on nickel and chrome was conducted by the United Nations Revolving Fund for Natural Resources Exploration (UNRFNRE) in the area along the west coast of south-western Palawan and the portion north of Puerto Princesa.

The Cooperative Mineral Exploration Project in the South Central Palawan has been conducted based on the Implementing Arrangement between the Government of the Philippines through the Mines and Geosciences Bureau(MGB) and the Government of Japan through the

Japan International Cooperation Agency(JICA), together with the Metal Mining Agency of Japan(MMAJ). The Implementing Arrangement was signed on July 5, 1990 and the project was officially titled as "Geological Assessment of Chromite,Base Metals,Platinum and related precious Metal Occurrences in South Central Palawan and Northeastern Panay".

The objective of this survey is to delineate the type of mineralization present such as Ni, Cr, and other minerals to identify promising areas by clarifying the geological setting,and to recognize the mode of occurrence of the mineral deposits through geological and geochemical explorations.

This program consisting of geological and geochemical explorations was conducted in the above mentioned three areas from October to December, 1990, and an additional program, which was based on the results of the preceding program. The additional program was conducted from January to February, 1991 surveying in detail areas extracted from the preceding survey results, area A-1 from the A-area and area B-1 from the B-area.

1-2 Contents of the survey

Coverage and extent of the survey and sample targets for A, B, and C areas and detailed survey areas A-1 and B-1 are shown in Table 1 and 2.

Table 1 Contents of Field Survey

Name of Area		Contents (Geological & Geochemical Survey)			
		Area	Route Length	Test Pit	Number of Geochemical Samples
A-area		300 km²	117 km	—	Soil Samples : 1,040 pcs Semi-Quantitative Analysis of Chromite : 2,546 pcs
B-area		1,200 km²	441 km	—	Rock Samples : 210 pcs
C-area		100 km²	105 km	—	Soil Samples : 210 pcs Rock Samples : 44 pcs
Area A-1		37 km²	88 km	30 points	Soil Samples : 1,569 pcs Rock Samples : 84 pcs
Area B-1	a	19 km²	44 km	30 points	Soil Samples : 1,355 pcs
	b	15 km²	55 km		Rock Samples : 82 pcs

Table 2 Laboratory Examinations

Name of Area	Examination Items	Quantity
A-area and B-area	Preparation of thin section	60 pcs
	Preparation of polished thin section	15 pcs
	EPMA quantitative analysis	10 pcs
	Chemical analysis	
	1 Whole rock analysis (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, LOI)	60 pcs
	2 Geochemical analysis	
	soil sample (Pt, Pd, Au, Ni, Cr, Fe, Co)	1,040 pcs
	soil sample (Cu, Pb, Zn, Ag, As, Sb, Hg)	101 pcs
	Rock sample (Pt, Pd, Au, Ni, Cr, Fe, Co)	210 pcs
	3 Ore analysis (Cr, Fe, Al, Mg, Si)	10 pcs
	X-ray diffraction examination	50 pcs
C-area	Preparation of thin section	21 pcs
	Chemical analysis	
	1 Whole rock analysis (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, LOI)	21 pcs
	2 Geochemical analysis	
	soil sample (Cu, Pb, Zn, Au, Ag, As, Sb, Hg)	210 pcs
	heavy minaral sand (Au, Ag)	44 pcs
	X-ray diffraction examination	11 pcs

Table 3 Laboratory Examinations

Name of Area	Examination Items	Quantity
Area A-1	Preparation of thin section	53 pcs
	Preparation of polished thin section	18 pcs
	EPMA quantitative analysis	10 pcs
	Chemical analysis	
	1 Whole rock analysis (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, LOI)	32 pcs
	2 Geochemical analysis	
	soil sample (Pt, Pd, Au, Ni, Cr, Fe, Co)	1,569 pcs
	Rock sample (Pt, Pd, Au, Ni, Cr, Fe, Co)	84 pcs
Area B-1	Preparation of thin section	52 pcs
	Preparation of polished thin section	12 pcs
	EPMA quantitative analysis	10 pcs
	Chemical analysis	
	1 Whole rock analysis (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, LOI)	22 pcs
	2 Geochemical analysis	
	soil sample (Pt, Pd, Au, Ni, Cr, Fe, Co)	1,355 pcs
	Rock sample (Pt, Pd, Au, Ni, Cr, Fe, Co)	82 pcs

1-3 Members of survey team

(1) Survey Planning and Negotiation

JAPAN	PHILIPPINES
Yoichi Yamaguchi (MMAJ)	Joel D. Muyco (MGB, Director)
Norio Nakano (Ministry of Foreign Affairs)	Salvador Martin (MGB)
Hajime Ikeda (JICA)	Edwin G. Domingo (MGB)
Koichi Koyama (MMAJ)	Romeo L. Almeda (MGB)
Yoshitaka Hosoi (MMAJ)	Noel V. Ferrer (MGB)
Yuji Kajitani (Manila Office)	
Kenzo Masuda (MMAJ)	

(2) Site Survey Team

1) A, B, and C areas

	JAPAN	PHILIPPINES
* Team Leader, Coordinator	Akio Shida	Romeo L. Almeda
* A-area	Hideaki Nabeshima	Noel V. Ferrer
	Junichi Maeno	Benjamin Cadawan Jr.
		Joselito Velasquez
* B-area (Eastern Part)	Yasunori Ito	Rogel Santos
	Minoru Nonoguchi	Oliver Relova
		Noel Ariel Cruz
* B-area (Western Part) and C-area	Tsuyoshi Yamada	Eugenio Esguera
	Fumitaka Yoshimura	Ronaldo Miranda
	Shigeyuki Yamasawa	Reinhold Salas
		Emmanuel Cruz

2) Detailed Survey Area A-1 and B-1

	JAPAN	PHILIPPINES
* Team Leader, Coordinator	Akio Shida	Romeo L. Almeda

* Detailed Survey Area A-1	Itoshi Kono	Noel L. Ferrer
	Makoto Miyoshi	Joselito Velasquez
		Emmanuel Santos
		Oliver Relova
* Detailed Survey Area B-1	Yasunori Ito	Antonio N. Apostol Jr.
		Rogel Santos
		Ronaldo Miranda
		Reinhold Salas

Survey Period

* A, B, and C areas

October 21, 1990 to December 9, 1990 (50 days)

* Detailed survey areas A-1 and B-1

January 30, 1991 to April 18, 1991 (79 days)

Chapter 2 Existing Geological Information of Survey Area

2-1 Past exploration activity

The survey area occupies the south central portion of Palawan Island.

The stratigraphy and geological structure of Palawan Island are summarized in "Geology and Mineral Resources of the Philippines, volume One, Geology" (Bureau of Mines and Geo-Sciences, 1982) which has integrated almost all the previous geological papers on the Philippines. Volume Two (1986) of this series, which deals with mineral resources, describes nickel, chrome, and other mineral deposits of Palawan Island.

"UNDP Technical Report No.6, Geology of Palawan" (UNDP, 1985) describes the stratigraphy, geological structure, and mineral deposits of central Palawan Island. This report also describes the results of the geochemical survey done in the same time. The results of the UNDP Project are also presented in "Geologic Map of the Bacungan Quadrangle (BMG-UNDP, 1986).

Geological and geochemical surveys were conducted in Palawan III (Puerto) and Palawan IV (Narra), encompassing the B-area, through the RP-JAPAN Project (1986). The stratigraphy, geological structure, mineral occurrences, and geochemical anomalies recognized during these surveys are embodied in "Report on Mineral Exploration" (JICA-MMAJ, 1987). "Report on the Mineral Exploration" (JICA-MMAJ, 1988) describes the results of the survey in Palawan VI area (Quezon-Rio Tuba), which includes the C-area.

Similar survey was conducted in the Victoria area where the B-area is located. "Report on the Mineral Exploration" (JICA-MMAJ, 1989) describes the results of this survey.

UNRFNRE conducted a more detailed geological and geochemical survey along the west coast of the Victoria area where the B-area overlaps. "Chromite Exploration in the Philippines" (UNRFNRE, 1990) describes the results of the survey.

2-2 General geology

The Palawan Group of Islands which includes the Calamian Islands has been divided into two terranes, the Northern and Southern Palawan. The Northern Palawan is dominantly underlain by pre-Cretaceous sedimentary rocks and Paleogene acid plutons. Whereas the Southern Palawan is characterized by the dominance of basic and ultramafic rocks.

Although opinions are diverse concerning the boundary between Northern Palawan and Southern Palawan, the Sabang Fault situated on the east of Ulugan Bay will be regarded as the boundary in this report.

The Palawan Ophiolite which is mainly distributed in the Southern Palawan enclosed in its northern part the A and B-survey areas which is situated in the southwest of the Sabang Fault. The Palawan Ophiolite is composed of ultramafic rocks of the Mt. Beaufort Ultramafics, and the basic rock of the Stavely Range Gabbro, the Sultan Peak Gabbro, and the Espina Basalt. The Mt. Beaufort Ultramafics is thrust over the Inagauan Metamorphics which could have been formed from a dynamic metamorphism due to the overthrust on the underlying the Panas Formation.

The Tagburos Siltstones and the Sulu Sea Mine Formation are distributed in the north as post ophiolite sequence.

Younger sedimentary formations such as the Isugod Formation, the Alfonso XIII Formation, and the Iwahig Formation, are distributed in lowland areas flanking the ophiolite.

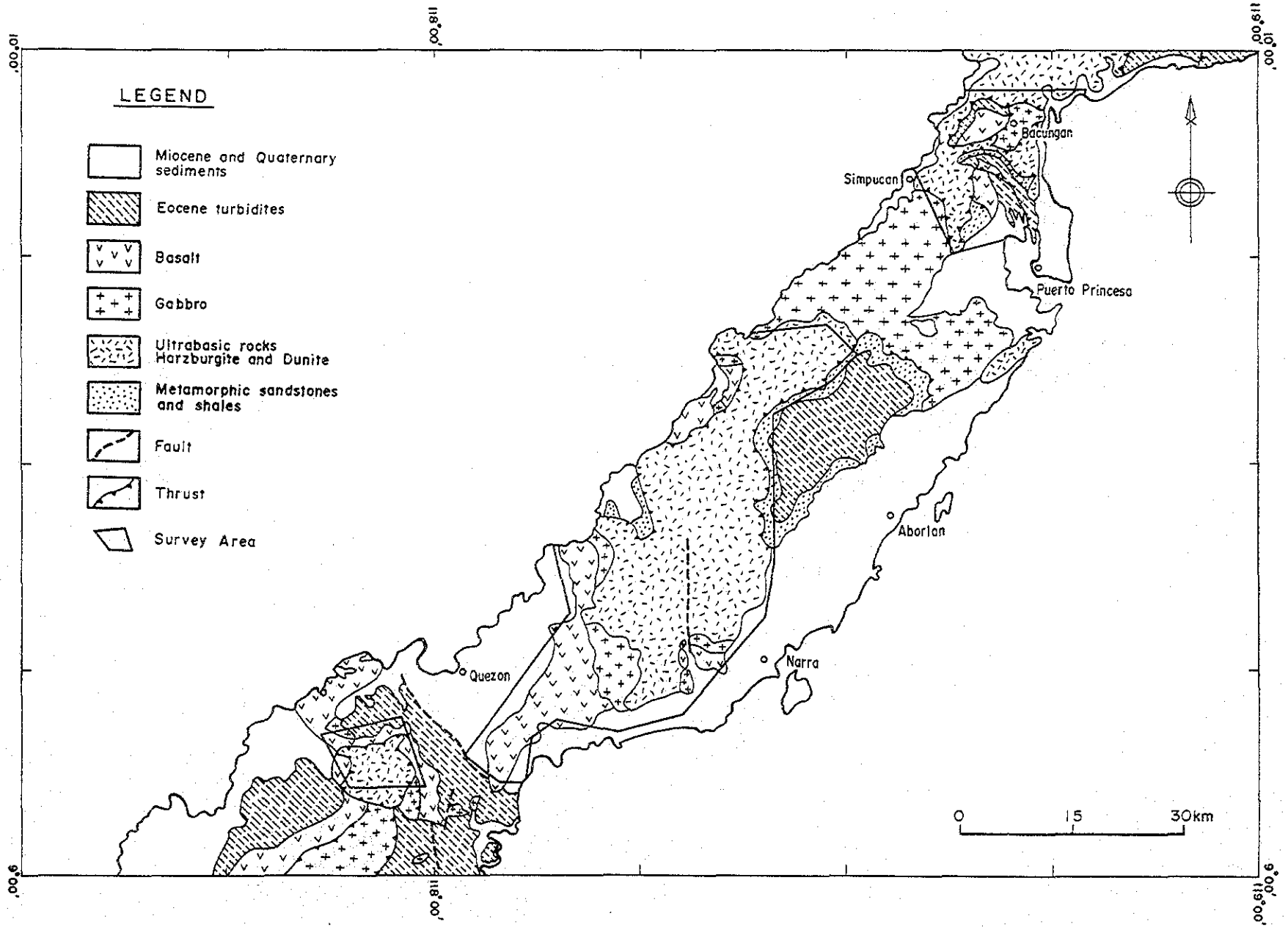


Fig. 2 Simplified geologic map of South Central Palawan

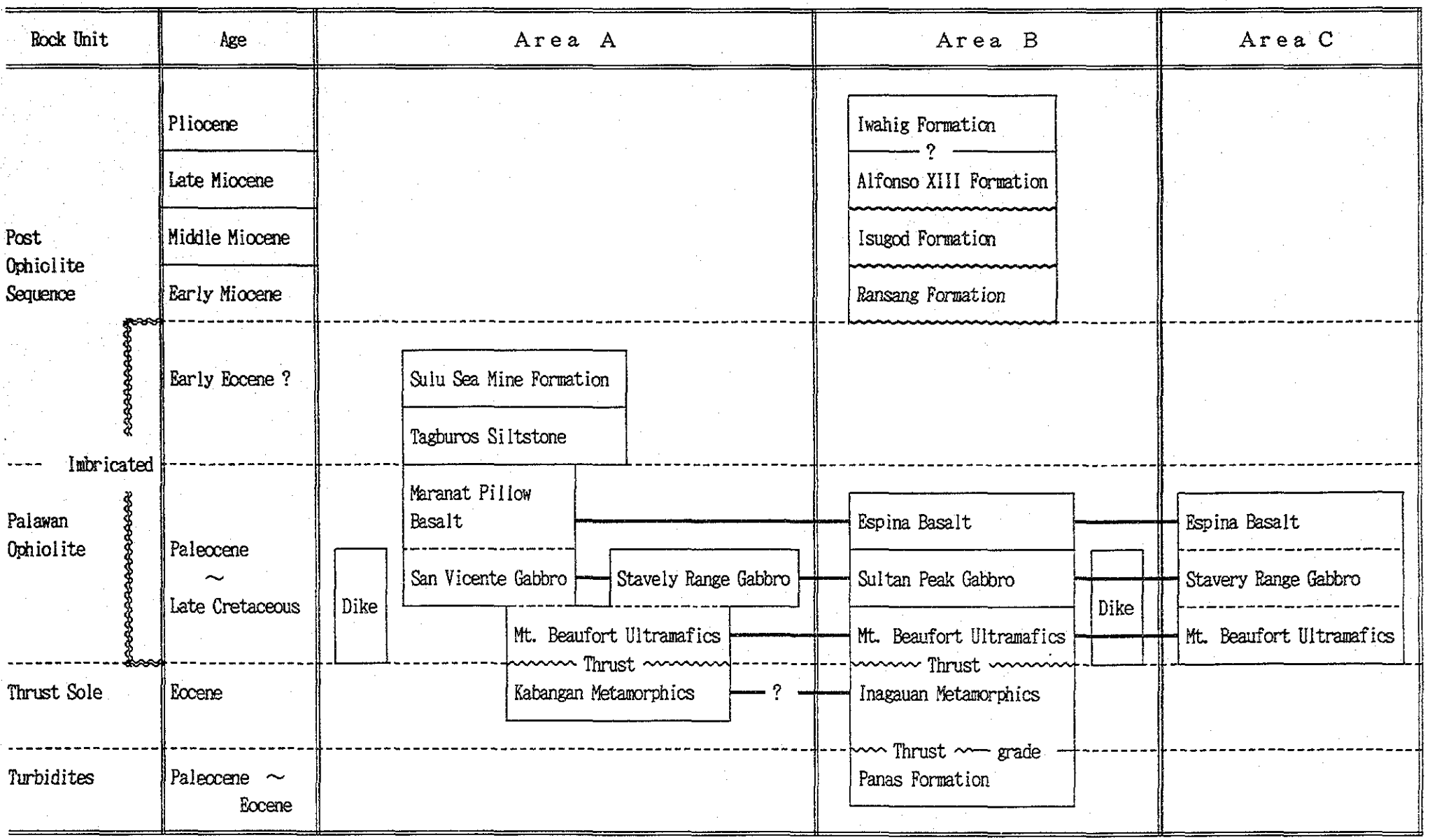


Fig. 3 Columnar section of the survey area

Chapter 3 Summary of the Survey Results

This year's programs have revealed many facts and data regarding geology, mineral occurrences, geochemical characteristics of the survey area. The summaries of the survey results for each area are as follows.

3-1 A-area and detailed survey area A-1

The A-area is underlain by the Palawan Ophiolite, Kabangan Metamorphics (UNDP, 1985), Tagburos Siltstone, and Sulu Sea Mine Formation.

The Palawan Ophiolite covers a large part of the area, and the suite is composed of the Mt. Beaufort Ultramafics, the San Vicente Gabbro, the Stavely Range Gabbro, and the Maranat Pillow Basalt (UNDP, 1985) from the bottom. These formations have been sheared and imbricated due to thrust faulting during the ophiolite emplacement. Accordingly the geological structure of the area is very complicated.

Mineral occurrences in the area are of chrome and nickel, which are hosted by the Mt. Beaufort Ultramafics.

The main chromite occurrences were found through the detailed survey of area A-1, which was selected based on the results of the initial geological and geochemical survey in A-area. Area A-1 is mainly underlain by the harzburgite of the Mt. Beaufort Ultramafics, and most of the chrome occurrences are in dunite tectonite, which intruded as diapir-like bodies into harzburgite. These are in the San Chromite area, Macasaet area, Upper Pananlagan, Lower Pananlagan, Tagkawayan, and Tagminatay. The observed occurrences are small in scale, and as lenses with several meters width, as pods, or as disseminated seams.

The survey results have revealed several nickel occurrences in the Bacungan area in the north of A-area and in the basin of the Tagkawayan River in area A-1. The thickness of the residual laterite layers in the Bacungan area is very thick, on the other hand the laterites in the basin of the Tagkawayan River is thin.

In the geochemical survey in the A-area, the in-situ panning method was applied at the initial

stage to investigate heavy mineral ratio in soil, which could indicate potential areas. This survey yielded several heavy mineral concentrate anomaly zones in the area north of Tagburos, the surrounding area of Bacungan, the northwestern area, and the west coast area. The soil geochemical survey results, assaying seven elements, Pt, Pd, Au, Ni, Cr, Fe, and Co, indicated several overlapping geochemical anomaly zones in the area north of the Tagburos, area north to northwest of Bacungan, basin of the Malinao River, and area along the west coast. These elements are classified into two categories due to their chemical behavior, a group consisting of Ni, Cr, Fe, and Co, relating to chromium, and a group consisting of Pt, Pd, and Au, relating to precious metals. The integrated interpretation map, Fig. 4, shows overlapping areas of the geochemical anomaly zones and the distribution areas of ultramafics in the A-area. This map indicates three potential areas for chromium, the area north of Tagburos, the area from the north of Bacungan to the west coast, and the area from the Malinao River to Tagminatay in the west coast.

The results of the soil geochemical survey has led to the selection of detailed survey area A-1, the area from the Malinao River to Tagminatay. The results of this detailed survey clarified that the geochemical behaviors of those two groups are different, a group consisting of Ni, Cr, Fe, and Co, relating to chromium, and a group consisting of Pt, Pd, and Au, relating to precious metals. The integrated interpretation map, Fig. 5, shows overlapping areas of the geochemical anomaly zones and the distribution areas of dunite. This map indicates two potential areas for chrome, the area containing the Pananlagan mineral showings and area from the Tagkawayan mineral showings to the Tagminatay area.

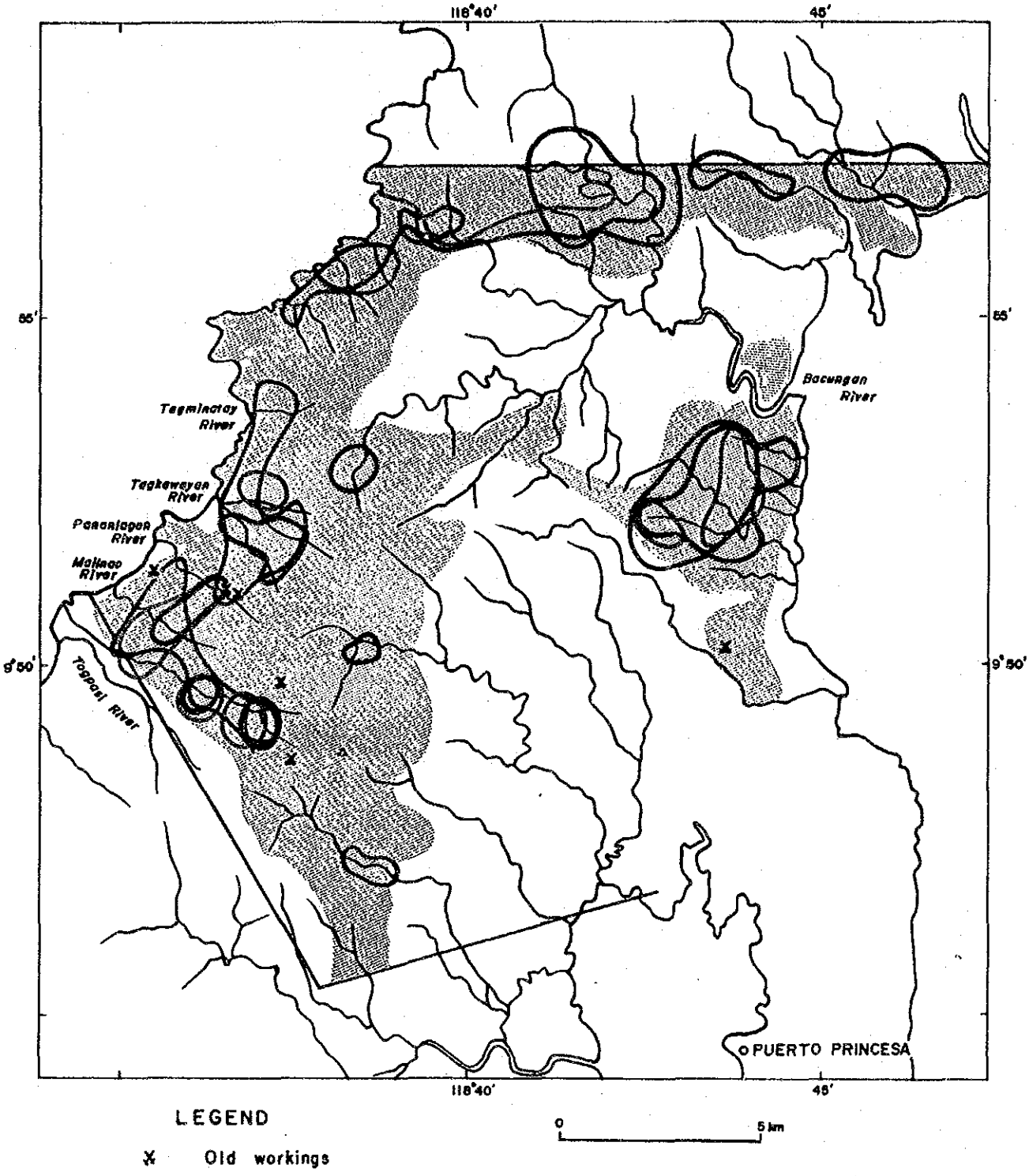


Fig. 4 Interpretation map of the area A

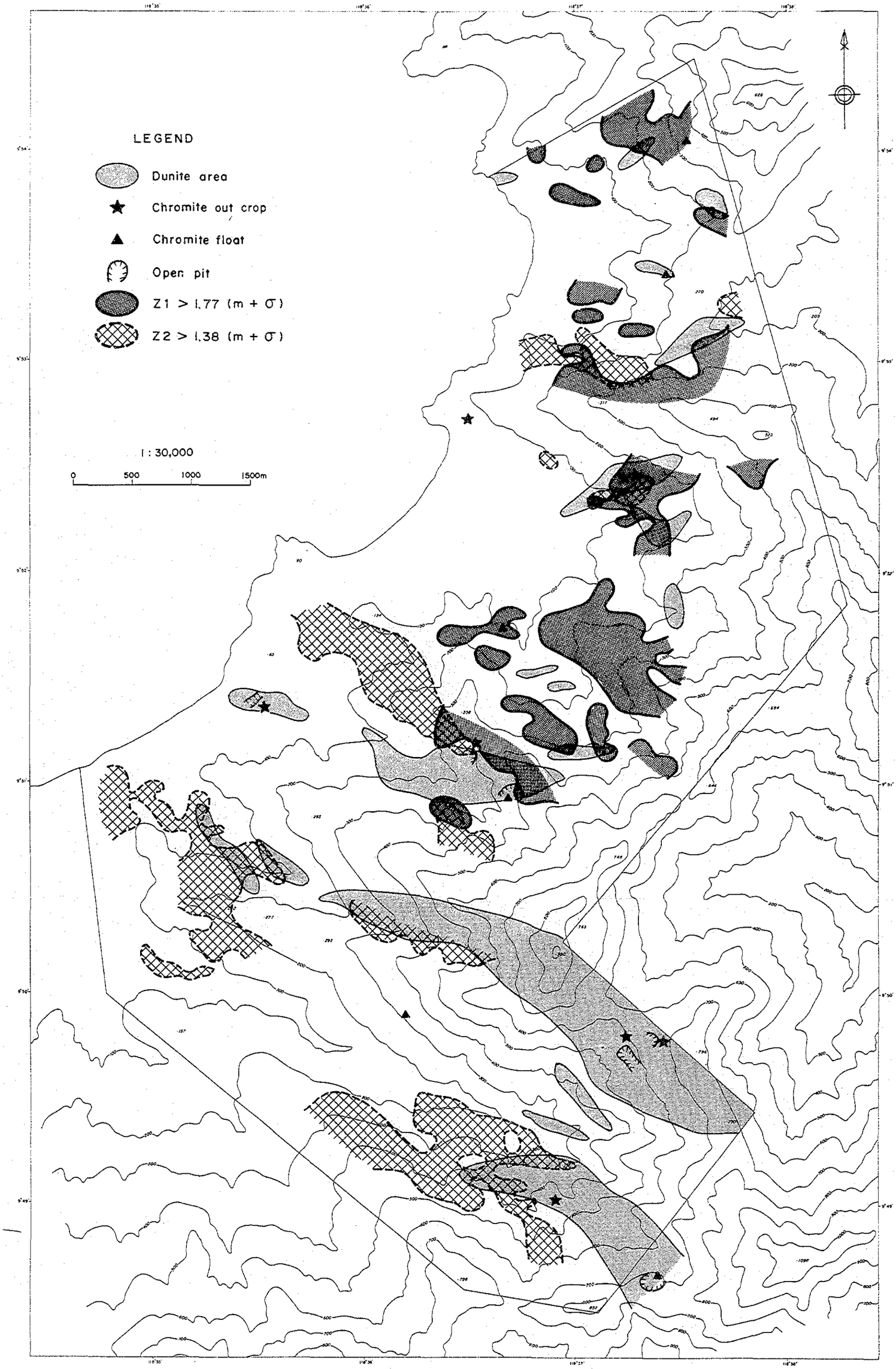


Fig. 5 Interpretation map of the area A-1

3-2 B-area and detailed survey area B-1

The Palawan Ophiolite is observed to be thrust over the Panas Formation in the B-area. The Palawan Ophiolite is composed of the Mt. Beaufort Ultramafics, the Sultan Peak Gabbro, and the Espina Basalt. The Inagauan Metamorphics, which probably were formed during the thrust movement, lies between the Panas Formation and the Palawan Ophiolite.

Mineral showings in the area are of chrome and nickel, and they are limited in the Mt. Beaufort Ultramafics. The Cyprus type sulphide mineralization was expected in the basalt of the B-area, but no indication has been found in this survey.

Two types of chrome occurrences exist in the area, one is associated with cumulate dunite in the layered gabbro and the other is associated with dunite tectonite in the harzburgite. The former is typical in the occurrences in the basin of the Malinao River, west of Narra, and the latter is typical in the occurrences in the Norsophil Mine and Berong area in the west coast. The successive detailed survey in area B-1, especially for the mineral showings in the basin of the Malinao River, has revealed that dunite bodies with disseminated chromite are distributed in the northwestern part of the B-1 area.

Regarding nickel occurrences, no new significant indication has been found, except only wherein about 1% Ni contents were obtained from soil in several test pits in the central portion of the area B-1.

In the geochemical survey in the B-area, volume ratios of heavy minerals in soils were investigated by panning a known volume of soil in sites as well as soil sampling for geochemical analyses were conducted in order to extract the promising areas. The survey results have revealed the following heavy mineral concentrate anomaly areas; near the Norsophil Mine, the upper stream area of the Malasgao River, the basin of the Malinao River, the surrounding area of Long Point, and Berong area. Seven elements assayed in the soil geochemical survey are classified into two groups judging from their chemical behavior. One is a group of Ni, Cr, Fe, and Co, related to chromium, and the other is a group of Pt, Pd, and Au related to precious metals. Anomalies of the group related to chromium overlap in the anomaly zones on the heavy minerals. The

integrated interpretation map in Fig. 6 shows the distribution areas of the ultramafics and the anomaly zones of all geochemical surveys. The map indicates five potential areas for mineralization; the upper stream area of the Malasgao River, the surrounding area of the Norsophil Mine, and the upper stream area of the Malinao River --in the east coast, and the surrounding area of Long Point, and Berong area --in the west coast.

The results of the soil geochemical survey have led to the selection of the detailed survey area B-1. The successive geochemical survey results have revealed that the two groups of elements, one consisting of Ni, Cr, Fe, and Co, related to chrome, and the other consisting of Pt, Pd, and Au, related to precious metals, and have different geochemical behavior. The former group is concentrated in transition zones between gabbro to peridotite and along areas covered by the peridotite. Whereas the latter is concentrated in areas covered by basalt in the upper tributary of the Malinao River and in the southern most part of area B-1. The integrated interpretation map, Fig. 7, shows all the confirmed mineral occurrences, the distribution areas of the dunite, and all geochemical anomalies detected in area B-1. The map indicates that the northwestern area is a potential area for nickel.

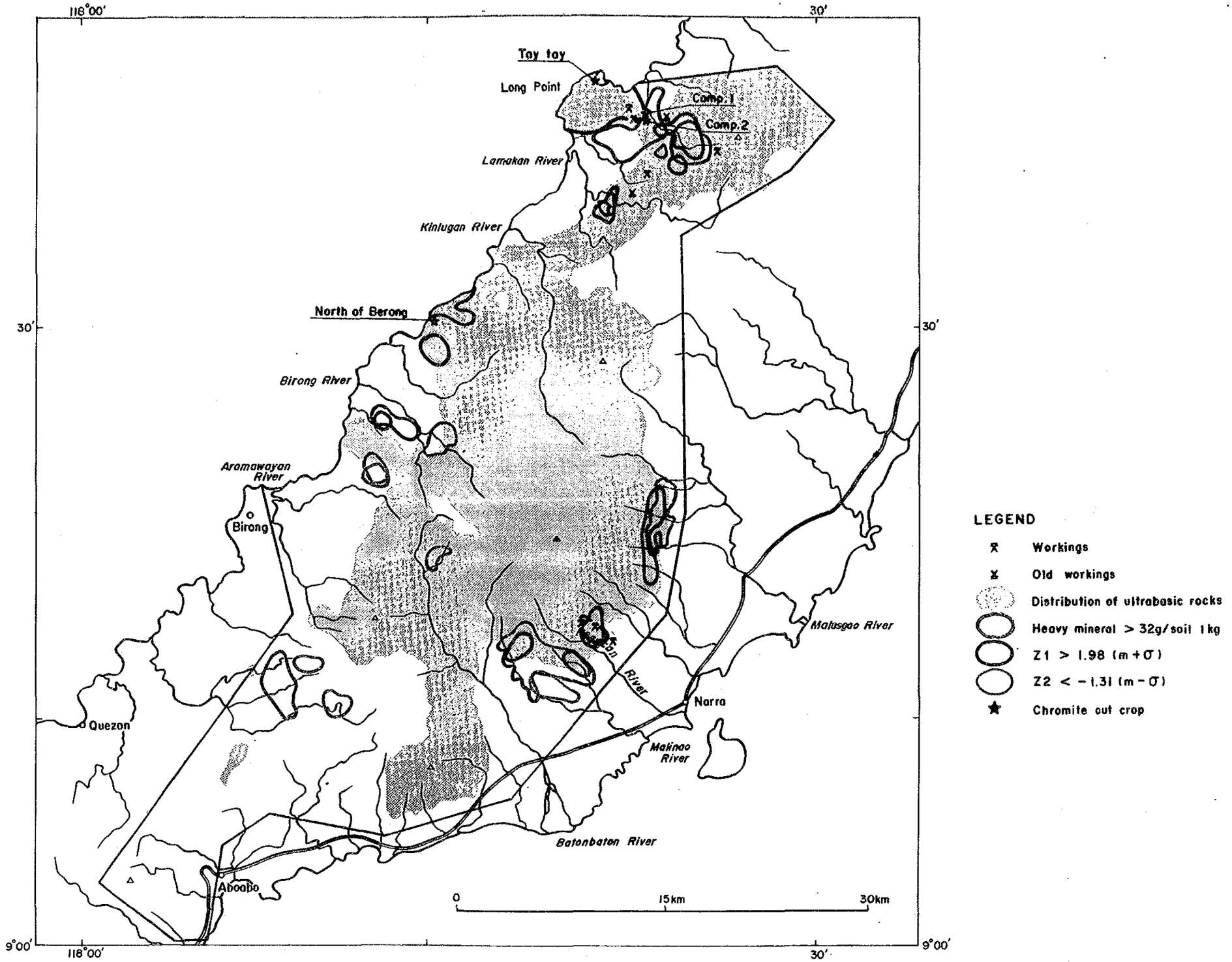


Fig. 6 Interpretation map of the area B

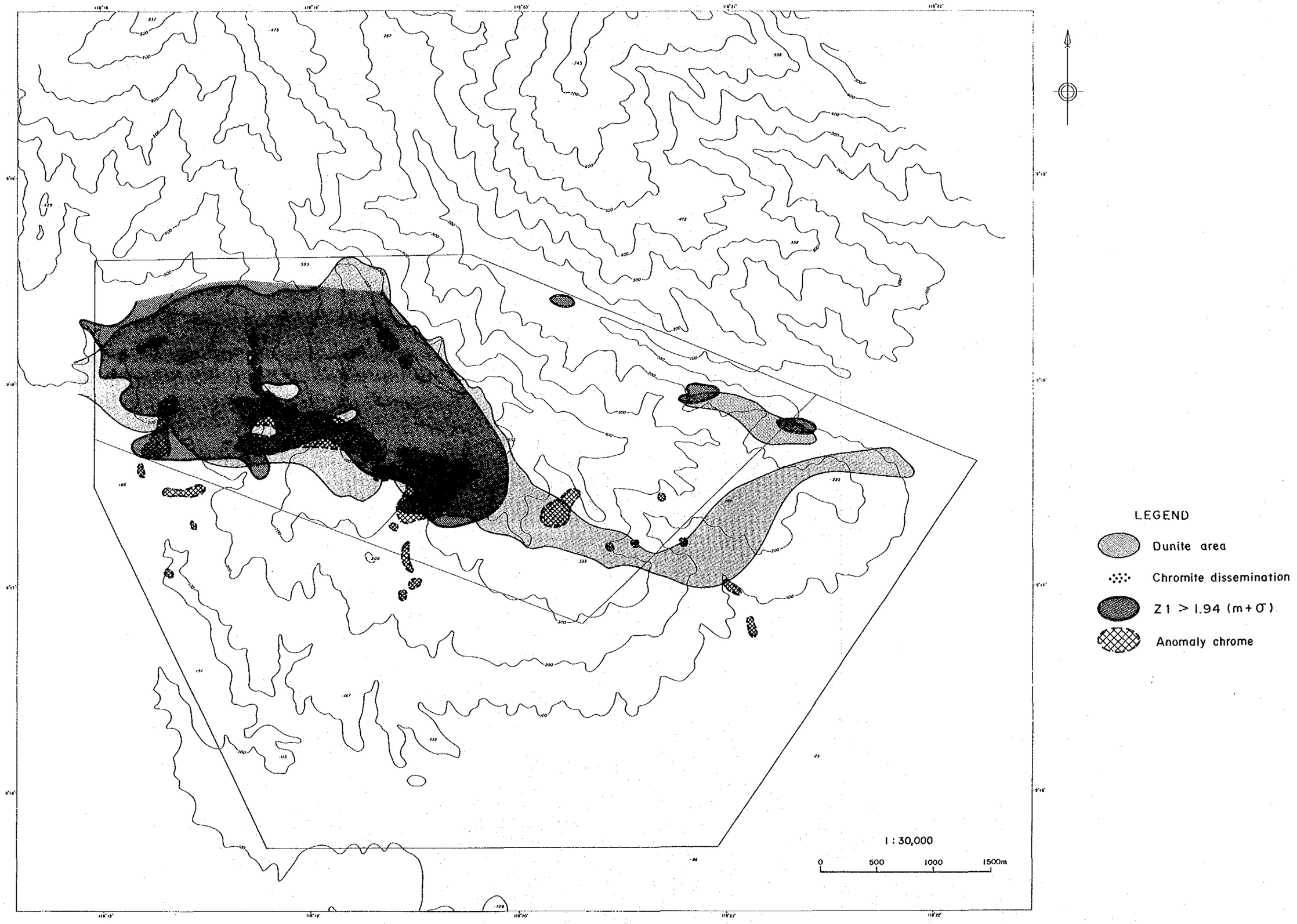


Fig. 7 Interpretation map of the area B-1

3-3 C-area

The C-area is also underlain by the Palawan Ophiolite. The Palawan Ophiolite is composed of the Mt. Beaufort Ultramafics, the Stavely Range Gabbro, and the Espina Basalt from the bottom. Almost all part of this area is underlain by the harzburgite of the Mt. Beaufort Ultramafics, but small areas towards lowland are underlain by gabbro and basalt.

Existing data indicates that the C-area is largely underlain by basaltic rocks, which suggests some potential for the Cyprus type sulphide ores. The survey results have revealed, however, very limited distribution areas of the basaltic rocks and no sulphide indication as well. Chrome indication in the ultramafics is not of geochemical significance.

In this survey, elements relating to copper ore deposits were assayed, because the stream sediment geochemical anomaly relating to sulphide ores was recorded in an old report. The results of the soil geochemical survey have revealed relatively high anomalous zones for each assayed element. However no relation between those anomalies is recognized, and the values are close to the average contents in the earth crust. The geochemical survey of panned stream sediments indicated that gold and silver contents of the samples were almost less than the detection limit. The highest value assayed for gold is 6 ppb.

Chapter 4 Conclusions and Recommendations

4-1 Conclusions

The conclusions of this year's geological and geochemical survey program are as follows.

A-area and area A-1

(1) The A-area is underlain by the Palawan Ophiolite, Kabangan Metamorphics, Tagburos Siltstone, and Sulu Sea Mine Formation.

(2) Mineral occurrences observed in the A-area are of chrome and nickel, and both are restricted in the Mt. Beaufort Ultramafics.

(3) Most of the chromite occurrences are in dunite-tectonite intruded into harzburgite. Principal chromite occurrences have been found by the detailed survey in area A-1, which was selected based on the results of the initial geological and geochemical survey in the A-area. The mineral showings are distributed in the San Chromite area, Macasaet area, Upper Pananlagan, Lower Pananlagan, Tagkawayan, and Tagminatay.

(4) Laterite is distributed in Bacungan, and has a potential for nickel resources.

(5) Evaluation of volume ratios of heavy minerals obtained by panning of soil samples has revealed the following high concentration areas of heavy minerals; the area north of Tagburos, the surrounding area of Bacungan, the northwestern area, and the area along the west coast.

(6) The results of the soil geochemical survey for seven elements, Pt, Pd, Au, Ni, Cr, Fe, and Co, have revealed following the anomalous areas; the area north of Tagburos, the area north to northwest of Bacungan, and the area from the Malinao River to Tagminatay along the west coast.

(7) The results of the above mentioned surveys lead to the selection of following potential areas in the A-area; the area north of Tagburos, the area from the north of Bacungan to the west coast, the area from the Malinao River to Tagminatay.

(8) The detailed survey area A-1, the area from the Malinao River to Tagminatay, was selected from three geochemical anomaly areas which were found by the initial geochemical survey in the A-area. The results of the detailed geological survey clarified occurrences of dunite bodies and

mineral showings.

(9) The results of the detailed geochemical survey in area A-1 lead to the selection of following potential areas for chrome ores; area containing the Pananlagan mineral showings, area from the Tagkawayan mineral showings to the Tagminatay area.

B-area and area B-1

(1) The B-area is underlain by the Palawan Ophiolite, Inagauan Metamorphics, and Panas Formation.

(2) Mineral occurrences observed in the B-area are of chrome and nickel, and they are restricted in the Mt. Beaufort Ultramafics.

(3) Two kinds of chrome occurrences exist in the area. One is associated with cumulate dunite close to layered gabbro, and the other is associated with dunite tectonite in harzburgite. The former is typical in the mineral showings in the basin of the Malinao River, and the latter is typical in the mineral showings within the Norsophil Mine and in the Berong area in the west coast.

(4) The results of interpretation of the chromite components obtained by EPMA analysis have revealed that the chrome grade of the chromite from the transitional zone to the cumulate dunite is lower than those from the dunite tectonite.

(5) Evaluation of volume ratios of heavy minerals obtained by panning from soil samples has revealed the following high concentration areas of heavy minerals; the area within the Norsophil Mine, the upper stream area of the Malasgao River, the basin of the Malinao River, the surrounding area of Long Point, and Berong area.

(6) The results of the soil geochemical survey for seven elements, Pt, Pd, Au, Ni, Cr, Fe, and Co, have revealed that geochemical anomalies are overlapping in the same areas of the heavy mineral anomalies.

(7) The results of the above mentioned surveys lead the selection of following five potential areas in the B-area; the upper stream area of the Malasgao river, the area within the Norsophil Mine, and the upper stream area of the Malinao River, --in the east coast; the surrounding area of

the Long Point, and Berong area, --in the west coast.

(8) The detailed survey area B-1, the upper stream area of the Malinao River, was selected from geochemical anomaly areas which were found by the initial geochemical survey in the B-area. The results of the detailed geological survey revealed the existence of the transitional zones of gabbro and peridotite, and clarified mineral occurrences in dunite bodies.

(9) The results of the detailed geochemical survey in area B-1 lead the selection of the northwestern portion of area B-1 as a promising area for chrome ores.

C-area

(1) Harzburgite is thrust over the Espina Basalt and the Sultan Peak Gabbro in the C-area.

(2) Potential for Cyprus type sulphide ores was previously expected in this area. The survey results, however, indicate that the distribution area of basaltic rocks is small and no mineral indication exists.

(3) No promising area was detected from the geochemical survey.

4-2 Recommendations for second year's survey

The results of this year's survey show that the geochemical anomalies in the area north of Tagburos and the area from the north of Bacungan to the west coast in the A-area, and the upper stream area of the Malasgao River in the east coast in the B-area are favorable for further exploration activities for chrome ores, besides areas A-1 and B-1 where were surveyed this year. Accordingly, It is recommendable to conduct further detailed surveys in those areas to find mineral showings.

The Pananlagan mineral showings and the surrounding area of the Tagkawayan mineral showings in detailed survey area A-1 are significant geochemical anomaly zones, and high potential areas for new ore deposits. Also the geochemical anomaly area in the northwestern portion of the area B-1 is in the chromite disseminated mineralized zone, and a promising area for chromite ores. It is recommendable to conduct an additional pit survey to find new ore bodies in these three areas.

PART II REGIONAL DISCUSSION

Chapter 1 A-area and Detailed Survey area A-1

1-1 Location and transportation

Palawan Island is situated on the Southwestern end of the Philippine Archipelago. It faces the Sulu Sea to the east and the South China Sea to the west. The survey area is situated in the south western part of the island, stretching from the east coast to the west coast, between the latitude of 9°45'N and 9°57'N. The detailed survey area A-1 is situated in the southwestern portion of the A-area, west side of the backbone mountains, from Simpucan to the south of Bluff Point. Puerto Princes, the capital city of the Province of Palawan, is situated to the south of the survey area, on the east coast.

There are one or two daily flights and one or two weekly ferries services from Manila to Puerto Princesa. It takes approximately one hour by plane and 72 hours by ferry.

There is an unpaved road running from Puerto Princesa to the east coast of the survey area. There is also an unpaved road running from Bacungan to Nagtabon Beach on the west coast. But on this road, there are steep slopes in bad conditions, thus making it difficult to drive except for jeeps. There is also a road which runs down to the south from Iwahig (to the south of Puerto Princesa) to Simpucan (the southern edge of the survey area) through Napsan (on the west coast). The road is badly in need of reparation, and further more, there is a need to cross several large rivers like Iwahig River, thus making it sometimes difficult to cross during the rainy season.

There are no roads along the west coast from Nagtabon Beach (northern edge of the survey area) to Simpucan through Bluff Point, so all traveling must be done on foot or by using bancha boats.

1-2 Topology and drainage

The Beaufort Range nearby the west coast is running parallel to the shore line, which divides the survey area into two, the east and west. In this range, there are peaks, Thumb Peak (1,269 km, outside of the southwestern edge of the survey area) and Mt. Beaufort (1,098m, in the south-

central part of survey area).

In the west part, the distance from the coast to the range is approximately 7 km nearby the basin of the Malinao River, but in other areas it is only 2 to 4 km away. It is very steep around there. The waters run northwestward into the South China Sea.

The east part is divided into two parts; the north that mainly consists of hills that are 200 to 400 m high, and the south that is centered on Mt. Beaufort and has steep mountains.

The northern part of the east part is the basin of the Bacungan River, the largest one in the area, rivers gather water from the north, west, and south, and run off eastward into the Honda Bay. The other rivers (such as the Tagburos River) flow in the same way to the east and into the Honda Bay.

In the southern part of the east part, the rivers (such as the Irawan River) run out on the southeastern slope and the north of Mt. Beaufort, and flow southeastward into Puerto Princesa Bay.

1-3 Climate and vegetation

This survey area belongs to the tropics, and the climate season is divided into the wet season and the dry season. Generally the dry season is from January to May, and the wet season is from June to December. The average rainfall is about 2,700 mm per year, relatively little as of tropical.

The vegetation of this area is largely affected by the topographic environment. The low weeds that are several tens centimeters high, grow in the lowlands along the east coast. Coral reefs are seen along the shoreline.

There are weeds and shrubs growing on in the lowlands and hills in the northern area on the east side. Along the river, bamboo is seen growing in large groups. Along small streams and rivers, rice fields and farms are often cultivated.

On the west side low shrubs and virgin forests are the vegetation seen there.

The mountains are commonly covered with virgin forests. It mainly consists of latifoliate trees, and needle-leaf trees are seen only in the areas of high altitudes.

1-4 Survey method

1) Geological Survey

(1) A-area

The survey in the A-area was done using topological maps on the scale of 1:10,000, which were enlarged from its original 1:50,000. Most of survey routes were set up along streams. The length of the survey route lines is 100 km in total. The results were recorded on the enlarged 1:10,000 route maps. Samples were taken for laboratory studies and geochemical investigations.

Surveys in the eastern area were mainly conducted from the basecamp set up in Puerto Princesa. But surveys for hard access areas were conducted from mobile camps. Surveys in the western area were conducted from a subcamp in Nagtabon Beach, using bancha boats from there.

(2) Detailed Survey Area A-1

The survey for detailed survey area A-1 was conducted using maps on the scale of 1:10,000, which were enlarged from its original 1:50,000 scale maps. Survey routes were set up for main stream lines and ridges. On each survey route, simple topographic surveys using a compass and tape were conducted. The length of the route surveyed is 80 km in total. Results were recorded on the route maps on a scale of 1:5,000, and then transcribed to 1:10,000 scale map.

2) Pit Survey

Pit surveys were conducted in some important places, where mineral occurrences crop out.

Thirty-four test pits were dug in detailed survey area A-1 and 11 pits in the north of Bacungan. In the area A-1, 13 pits were dug in the laterite zone, the rest of pits were dug to examine the extension of chromite occurrences. The pits in the north of Bacungan were to confirm the existence of nickel occurrences.

The pits are approximately 1m x 1m in size, 1.2 to 3.0m deep. But the pit in the north of Bacungan is 5m deep. They were dug by hands using shovels, iron staffs, ropes, and pulleys.

Soil profiles of the pits were sketched on the scale of 1:50. Samples were taken from each soil horizons or every one meter. The sketches and the result of chemical analyses of the pits are shown in Appendix 5.

1-5 Geology

1-5-1 Outline of geology

1) A-area

The A-area is underlain by the Palawan Ophiolite, the Kabangan Metamorphics, the Tagburos Siltstone, and the Sulu Sea Mine Formation.

The Palawan Ophiolite is extensively distributed in this survey area, and is composed of the Mt. Beaufort Ultramafics, the San Vicente Gabbro, the Stavely Range Gabbro, and the Maranat Pillow Basalt. They were cut by several thrust faults during the emplacement of the ophiolite, and imbricated each other. The geological structure of the area is therefore very complicated, and the formations are situated upside-down in many places.

The Kabangan Metamorphics are in contact with the bottom of the Mt. Beaufort Ultramafics. The Kabangan Metamorphics is restricted in distribution, and possibly resulted from the dynamic metamorphism at the ophiolite sole.

In the A-area, two large scale windows, the Bacungan Window and the Iratag Window, exist. They resulted from the erosion of the Mt. Beaufort Ultramafics thrust over as a nappe. In these windows, the Maranat Pillow Basalt which is the uppermost part of the ophiolite, Tagburos Siltstone, and Sulu Sea Mine Formation are distributed. They are conformably overlie each other, and are referred to the Bacungan River Group (UNDP, 1985). The Tagburos Siltstone and Sulu Sea Mine Formation are probably deposited during the ophiolite thrust movement on the ocean floor and fore arc basin.

2) Detailed Survey Area A-1

Detailed survey area A-1 is situated along the west coast of the A-area, and is largely underlain by the Stavely Range Gabbro and the Mt. Beaufort Ultramafics.

The Stavely Range Gabbro is distributed in the southern edge and western part of the survey area, and assumably is thrust fault contact with the Mt. Beaufort Ultramafics. Banded structure is well observed in the gabbro. The Gabbro mass consists of gabbro, olivine gabbro and troctolite.

The Mt. Beaufort Ultramafics is dominantly distributed in this area, and consists mainly of

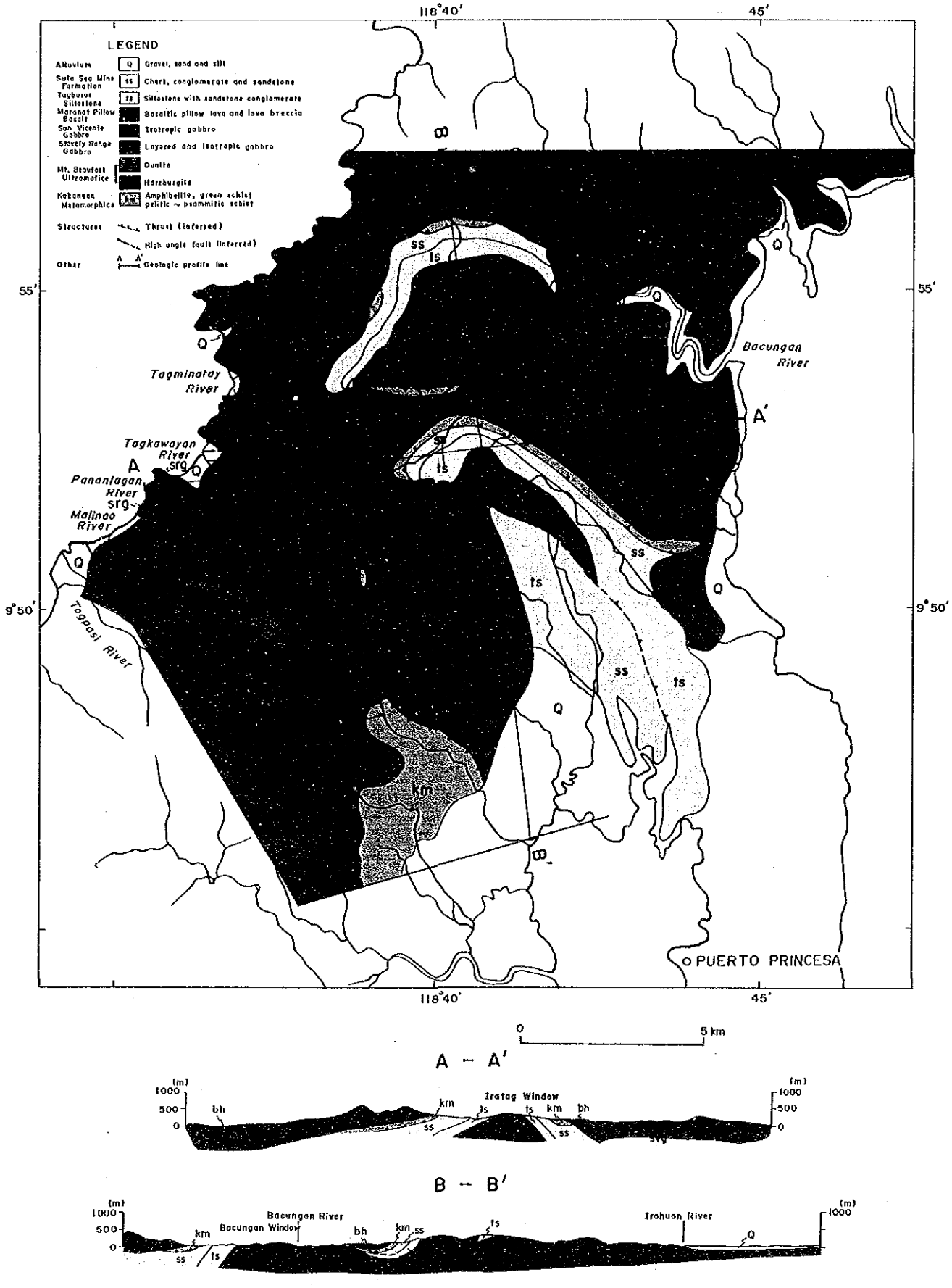


Fig. 8 Geologic map and profile in area A

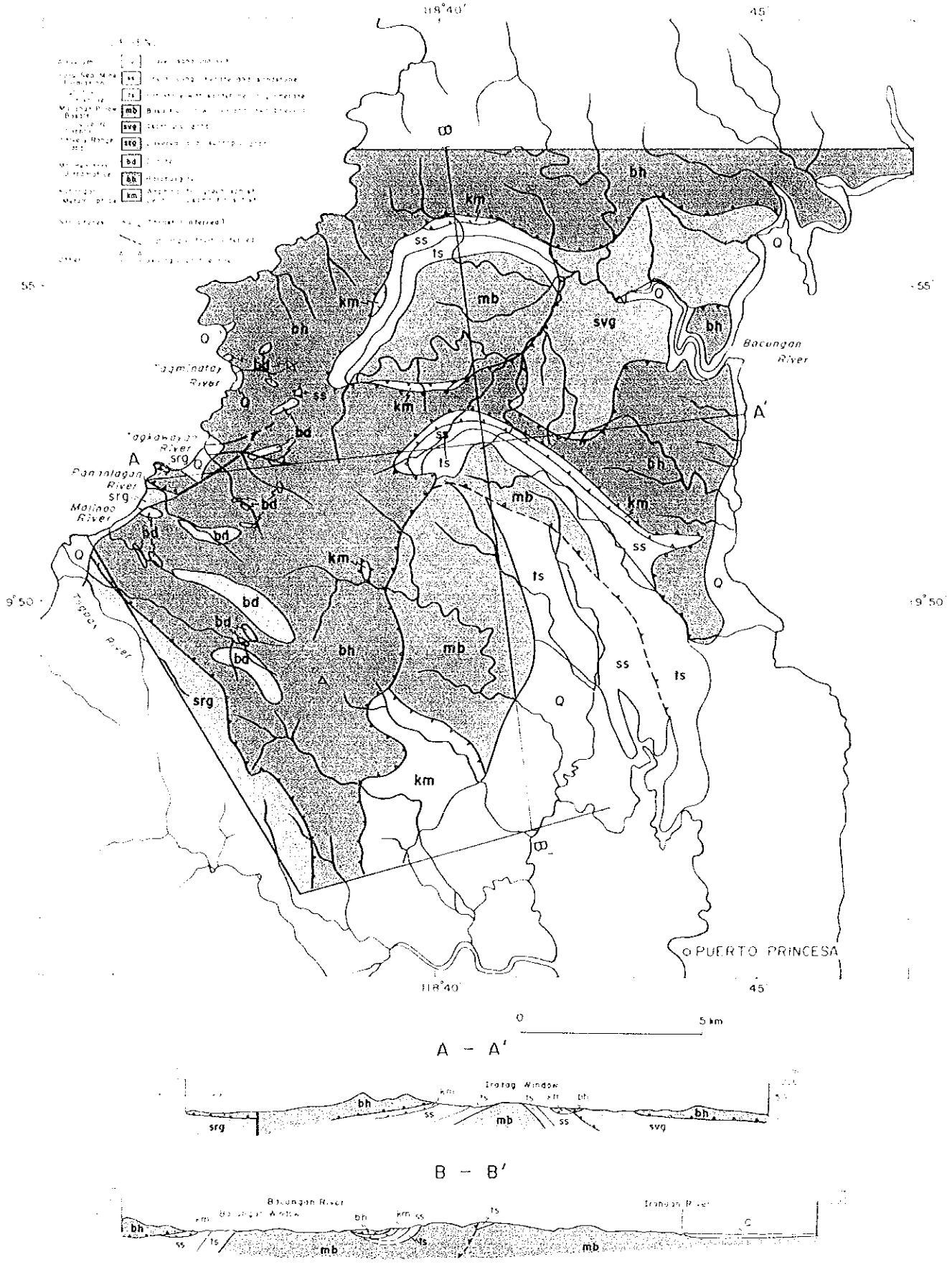


Fig. 8 Geologic map and profile in area A

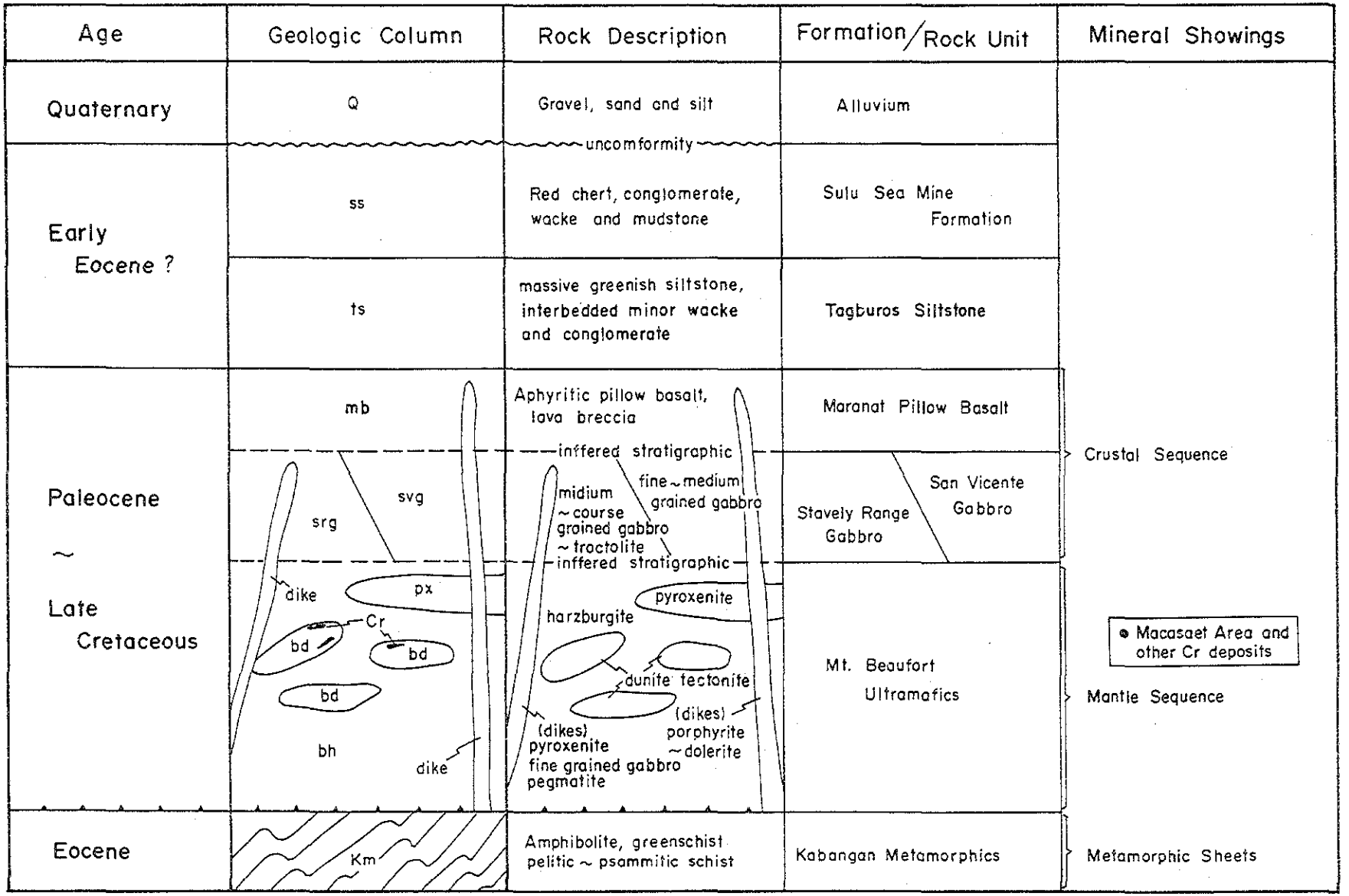


Fig. 9 Schematic geologic column in area A

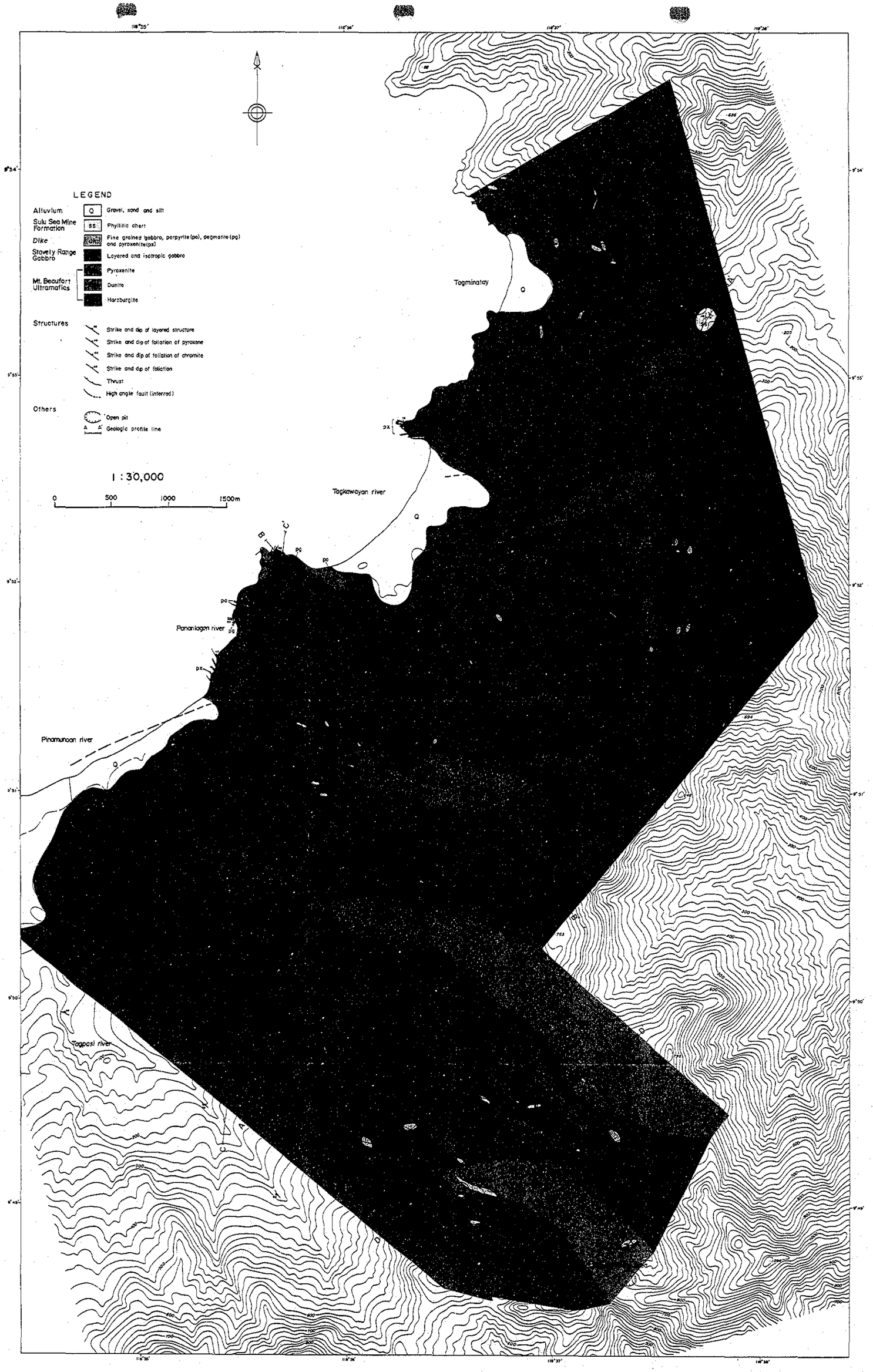


Fig. 10 Geologic map in area A-1

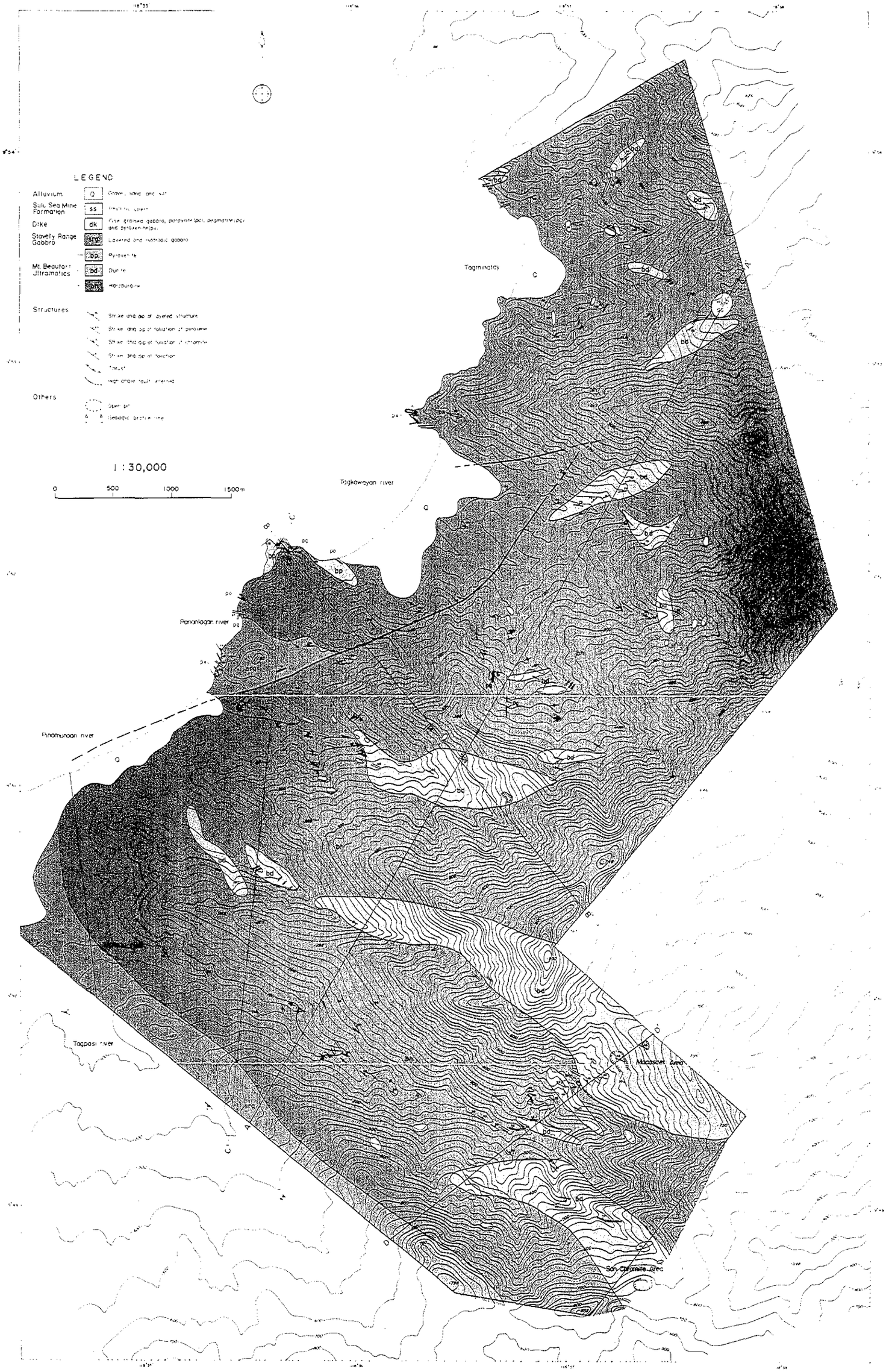


Fig. 10 Geologic map in area A-1

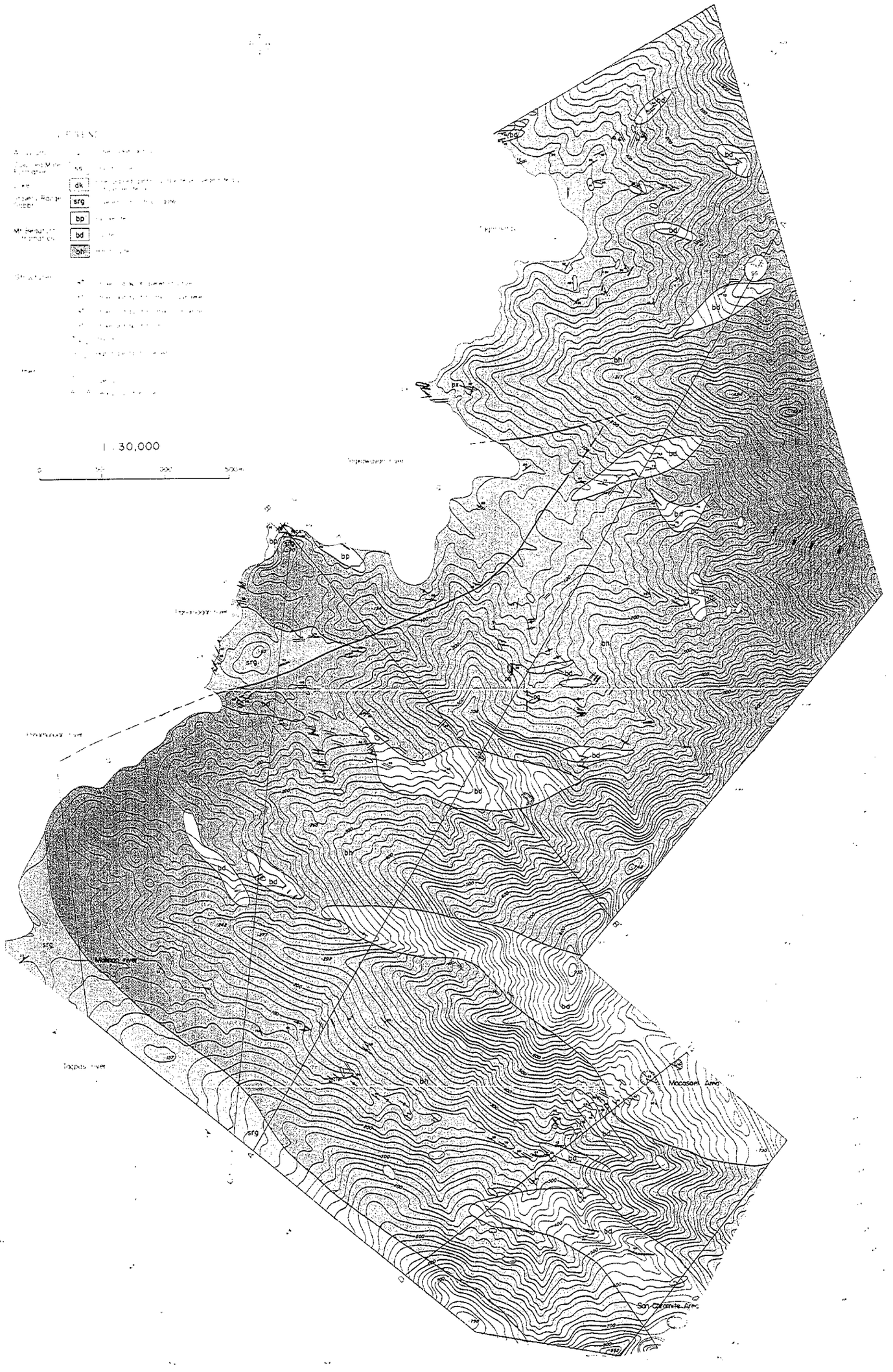
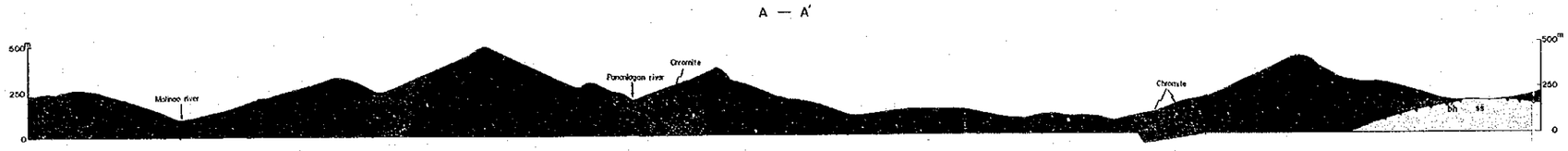
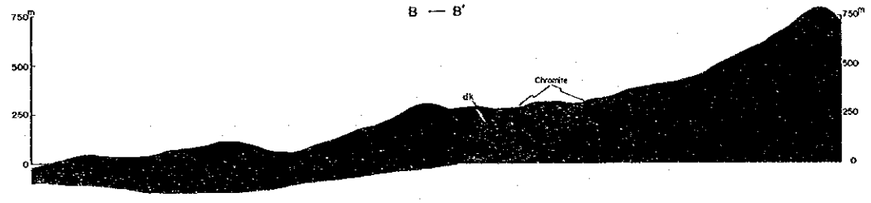
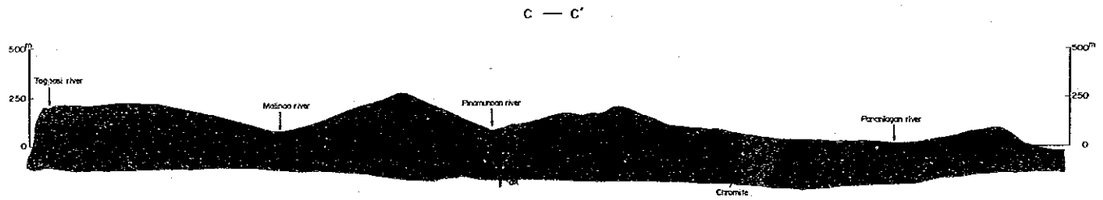
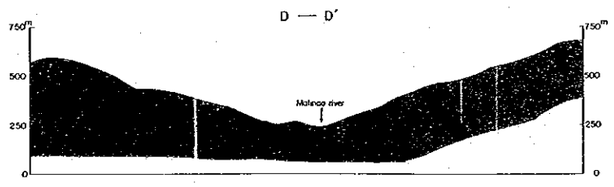


Fig.10 Geologic map in area A-1









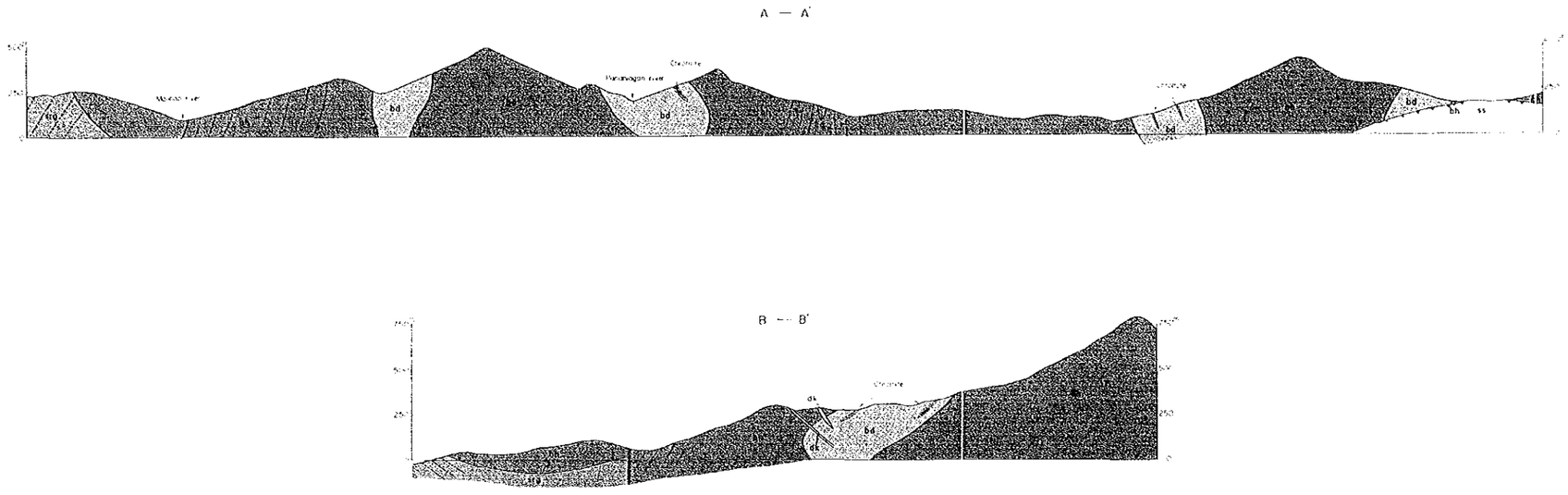
LEGEND

Alluvium	Q	Gravel, sand and silt
Sulu Sea Mine Formation	ss	Phyllitic chert
Dike		Fine grained gabbro
Stavely Range Gabbro		Layered and Isotropic gabbro
Mt. Beaufort Ultramafics		Pyroxenite
		Dunite
		Harzburgite
Others		Thrust
		High angle fault (inferred)
		Chromite mineralization

1 : 30,000

0 500 1000 1500m

Fig. 11 Geologic profile in area A-1



LEGEND

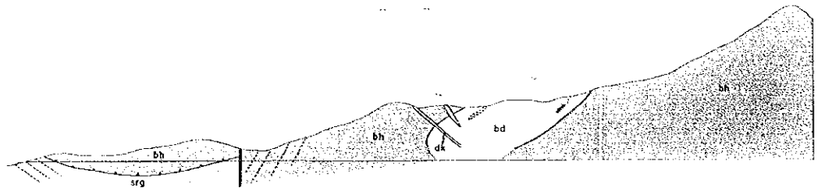
Alluvium	Q	Gravel, sand and silt
Sulu Sea Mine Formation	ss	Phyllitic slate
Dike	dk	Fine grained gabbro
Stavely Range Gabbro	srg	Layered and isotropic gabbro
	bp	Pegmatite
Mt Beaufort Ultramafics	bd	Dunite
	bh	Harzburgite

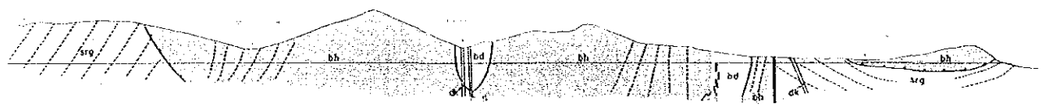
Others

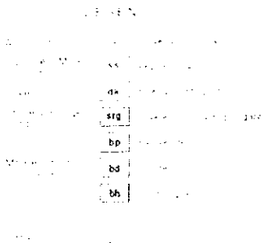
1 : 30,000

0 500 1000 1500m

Fig. 11 Geologic profile in area A-1







1 : 30,000

Fig. 11 Geologic profile in area A 1

harzburgite. Dunite tectonites occur in dike shape or alternatively of various sizes in the harzburgite. Chromite deposits are embedded in dunite bodies. Pyroxenite (websterite) crops out in the western area.

In the northern area, phyllitic red chert of the Sulu Mine Formation is exposed as small-scale windows.

Pyroxenite, fine grained gabbro, porphyrite, plagioclase- hornblende pegmatite intruded into the ultramafic rocks and gabbro.

1-5-2 Detailed geology

1) Kabangan Metamorphics

The Kabangan Metamorphics consist of amphibolite, greenschist, sandstone, and phyllitic schist, and are distributed in the northern and southern edges of the Bacungan window, which is situated in the middle stream area of the Bacungan River, and in the northern and eastern edges, and along the southwestern edge of the Iratag Window, which is situated to the west of Tagburos. The scale of the each body is smaller than 300m wide.

It is believed that they have formed along the thrust fault during the emplacement of the ophiolite suite. The psammitic to pelitic metamorphic rocks are probably metamorphosed from turbidite, similar to the Panas Formation distributed in southern Palawan.

2) Mt. Beaufort Ultramafics

The Mt. Beaufort Ultramafics are the ultramafic complex body, which is the main constituent of the Palawan Ophiolite. It is largely distributed in the southern area, from the area nearby Mt. Beaufort to the north as a nappe. It mainly consists of slightly serpentinized harzburgite, accompanied with dunite, and pyroxenite. In the middle stream area of the Bacungan River and the area west of Tagburos, the Mt. Beaufort Ultramafics have been eroded, resulting in forming the Bacungan Window and Iratag Window.

The harzburgite, which consists of several millimeters to 2 cm of olivine and orthopyroxene,

differs in color between the weathered parts and the fresh parts. It is brown to pale brown in the weathered parts, and dark grayish green to black in the fresh parts. By microscopic observation generally it was altered, orthopyroxene to bustite and olivine to serpentine. Chromespinel (chromite) is accompanied as an accessory mineral. The orientation of the orthopyroxene is well observed in the weathered facies.

Many dunite diapir-like bodies intruded into the harzburgite in spindle to irregular shapes at a scale of several meters to several hundred meters. They are usually yellowish brown to brown in color in the weathered facies, and dark green to olive in color in the fresh facies. They are also slightly altered to serpentine shown a mesh texture under the microscope, which is identified as antigorite by X-ray diffraction. The boundary between the dunite and harzburgite often comes across slightly diagonally with the orientation of the orthopyroxene in the harzburgite, but the dunite bodies generally stretch in the direction of the texture of harzburgite. Chromite grains are commonly observed megascopically in the dunite, and orientate. The direction of intrusives is in some cases parallel to the orientation of minerals, chromite seams, and lenses.

In detailed survey area A-1, pyroxenite (websterite) is distributed in a layered shape in the harzburgite.

3) Stavely Range Gabbro

The Stavely Range Gabbro is distributed in the area to the southwest of the Malinao River and the Balsahan River in the southwestern margin of the A-area. It consists of medium to coarse grained gabbro, and is accompanied by olivine gabbro and troctolite.

Banded structure is not significant in the south part of the survey area, but well observed in the western survey area. The structure is due to the difference of grain size and volume ratio of colored minerals. At the Tagpasi River, it strikes NW-SE and dips to the north. In the downstream area of the Pananlagan River, it strikes N-S, dips to the east. On the downstream area of the Pananlagan River, alternated layers of pyroxene-plagioclase gabbro, amphibole gabbro and troctolite are found.

4) San Vicente Gabbro

The San Vicente Gabbro is distributed at Bacungan, along the national highway running from Puerto Princesa to the north, and the area centered by San Vicente. This gabbro mass distribution area shows very gentle and low hills because of intense weathering. The rock facies are of fine to medium grained pyroxene-plagioclase gabbro, and layered and banded structures due to the different volume ratio of colored minerals are unclear.

The Mt. Beaufort Ultramafics were thrust over this gabbro mass, and this gabbro mass is thrust over the Maranat Pillow Basalt. It is assumed that this gabbro mass is correlative with the Sultan Peak Gabbro distributed in southern Palawan.

5) Maranat Pillow Basalt

The Maranat Pillow Basalt mainly consisting of pillow lava and basaltic tuff breccia, is distributed in the area centered by the Maranat Creek in the Bacungan Window and the area centered by the Irawan River in the Iratag Window.

The Basalt distributed in the Bacungan Window consists of aphyric or non-amygdaloidal basalt, and has commonly undergone chloritization.

The Basalt distributed in the Iratag Window consisting of the same types of basalt as seen in the Bacungan Window has in some places thin layers of mudstone, several meters to several tens of meters thick.

It is believed that the Maranat Pillow Basalt is correlative with the Espina Basalt extensively distributed in southern Palawan. The San Vicente Gabbro and harzburgite are thrust over this rock, and is conformably overlain by the Tagburos Siltstone.

6) Dikes

Many of dikes of fine grained gabbro, dolerite, porphyrite, pyroxenite, and pegmatite intruded into the Mt. Beaufort Ultramafics, the Stavely Range Gabbro, the San Vicente Gabbro, and the Maranat Pillow Basalt.

The fine grained gabbro to dolerite and porphyrite are light gray to dark gray hard rocks, and distributed in many places. They are 1 to 10 cm wide, and the orientation of dikes varies

sporadically.

The pyroxenite dikes intruded into the Mt. Beaufort Ultramafics and the Stavely Range Gabbro, particularly in detailed survey area A-1 in the west coast. They are greenish green to dark greenish gray in color, and 0.1 to 1 m in wide. The pyroxenites are websterite or olivine websterite, and its crystals are equigranular and 5 to 7 mm in size.

The pegmatite consists of large crystals of hornblende and plagioclase crystals, which are several centimeters in size, and intruded into the Mt. Beaufort Ultramafics and Stavely Range Gabbro as dikes with about 1 m wide.

7) Tagburos Siltstone

The Tagburos Siltstone is distributed in the northern part of the Bacungan Window, the Bacungan River area in the Iratag Window, and the Iratag River area.

In the Bacungan Window, it consists of massive green siltstone and fine grained sandstone, and intercalates sandstone layers. In the Iratag Window, it consists of massive green siltstone, and intercalates sandstone and conglomerate layers.

It has conformable contacts with the underlying Maranat Pillow Basalt and overlying Sulu Sea Mine Formation.

8) Sulu Sea Mine Formation

The Sulu Sea Mine Formation is distributed in the northern Bacungan Window and eastern Iratag Window, and consists of alternated layers of red chert, ferruginous siliceous rock, conglomerate, sandstone, and mudstone. In the northern part of detailed survey area A-1, phyllitic red chert is distributed in harzburgite in a small scale as window.

It conformably overlies the underlying Tagburos Siltstone.

1-5-3 Geological structure

The geological structure of the A-area has resulted from the emplacement of the ophiolite, which was generated on the ocean floor during the Late Cretaceous to Paleocene age. It appears that the thrust movement occurred in Late Eocene to Early Paleocene.

[Thrust Fault]

The thrust fault situated at the bottom of the Mt. Beaufort Ultramafics or Kabangan Metamorphics is the lowest angle one in this area. These rocks are commonly distributed as a nappe due to the almost horizontal thrust fault.

Because the bottom of the Ultramafics is confined by the thrust fault, windows of various sizes have been formed in eroded parts of the Ultramafics. The largest windows are in the areas nearby Bacungan and Iratag. These are known as the Bacungan Window and Iratag Window (UNDP, 1985). Near the thrust fault, harzburgite is extensively serpentinized, and in some places even mylonitized.

Also in this area, there are thrust faults, which resulted from imbricated thrust movement of the ophiolite to the northern Palawan Block. They are in between the San Vicente Gabbro and Maranat Pillow Basalt, and the Maranat Pillow Basalt and Tagburos Siltstone.

[High angle Fault]

A high angle fault is observed along the west coast, extending ENE to WSW. It cuts harzburgite and gabbro, and appears a right lateral fault in the geological map of the area.

1-5-4 Ore deposit and mineral showings

The most important ore deposits in the A-area are of chromite associated with the peridotite. It is presumed that chromium is concentrated by partial melting of the mantle. On the other hand, nickel laterite occurrences resulted from weathering of the peridotite are also distributed in this area. A mercury mine is situated near Tagburos, where research for gold is presently being conducted by Atlas Cons..

As for chromite showings, a detailed survey was conducted in the west coast, where it has a high potential, and revealed its distribution. A test pit survey was conducted to confirm the scale of the chromite showings.

As for nickel occurrences, the results of the survey revealed distribution zones of laterite in the harzburgite area of the Bacungan area in the northern A-area and detailed survey area in the west coast. In these areas, a test pit survey was conducted to confirm their mode of occurrences. Appendix 4 shows the sketch of the test pit and a profile of assay results.

Details on each mineral showings are as follows.

1) Chromite deposit and showings

In the detailed survey area A-1, situated on the west coast of the A-area, chromite outcrops and floats are seen in more than 10 locations. These are divided into three regions; 1) the San Chromite Area, Macasaet Area in the southwestern area, 2) Upper Pananlagan and Lower Pananlagan in the middle area, 3) Tagkawayan and Tagminatay in the northern area. Fig.12 shows the location of the mineral showings.

There is no operating mine in this area, but there are old workings of open pit operation in the Macasaet Area and San Chromite Area. They are of fairly large scale. In Upper and Lower Pananlagan, there are smaller old workings of open pit mining. No old working exists in the Tagkawayan River area and Tagminatay area, but some floats of chromite ore are found at several spots.

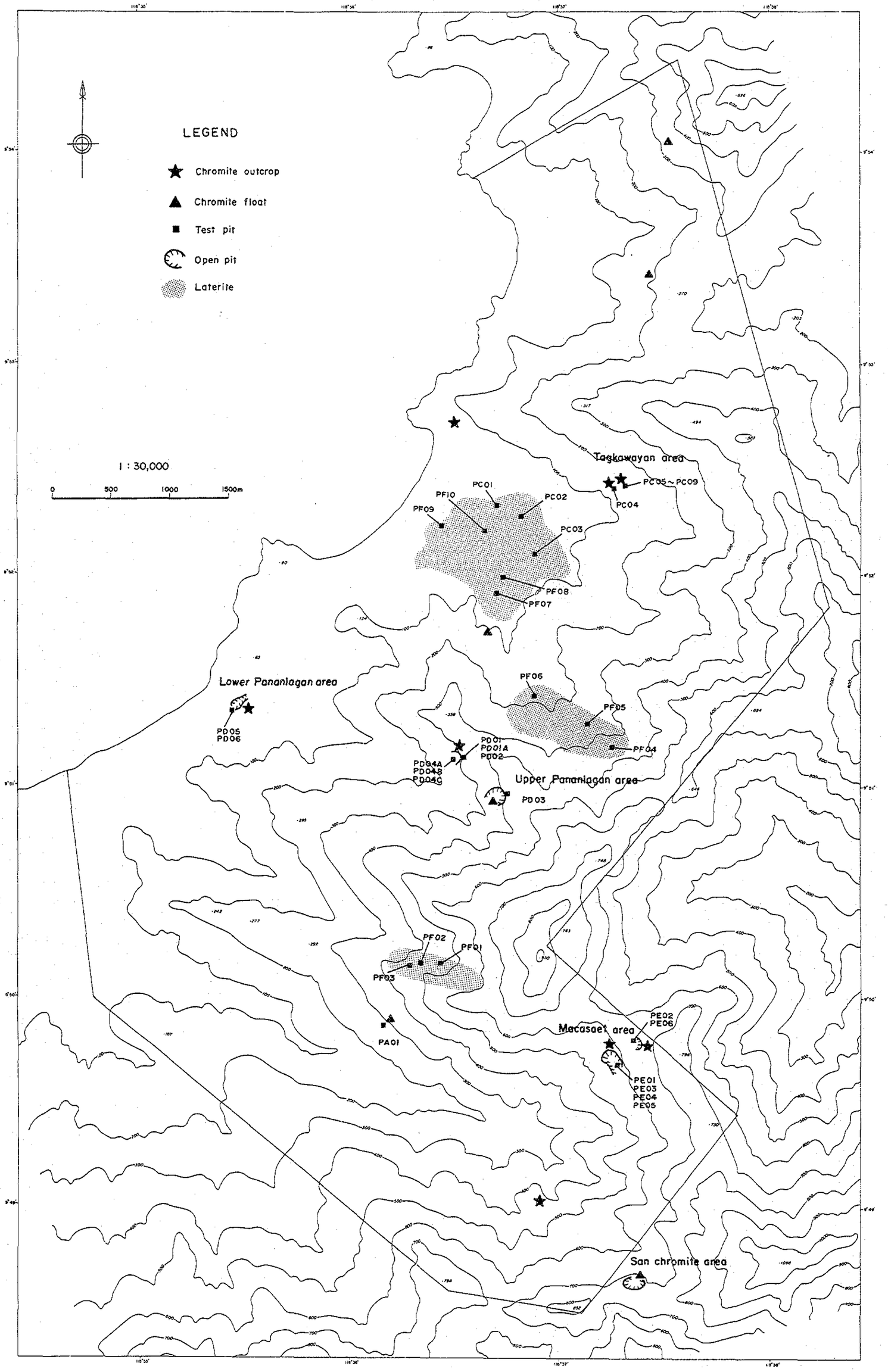


Fig. 12 Location of mineral showings and test pits in area A-1

i) Macasaet Area

This area is situated in the upstream area of the Malinao River, in the northeastern area, and occupies an area of 500 m south to north and 400 m east to west. An open pit working extending 500 to 200 m and eight outcrops of massive chromite ore having various sizes are observed (Fig. 13). A road comes from Iraan, and it goes to the San Chromite Area. This area is situated in the largest dunite tectonite body in Area A-1. The dunite hosts extensive dissemination of chromite.

The old working of open pit mining was presumably performed by means of machines in large-scale. It is said that an underground mining was also partially applied. Benguet performed a prospecting program consisting of geological and soil geochemical surveys, and the results revealed the distribution of the chromite boulders. The company followed up those results by a test pit survey.

The ore deposits confirmed by above mentioned surveys are 1 to 2m wide, and extend as long as 60m. Beside the largest ore body, 150 tons of high grade massive ores are stocked. Each ore body mainly consists of massive ores, accompanied with nodular ores (Leopard type) in some cases. The ore bodies extend NNW-NW to SSE-SE, and dip 50° to 60° east. A test pit survey consisting of six pits was performed in this survey, and revealed chromitite outcrop at the test pit PE01.

ii) San Chromite Area

An old working of open pit mining exists in the uppermost part of the Malinao River, southeastern end of the area A-1. The working is 200m east to west and 200m north to south in size. The working zone is underlain by dunite disseminated by chromite. At present, no ore outcrop is seen, but some floats of massive ore are scattered there. Judging from those evidences, this area used be mined for massive ore as well as the Macasaet area.

An lense of massive ore crops out on the ridge north of this open pit, traceable to 20m long with 1m wide. Several tons of ore is stocked there.

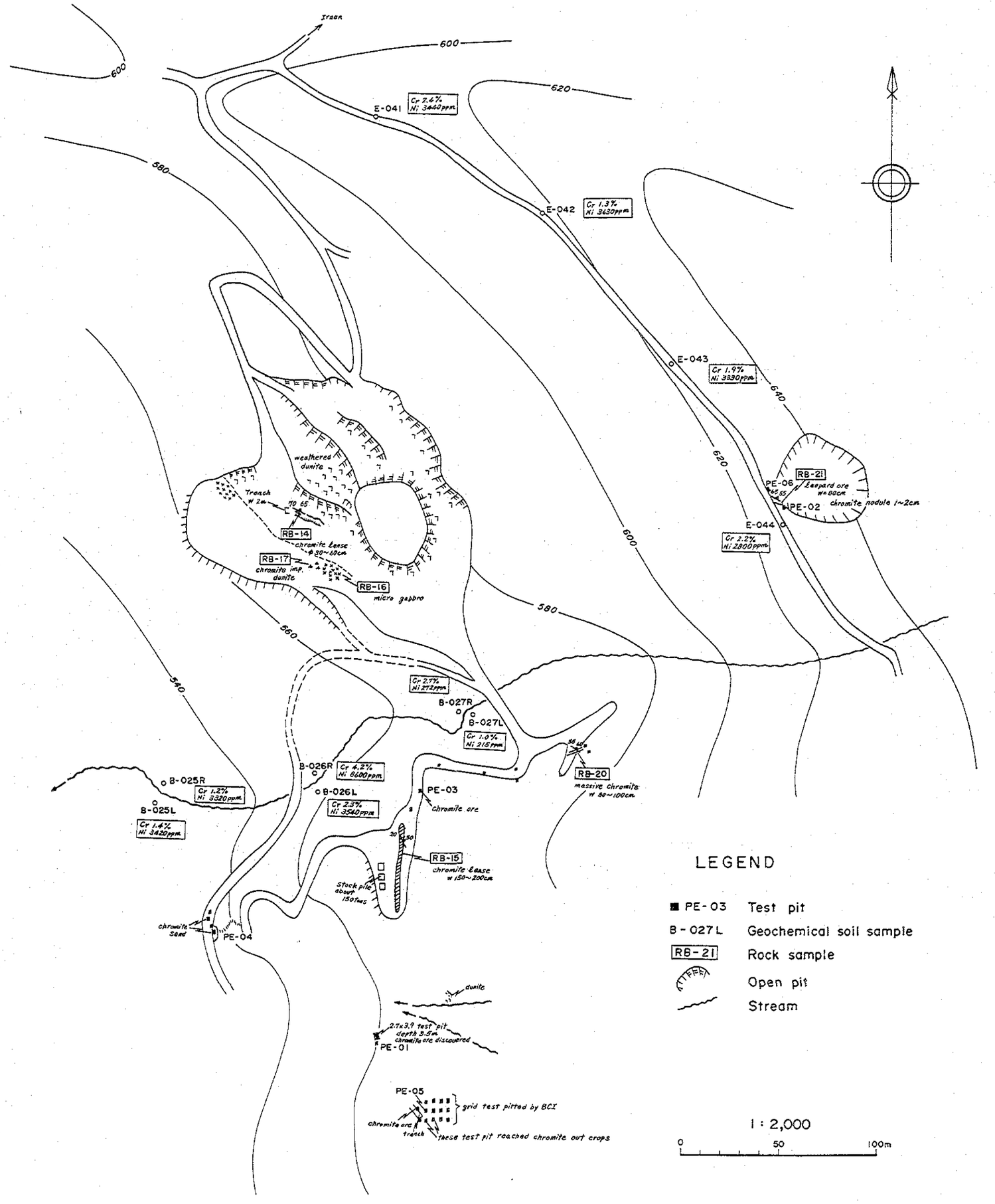


Fig. 13 Map of the Benguet Macasaet area

iii) Lower Pananlagan Area

This zone is situated in the downstream area of the Pananlagan River, and contains three chromitite outcrops. The largest outcrop is seen in an old working of open pit mining, 40m x 20m in size (Fig. 14). Several chromite lenses in spindle shape are observed in the direction of N80°W, dipping 60° to 80° west in weathered dunite. Chromite disseminated ores surround the massive ores. A test pit survey was performed at four sites to follow the extension of the ore bodies, but no chromitites were found.

iv) Upper Pananlagan Area

On the northern slope of the Pananlagan River, two workings of open pit mining exist (Fig.15). One in the downstream side is of small size, only 20m x 10m, with approximately 10m wide. Disseminated chromite ores extend from east to west. A test pit survey consisting of six pits was performed in this zone, and revealed the extension of the chromite ores.

The other one in the upstream side is approximately 200m x 50m in size. The slope has generally collapsed and no chromite ore outcrop was found. But some boulders of massive chromite ore are observed in the collapsed material. Several tons of massive ore stock is seen in the area. One test pit was dug at the topmost working, but no chromite ore was found.

v) Tagkawayan Area

In two places in the tributary of the Tagkawayan River, dunite layers containing disseminated chromite in 3m wide exist. The direction of the chrome dissemination is N70°E-E to S70°W-W, dipping 60° to 70° to the north. In the downstream and upstream areas of the tributary, many floats of massive chromite ore are scattered, but no outcrop is found. On the west slope, a small amount of chromite ore stock exists, suggesting small scale mining was previously conducted there. The test pit survey was performed at nine sites in the area. Dunite disseminated by chromite were observed at every pit, but no outcrop of the ore was found.

In the tributary south of the Tagkawayan River, boulders of massive chromitite were found but no chromitite outcrop were discovered.

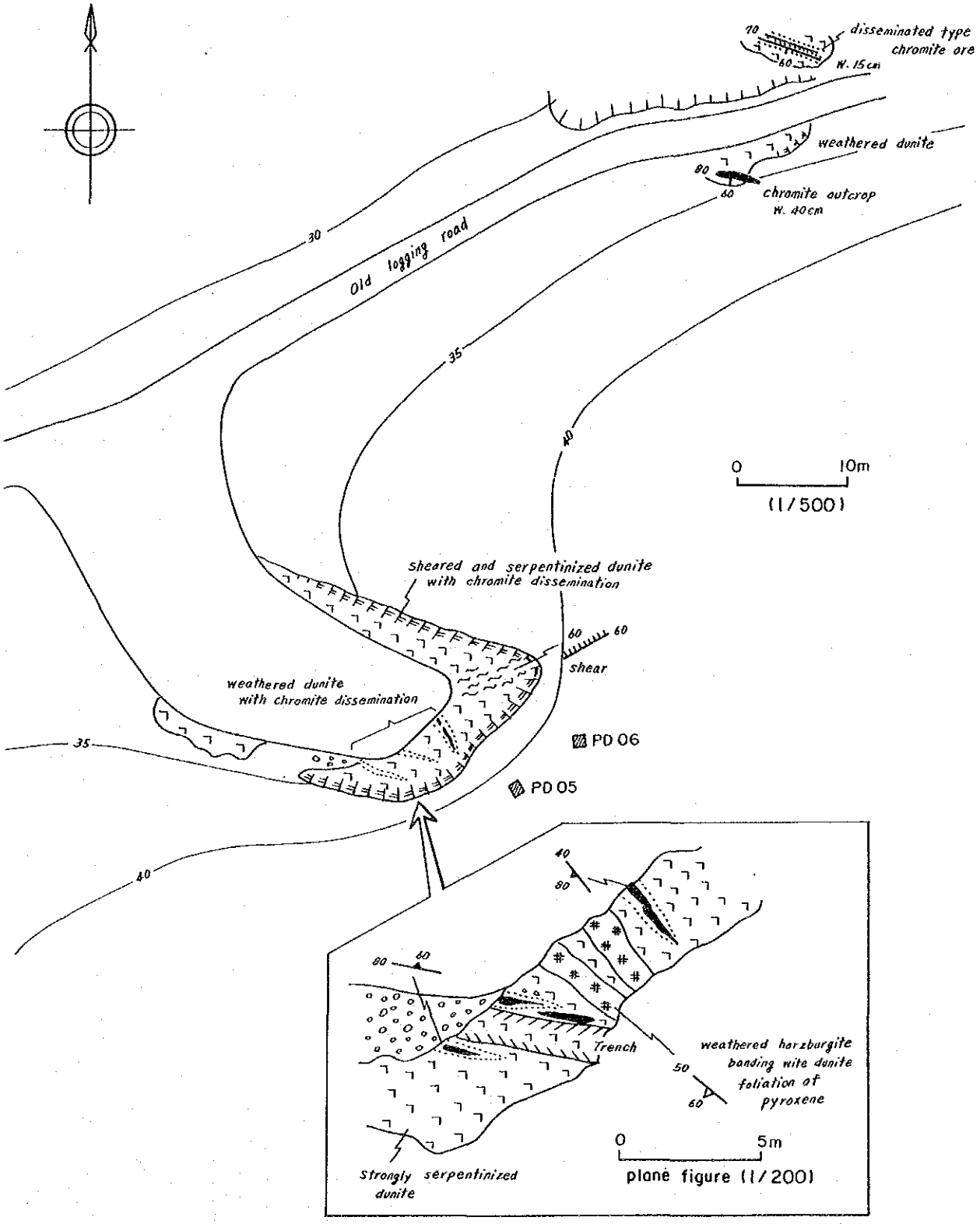


Fig. 14 Sketch map of the Lower Pananlagan area

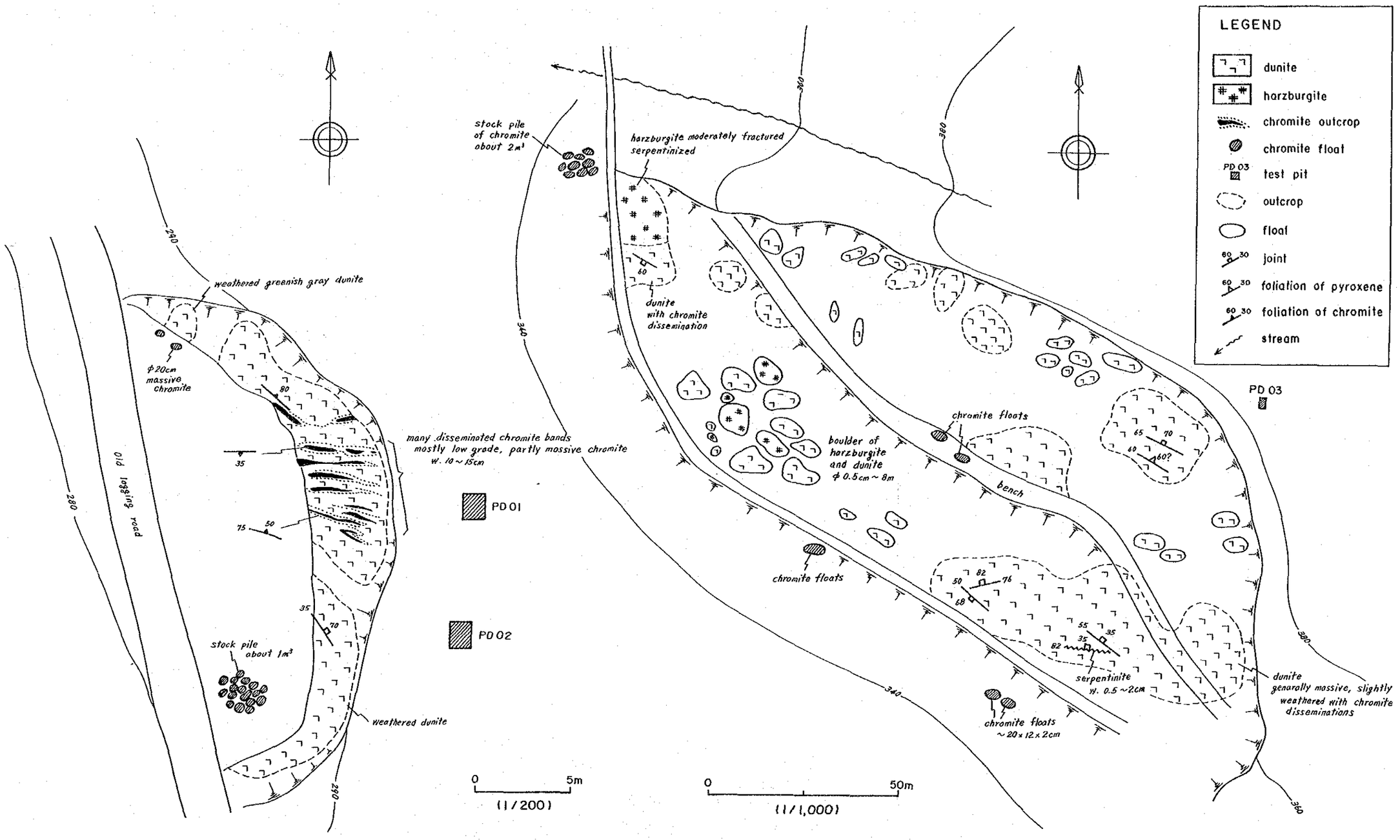


Fig. 15 Sketch map of the Upper Pananlagan area

vi) Tagminatay Area

Floats of chromite ore are scattered along the old forest road running from the Tagkawayan River area to Tagminatay. When the road was under construction, an outcrop of chromite ore in spindle shape, 30cm x 6m in size, was found in weathered harzburgite. The ore outcrop however thinned out in a short, then was covered by soil again.

Many floats of massive chromite ore were found in the northern tributary in the Tagminatay area, no outcrop however was found. Dunite is distributed around this area.

(2) Nickel Occurrence

Nickel laterite is distributed in the area near Bacungan in the northern A-area, as well as the upstream area of the Pinamonoan River and basin of the Tagkawayan River in the west coast. The test pit survey was conducted in these areas.

i) Bacungan Area

Eleven test pits were dug in this area. Fig. 16 shows the locations of the test pits and the distribution of laterite.

Lateritization in this area is intense. Laterite layers are more than 4.5m to 6.5m in thick at the nine pits out of eleven, and about 1m at the rest two pits, which reached to the basement rocks. About the half of the pits did not reach to the basement yet. The results of the assay have revealed that the grade of nickel content was 0.5 to 1%, showing poor grade as nickel ore. Also the results has indicated that the grade of iron was higher than 40% except two pits, BC-01 and BC-02. It means that the bottoms of those pits are still in residual laterite. Because the nickel is concentrated in the underlying peridotite (saprolite), almost all pits dug this time presumably do not reach nickel concentrated layers.

Grade of chrome shows higher than 2% at every pit, over 6% in some cases, which indicates high potentiality for the chromite deposits.

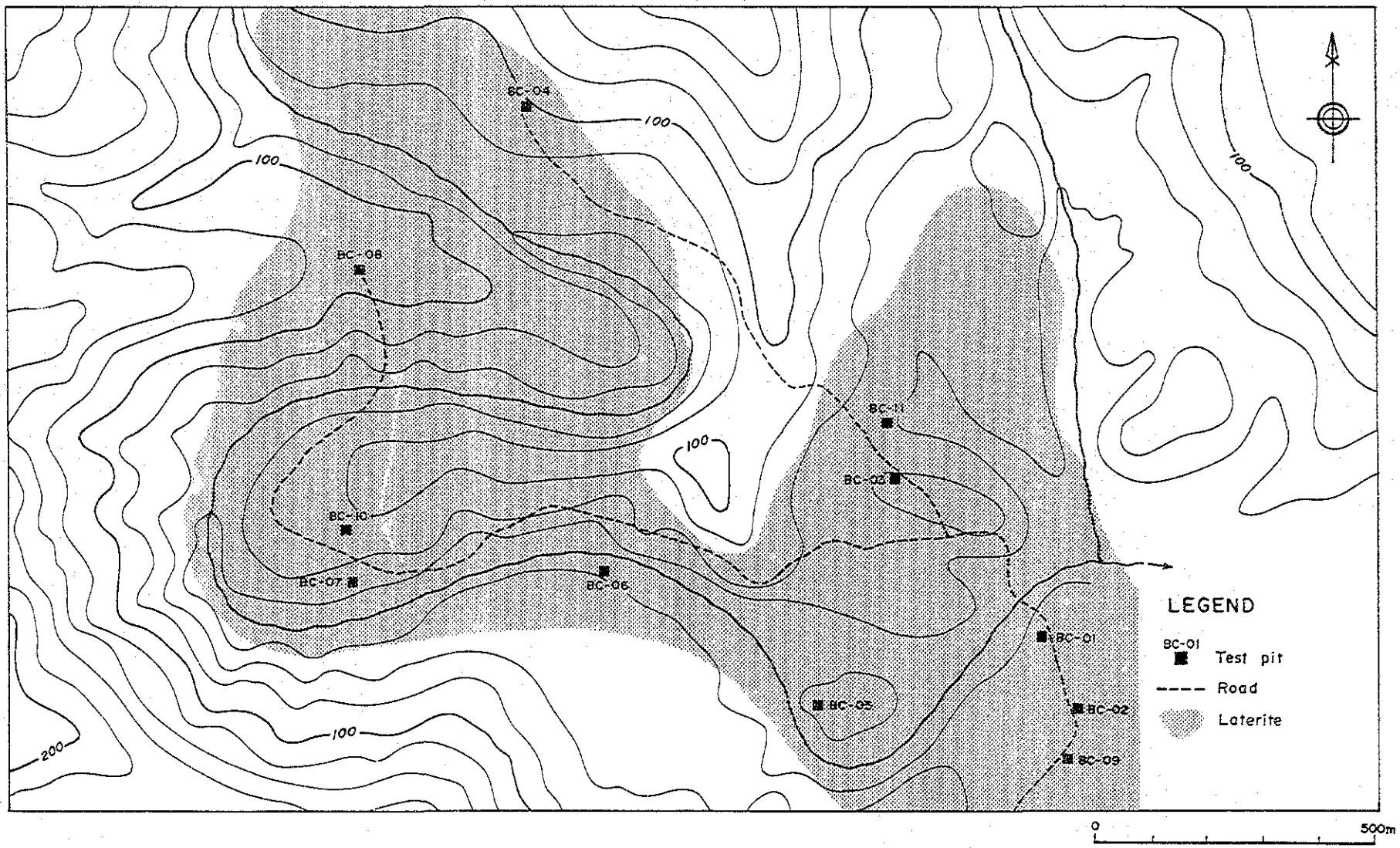


Fig. 16 Location map of test pits BC01 to BC11 in Bacungan area

ii) West Coast

Because laterite was found in the upstream area of the Pinamunoan River and the Tagkawayan River, the test pit survey consisting 13 pits was conducted in three areas. Fig. 12 shows the locations of the test pits. Weathered crusts of peridotite in the west coast are not thick compared with the Bacungan area, because of its steep topography.

Three test pits were dug in the upstream area of the Pinamunoan River. They reached to altered peridotite zones, however did not show any high assay results for nickel, 0.5 to 0.7%.

The test pits dug in the downstream area of the Tagkawayan River reached to the basement except one pit, PF10. The nickel grade is 0.5 to 1.0% at test pit PC02 and PC03, and 0.4% at the rest of pits.

A test pit survey consisting of three pits was conducted in the upstream area of the Tagkawayan River. The nickel grades show higher than 0.7%, except at PF05 which was dug into a weathered zone of fine-grained gabbro. The grade is particularly high at PF06, 1.9% at the zone 3m to 4m deep and 2.7% at the zone 4m to 5m deep.