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REPUBLIC OF THE PHILIPPINES

REPORT ON GEOLOGICAL SURVEY OF MINDORO ISLAND

PHASE II

SEPTEMBER 1983

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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PHASE II

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SEPTEMBER 1983

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

国際協力事業団
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PREFACE

The Government of Japan, in response to the request of the Government of the Republic of the Philippines, decided to conduct collaborative mineral exploration in Mindoro Island of the Philippines and entrusted its execution to Japan International Cooperation Agency (JICA) and Metal Mining Agency of Japan (MMAJ).

Between 31 January, 1983 and 5 May, 1983, Metal Mining Agency of Japan dispatched a survey team headed by Mr Hiroshi Fuchimoto to conduct the Phase II of the project.

The survey had been accomplished under close cooperation with the Government of the Republic of the Philippines and its various authorities.

This report is a compilation of the survey of the Phase II, and after completion of the project, the consolidated report will be submitted to the Government of the Republic of the Philippines.

We wish to express our appreciation to all of the organizations and members who bore the responsibility for the Project, the Government of the Republic of the Philippines, Bureau of Mines and Geo-Sciences (BMG), and other authorities and the Embassy of Japan in the Philippines.

July 1983

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan

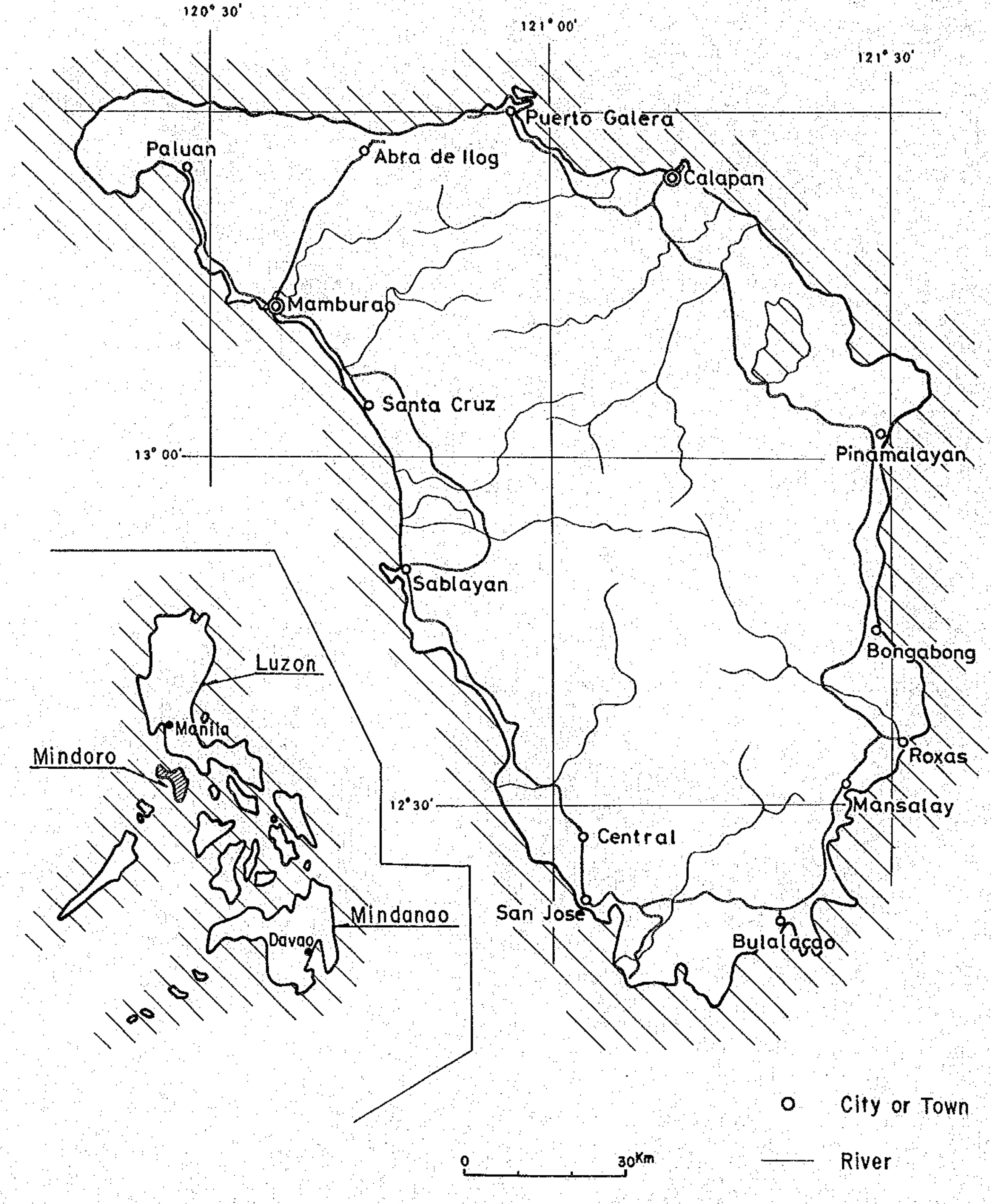
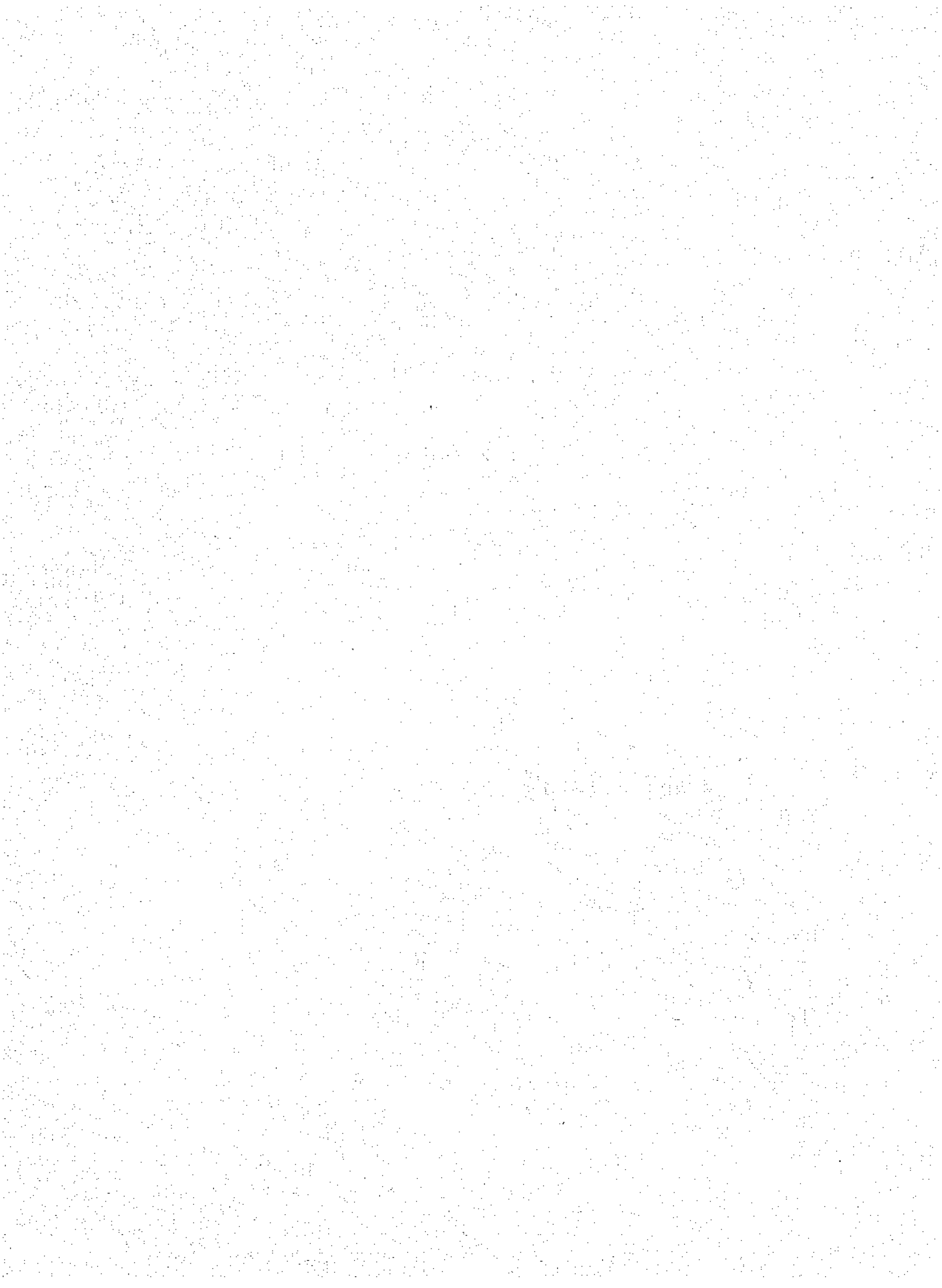


Fig. 1 Location Map of the Survey Area

CONTENTS

PART II GEOCHEMICAL SURVEY

LIST OF ILLUSTRATION



LIST OF APPENDICES

ABSTRACT

The ultimate aim of the geological survey of the Philippine island of Mindoro is the evaluation of its mineral resources.

This year marks Phase II of this survey and geological and geochemical surveys were carried out for areas remaining uncovered, and areas surrounding that covered by Phase I.

First of all, the geological survey confirmed that the generalized stratigraphy and the structure established by the geological survey and aerial photographical survey conducted in Phase I are mostly compatible.

Generally speaking, the geology of Mindoro Island has older pre-Cretaceous formations in its central area and tending to the north-west with the late Eocene to Pleistocene formations occurring on both sides of these. These older formations are composed mainly of pelitic metamorphic rock, and none metamorphosed or weakly metamorphosed rocks of muddy origin, as well as basic lavas. These types comprise more than 60 % of the island. The younger formations are neritic sedimentary rock which exhibit some differences in their rock facies with respect to the older formations. That on the western side is characterized by limestone and conglomerate and little volcanic rock, while that on the east is characterized by tuffaceous mudstone and sandstone having abundant volcanic sediment.

As a whole, the geological structure is of an anticlinal structure with a NW–SE axis, and a central uplift zone of older formations at its core and the overlying formations becoming younger towards the periphery. There are some fracture systems and the NNW–SSE system is the most remarkable of these. It is represented by the Mindoro Fault and the Wasig Fault which have clearly controlled the intrusion of the Ultramafic complex in the eastern and western areas. This phase of the survey disclosed that the complex is mainly composed of harzburgite, dunite and lherzolite, some of which show a large-scale body having a layered structure.

The occurrence of various ore deposits and the genetic relationship between ore deposits and igneous rocks was clarified as the following.

Chromite ore deposits occur in the Ultramafic complex and are closely related to dunite. One example of this is the Ogos ore body (5.0 m thick, 30 % Cr_2O_3)which occurs in dunite and another example is the Banus ore body (0.5 m thick, 30 % Cr_2O_3) which is very close to dunite. Although no chromite deposits had been previously reported for the east Ultramafic complex, new deposits were found and strong geochemical anomalies were obtained in this phase. These suggested that there is a high probability that ore deposits exist in this complex.

Ore deposits of copper which are located in the upper stream of the Pula River in the east,

are of the vein type and are related to the dioritic rocks from the Eocene to Oligocene periods. The mineralized area was almost determined and the nature of floats indicates the possibility of the existence of bedded cupriferous deposits.

Iron deposits concentrated in the northern part of the central range are composed of magnetite which is of the metasomatic type and which are related to the dioritic rock from the Eocene to Oligocene ages. Checks of these typical deposits verified that the ore was of good quality (50 % – 60 % Fe) and indicated that their further investigation may prove worthwhile.

Silica deposits located in the Mansalay area of the southeastern part are composed of highly indurated Jurassic arkose. Two arkose beds of 500 to 1,000 m thick were had their lateral extension estimated at more than 3 km.

There are coal deposits located in the Napisian and Siay areason the southeastern side of the island. The presence of four coal seams of 0.70 to 2.00 m thick was confirmed in the Miocene sandstone. It is presumed that these seams are strongly disturbed by folding since folding structures have developed along a NE–SW axis in the area.

The geochemical survey disclosed that there are concentrations of chromite at places in the Ultramafic complex but on the whole, these chromite anomalies in the eastern complex are stronger and wider than those of the western. In addition, Ba-anomalies were determined on the southeastern side of the Baroc basin and Au-anomalies were determined on the north-eastern side of the Binaybay basin and on the southeastern side of the Siange basin.

GENERAL REMARKS

Chapter 1. Introduction

1–1 Purpose and Scope of Survey

The purpose of this project is to evaluate the mineral resources of Mindoro Island in order to determine their potential for exploitation. Last year, geochemical and geological reconnaissance surveys, photogeological interpretation and aerial magnetic surveys were carried out for all of Mindoro Island (10,000 km^2) as part of Phase I of the survey to achieve this. The outlines of the geological structure and the mineragenetic province were obtained as a result.

1–2 Outline of the survey

Phase II of the survey was concerned with the performing of geological and geochemical surveys for the area left uncovered in Phase I and for the areas surrounding areas determined in the last phase as having mineral showings.

The survey team was composed of 5 Japanese geologists and 6 Filipino geologists who composed a route map at a scale of 1:20,000, and collected stream sediment samples from the main creeks crossing the geological survey routes.

It was expected from the results of the Phase I survey that Ni and Cr deposits existed in the ultramafic zones and so stream sediment samples with a higher sampling density and panning samples were taken to determine the anomalous area of chromite.

The outline of the field-work for this phase is shown in Table I.

Table 1 Outline of Field Survey in Phase II

	Duration	Area	Length of Survey Route	Remarks
Preparatory Work	Jan. 31 ~ Feb. 10 '83 11 days	——	——	
Geological & Geochemical Surveys	Feb. 11 ~ Apr. 26 '83 75 days	10,000 Km^2	844 Km	Geochemical Samples 1,109 pcs Panned Samples 101 pcs Checked Showings 25 sites
Compilation	Apr. 27 ~ May 5 '83 9 days	——	——	

1–3 Organization of the Survey Team

The personnel who participated in the survey are:

(A) Planning and Negotiations

(Japan)

TAKAHISA YAMAMOTO	Metal Mining Agency of Japan	
KAZUHIRO UEMATSU	do	
JIRO OSAKO	do	(Manila rep.)

(Philippines)

JUANITO C. FERNANDEZ	Bureau of Mines & Geo-Sciences
GUILLERMO R. BALCE	do
MARIO G. PACIS	do

(B) Survey Team

(Japan)

HIROSHI FUCHIMOTO (leader)	Metal Mining Agency of Japan
HIDEO SUZUKI	do
MIKIO KAJIMA	do
AKIRA TAKIGAWA	do
YOSHIAKI SHIBATA	do

(Philippines)

MARIO G. PACIS (leader)	Bureau of Mines & Geo-Sciences
LOPE M. CARIÑO	do
JESSIE S. MIGUEL	do
JESUS ROTONI	do
ELEAZER MANTARING	do
RONALDO MIRANDA	do

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Chapter 2. Outline of the Survey Area

2–1 Location and Accessibility

Mindoro Island is located centering at latitude 12°55' N and longitude 121°05' E and is about 130 km south of Manila. It can be reached within 30 mins by air and in about 4 and a half hours by car and ferry.

Central mountains divide the island into two provinces, viz., the Occidental and the Oriental and both of these are highly mountainous with no efficient road systems.

2–2 Topography

The topography of Mindoro Island is characterized by central mountain ranges lying in a NW–SE direction and by narrow plains stretching along both sides. The central ranges consist of mountains of over 1,500 m with Mt. Halcon (2,505 m) in the north and Mt. Baco (2,488 m) in the south.

The topography of the western side of the central mountain ranges is very gentle, while that of the eastern side is very steep because of the presence of many fault scarfs formed by large tectonic lines. In particular, the tectonic line running from Baco to Villacervesa is prominent and mountains of more than 1,000 m rise upright from the plain. Valleys in this area are deeply dissected with deep cliffs on both sides and high waterfalls which make it difficult to go up the river even in the dry season.

The nothernmost part of the central mountain ranges consists of limestone showing a peculiar topography of limestone with cliffs and dolines. The rivers of the area are almost dry since the surface water readily infiltrates into the ground.

2–3 Climate

The Philippines are in the Southeast Asia monsoon zone and so have the two seasons of the northeast monsoon and the southwest monsoon. Fig. 2 shows the climate of the Philippines, divided into four regions.

(1) The region having pronounced wet and dry seasons.

(2) The region having relatively unpronounced wet and dry seasons.

(3) The region having rainfall fairly evenly distributed throughout the year.

(4) The region with no dry season.

Because of the central mountain range, Mindoro Island has different climates on its eastern and western sides. The western side belongs to region (1) while the eastern side belongs to region (3). June to November is the rainy season for the western side as the southwest monsoon prevails, while although the rainfall for the eastern side varies, heavy rains often occur in June to August and there is very little precipitation in the period from February to April. There are many rivers with abundant water on the eastern side and these include the Alag River, the Bukayao River, the Magasawangatubic River and the river, all of which often overflow in the lowland areas after heavy rainfalls, destroying agricultural crops.

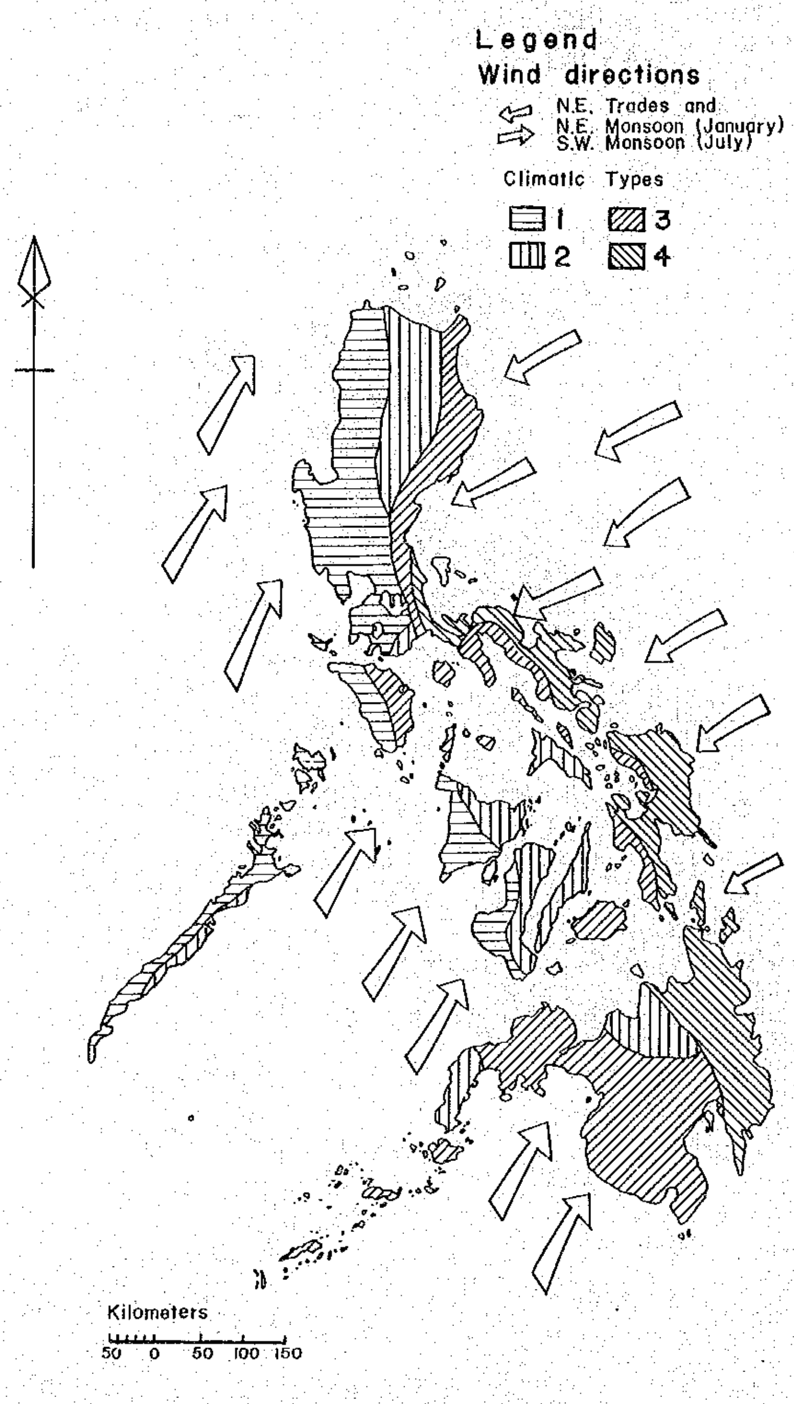


Fig. 2 Climatic Type of the Philippines

Chapter 3. General Discussion

Much important data on geology and ore deposits were collected in the Phase II survey and problems related to future surveys will be discussed in this chapter.

3–1 Geology

1. Relationship between Halcon Metamorphics and Mansalay Formation

The rocks named Mindoro Metamorphics or Basement Complex were divided into two groups in Phase I. There was the lower group consisting of metamorphic rocks of green schist and amphibolite facies and the upper group consisting of slate and phyllite. The Halcon metamorphics was a tentative name given to the lower group. The upper group was included in the Mansalay formation because it seemed to be Jurassic according to its rock facies and geological structure. The stratigraphic relationship between the two groups was considered to be uncomfortable from the evidence presented below.

1. The conglomerate of the upper group contains pebbles of the lower group
2. A structural discordance is recognized at the boundary between the two groups
3. The metamorphic grade suddenly changes from one group to the other

The Phase II survey disclosed that the Halcon metamorphics are distributed limitedly and are composed of two types: a green schist and a mica schist type which is distributed across the northern area, and the other type which is composed of amphibolite and epidote-amphibolite which are found with the Ultramafic complex. It would appear that the former type has a comfortable contact with the Mansalay formation and that the latter has a fault contact. It is inferred that the boundary between the mica schist and the phyllite are oblique to the structure of the Mansalay formation.

From this evidence it may be considered that the Halcom metamorphics and the Mansalay formation were formed at the same time and that their rock facies became different because of later metamorphism.

2. Rock Facies and Structure of Ultramafic Complex

This phase survey disclosed that the Ultramafic complex is predominantly composed of harzburgite, dunite and lherzolite along with orthopyroxenit, hornblendite, gabbro, diorite porphry and trondjemite, and that also alternating layered structures of dunite and harzburgite are developed in a large-scale complex body. The following zonal structures can be estimated in the five typical complex bodies in the area, based on the tendencies of these structures and the rock type distribution.

– Ogos body .... This is a concentric circular, zonal structure tending E–W at the center, NW–SE in the east and NE–SW in the west.

– Bongabong body .... This is zonal structure tending NW–SE.

– Pintin body .... This is a zonal structure tending NW–SE at its center and in the south, and tending E–W in the north.

– Liwliw body .... This is a zonal structure tending WNW–ESE.

– Igsoso body .... This is a zonal structure tending E–W to ENE–WSW.

A detailed survey is necessary to clarify the structure in the bodies in connection with the chromite ore horizon.

3–2 Ore Deposits

3–2–1 Chromite Deposits

(i) Characteritics of deposit, host rock and ore

There are two chromite deposits in the east, viz., the Ogos and the Banus, and six deposits in the west including the Igsoso. All of these occur in the Ultramafic complex.

The shape, ore texture and host rock are listed in Table 2 for each type.

Table 2 Characteristics of Each Deposit

Name	Type	Ore Texture	Host Rock
Ogos	layered	idiomorphic	dunite
Banus	massive	xenomorphic, cataclastic	harzburgite
San Vicente	massive	idiomorphic, cataclastic	harzburgite
Mariri	massive	idiomorphic	serpentinite (dunite?)
Marriel	?	xenomorphic, cataclastic	harzburgite ?
Igsoso	layered	xenomorphic	dunite
Liwliw	massive	xenomorphic, cataclastic	harzburgite
Pintin	massive	idiomorphic	harzburgite

As can be seen from the table, there are layered or banded deposits in the dunite, and which are composed of densely spotted, impregnated and massive (very few) ores. Examination by microscope reveals that most of the crystals have an idiomorphic form and have no shear fractures which indicate that the crystals have not moved since crystallization. On the other hand, the massive deposits in harzburgite occurring near dunite nearly always occur along faults or have been dislocated by fault. Examination by microscope reveals that most of the crystals have xenomorphic and fragmented forms with cataclastic textures indicative of some movement having occurred after crystallization. The ore bodies of this type are in pod-, lens- or other forms which result from either compression or tension.

When the chemical compositions of the chromite occurring in this area are plotted onto the Cr–Fe–Al diagram, the result shown in Fig. 3 is given.

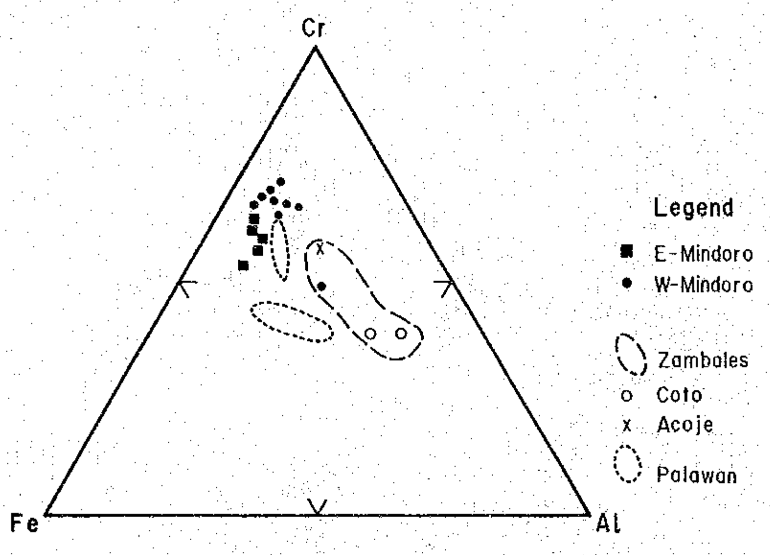


Fig. 3 Cr-Fe-Al Diagram of Chromite Ores

This figure shows that the chromite ores in this region are of the metallurgical type and have a high content of Cr and Fe, and are chemically different from Zambales and Palawan types. The chromite ores in the east tend to be rich in Fe and poor in Cr when compared to those in the west.

(ii) Relation between ore deposits and geochemical anomalies

The zones of geochemical anomaly correspond well to the areas of ore deposits in such a manner that the stream sediments collected in the Ultramafic complex area contain relatively high values of Cr and those in the ore deposit area have even high values.

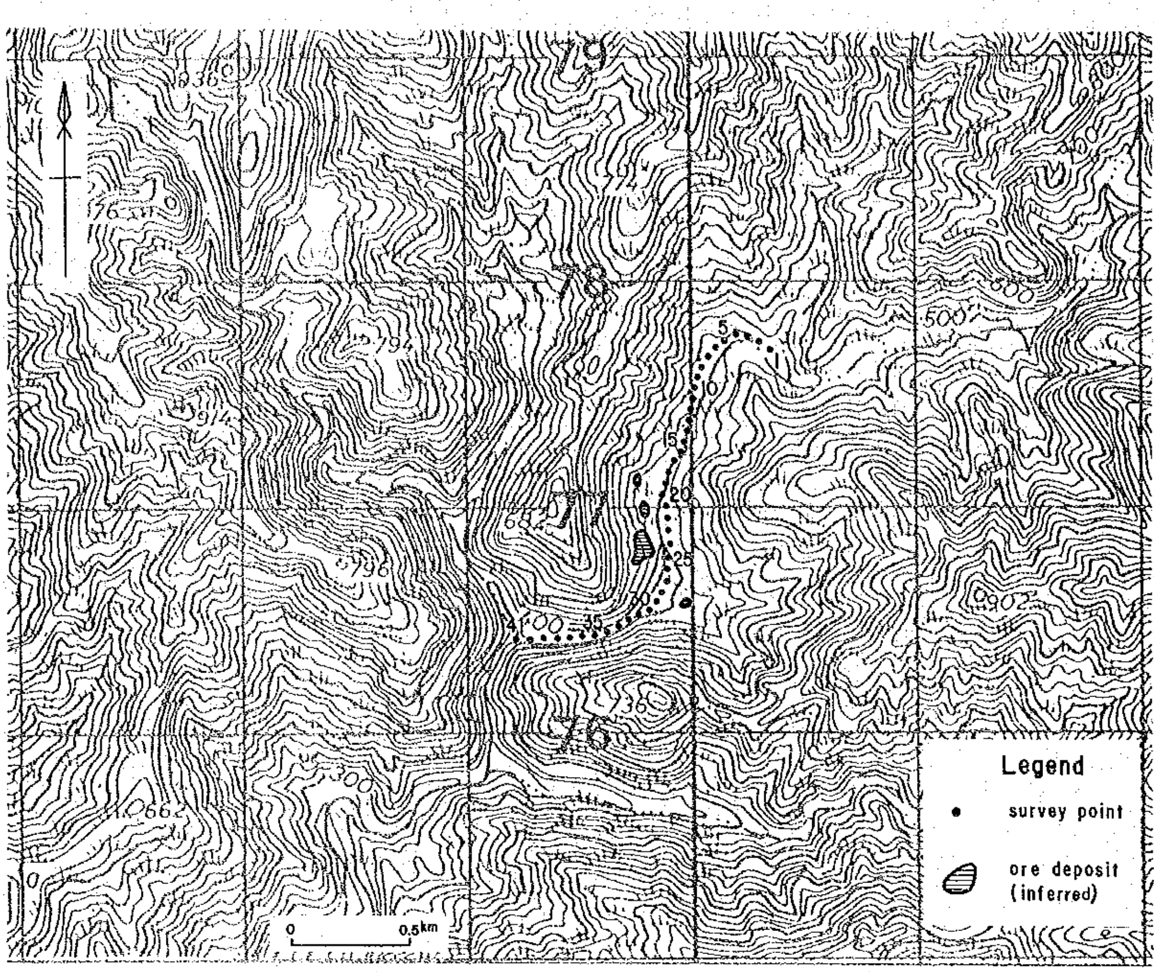
There are three bodies having an area of more than 100 km^2. These are the Ogos and Bongabong in the east and Pintin in the west. The Cr content is the highest and massing is most predominant in the Ogos body. The next highest values are shown by Bongabong and Pintin bodies respectively. A similar trend can be clearly observed in the chromite distribution in the heavy minerals, suggesting that there is a close relation between these trends and abundant dunite (clearly connected with Cr deposits) in the east.

3–2–2 Iron Deposits

The numerous iron deposits located on the top of the northern part of the central mountain range are contact metasomatic deposits formed by quartz diorite–diorite intrusion into limestone. They are mainly composed of magnetite with skarn minerals such as garnet, epidote and amphibole, etc.

There are three relatively massing iron deposits (viz., Nagsabongan, Lasala and Lapa-ao) occurring within an area of 12 km x 5 km in the upper stream of the Mamburao River. Each of these can be reasonably expected to have a $10^6 - 10^7$ ton ore reserve. Since the ores are in good quality (50–60% Fe) and have few penalty elements such as S, P and As, etc., a prefeasibility study may be beneficial.

Fig. 4 shows the results of the magnetic survey which was experimentally measured at about 50 m intervals using a proton-type magnetometer in the Lasala deposit area with very few exposures. The results show clear magnetic anomalies extending for about 300 m in the deposit area, indicating that the deposits consist of a few ore bodies. The ease of distinguishing ore bodies from skarns using magnetic intensity, indicates the effectiveness of ground magnetic surveys.



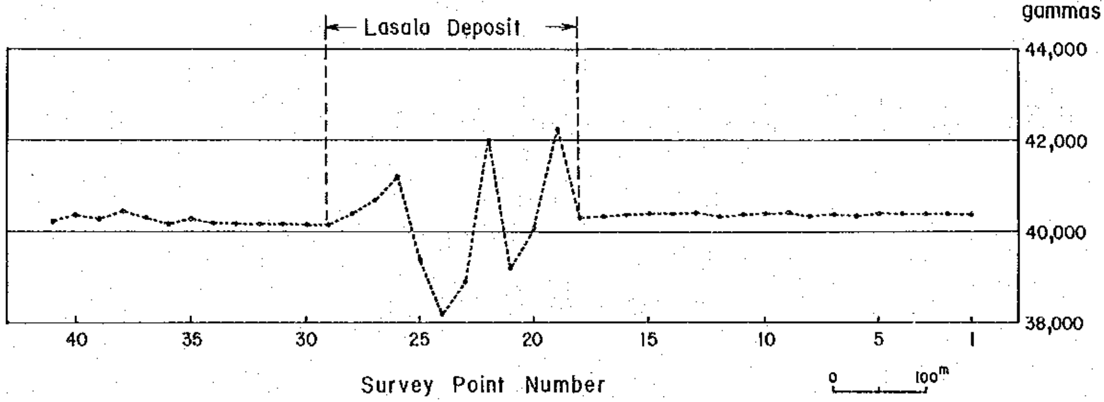


Fig. 4 Magnetic Survey Results in Lasala Area

Chapter 4. Conclusions and Recommendations for the Phase III Survey

4–1 Conclusions

The following is a summary of the conclusions drawn on the results of the geological and geochemical surveys which were carried out in the same manner as Phase I, in order to make more evident the geology and the occurrence of ore deposits in the area.

1. The stratigraphy and geological structure established in Phase I are almost applicable to the Phase II survey area.
2. The Ultramafic complex bodies composed mainly of harzburgite, dunite and lherzolite have intruded into the area as the shape of solid emplacement. The zonal structures can be estimated macroscopically in large-scale bodies based on the layering structures developed in the constituent rocks.
3. The occurrence of chromite deposits in the Ultramafic complex was clarified and consideration of their occurrence together with the geochemical survey results indicates that there is a possibility of the presence of chromite deposits in the eastern complex.
4. Iron deposits were proved to be contact metasomatic deposits formed by dioritic rock intrusion into limestone. Three encouraging iron showings were checked in the iron ore -bearing area and are 50 – 60 % Fe in grade and have the potential for growing larger up to the one to ten million ton level.
5. The mineragenetic province can be illustrated in Fig. 5 on the basis of the whole survey results in this phase. It has almost the same configuration as the one of Phase I, except that the Cu–Zn anomalous zone (Siange) of Phase I has changed into an Au zone and that some have disappeared (Rayusan, Mangpon and Alitaytayan).

4–2 Recommendations for the Phase III Survey

The check survey of known mineral showings for making an inventory table is considered to have almost finished in Phase I and Phase II. The outcrops of chromite and copper ores, etc. which were discovered in this phase are only indications but these are judged as being promissing from the viewpoint of geology and ore deposit. It is therefore, recommended to carry out the following surveys.

1. Geological and geochemical surveys emphasizing the clarification of the zonal structures in the Ultramafic complex. These will be effective for exploration of chromite ore deposits. Ogos, Bonganong, Igsoso, Pintin and Liwliw are the ultramafic bodies to be surveyed.
2. Geological and geochemical surveys to investigate the posibility of and to trace the extension will prove beneficial for the bedded cupriferous pyrite ore deposit in the upper stream

of the Agloban River and the vein type ore deposits in the Pula River.

3. Geological survey to investigate the extension will be effective for the iron deposits in anticipation of unexpectedly good quality ore.
4. Geological and geochemical surveys will be effective in case it is required to confirm a more specific occurrence of silica, gold, or other minerals.

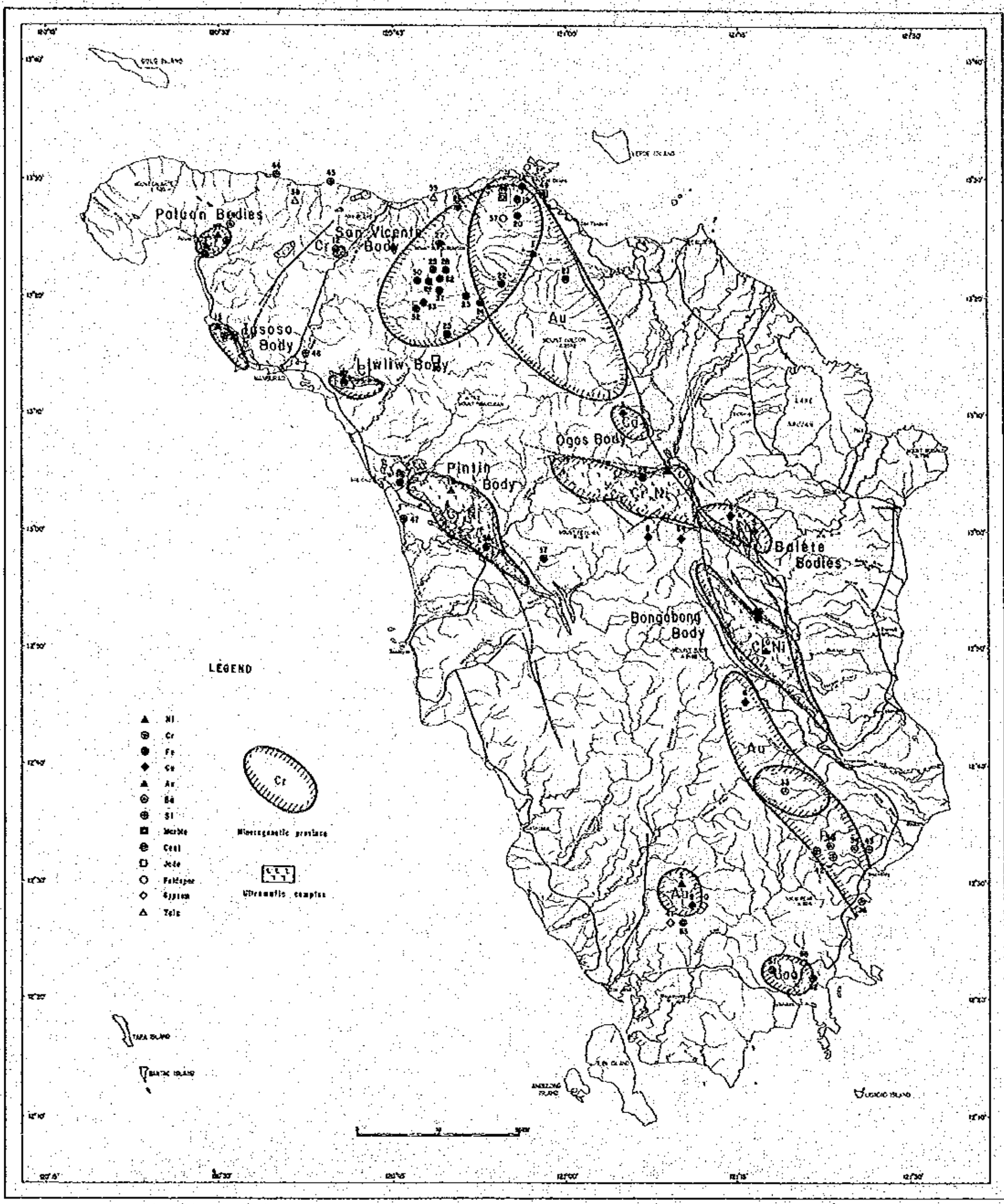


Fig. 5 Mineragenetic Province of the Survey Area