REPORT ON THE MINERAL EXPLORATION IN THE REPUBLIC OF THE PHILIPPINES PHASE II (I) MARCH 1986

# REPORT
# ON
# THE MINERAL EXPLORATION

## MINERAL DEPOSITS AND TECTONICS OF TWO CONTRASTING GEOLOGIC ENVIRONMENTS IN THE REPUBLIC OF THE PHILIPPINES

## PHASE II
## MASBATE AREA NORTHERN LEYTE AREA SOUTHERN LEYTE·DINAGAT·SIARGAO AREA AND PARAWAN I~IV AREA

## (I)

MARCH 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

NO. 56

# REPORT
# ON
# THE MINERAL EXPLORATION

## MINERAL DEPOSITS AND TECTONICS OF TWO CONTRASTING GEOLOGIC ENVIRONMENTS IN THE REPUBLIC OF THE PHILIPPINES

## PHASE II
## MASBATE AREA NORTHERN LEYTE AREA
## SOUTHERN LEYTE·DINAGAT·SIARGAO AREA
## AND PARAWAN I～IV AREA

MARCH 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

# REPORT
# ON
# THE MINERAL EXPLORATION

# MINERAL DEPOSITS AND TECTONICS OF TWO CONTRASTING GEOLOGIC ENVIRONMENTS IN THE REPUBLIC OF THE PHILIPPINES

## PHASE II
## MASBATE AREA NORTHERN LEYTE AREA SOUTHERN LEYTE・DINAGAT・SIARGAO AREA AND PARAWAN I~IV AREA



MARCH 1986

JAPAN INTERNATIONAL COOPERATION AGENCY

METAL MINING AGENCY OF JAPAN

## Preface

The Government of Japan, in response to the request by the Government of the Republic of the Philippines, decided to survey the potential of mineral resources in the eastern Luzon, Visayas and Palawan and entrusted the survey work to the Japan International Cooperation Agency. The Agency, considering the importance of technical nature of the survey work, in turn sought the cooperation of the Metal Mining Agency of Japan to accomplish the work.

In its second fiscal year, this Report presents the studies on geological, geochemical surveys and spot investigation for mineral showings in Masbate Area, Northern Leyte Area, Southern Leyte · Dinagat · Sargao Area and Palawan Area from August 1985 to February 1986.

The survey works was carried out according to schedule with great cooperation of the Philippine authorities concerned, especially the Bureau of Mines and Geo-Sciences (BMG), Ministry of Natural Resources.

Moreover, this report was compiled with the data on various chemical testings, those statistical treatment, microscope observation and fossils identification, which had been performed after the field work, and composes of one part of the final report.

As for survey results of Palawan Area detailed explanation will make in the report of next fiscal year.

In conclusion, we wish to take this opportunity to express our heartfelt gratitude to the officials of the Government of the Philippines and the Ministries of Foreign Affairs and International Trade and Industry of Japan, the officials of the Embassy of Japan in the Philippines and member of concerned companies.

March, 1986

Keisuke Arita

Keisuke Arita

President
Japan International Cooperation Agency

Masayuki Nishiie

Masayuki Nishiie

President
Metal Mining Agency of Japan

**Summary**

This survey have carried out as the second year field work for Impremental Agreement which concluded 26th of September 1984.

This report is summerized results of field survey and results of statistical analysis on microchemical analysis data on Masbate area, Northern Leyte area and Southern Leyte · Dinagat · Siargao Area.

Following items are clarified by synthetic consideration on these results .

1) Survey Area was divided by the Philippine Fault into east side and west side. Former basement consist of Pre-Tertiary Ophiolitic Terraine and crystalline schist and suffer strong block movement, on the contrary later basement consist of Palaeogene sedimentary rocks and show gentle folding.

2) Kinds of known mineralization are as follows; originating Pre-Tertiary ophiolitic terraine and green schist, originating dioritic activity which intruded in Miocene, sedimentary oringine deposit in Neogene, fumarole native sulpher deposit accompanying newly volcano and weathering residual deposit.

3) Extracted anomalous zones which assume to have intimate relation to strong mineralization are as follows; 1 Around Aroroy Mine (Masbate Is.) 2 Around Mt. Uac (Masbate Is.) 3 Northwest side of Tacloban City (Leyte Is.) 4 Around Antipole Mineral Showing (Leyte Is.) 5 East coast of Panaon Is. (southend of Leyte Is.) 6 Around Mt. Gaboc (southend of Dinagat Is.) 7 Westcoast of Masapelid Is.

4) Some extracted anomalous zones have difficulties to find out correspond mineralization, such anomalous zones are as follows;

   1 Anomalous zones of Cu, Zn, Ni, Co, Mo, As, in Pliocene and Pleistocene series at southside of Mt. Bagacay south eastern Masbate Is.
   2 Anomalous zones of Pb, Mn, Mo, As, Hg in Pliocene sediments at middle part of Northwestern Peninsula of Leyte Is.

## Contents

**List of Table**

## List of Illustrations

## List of Attached Plate



## Appendix

Fig-1 Location Map of the Survey Area

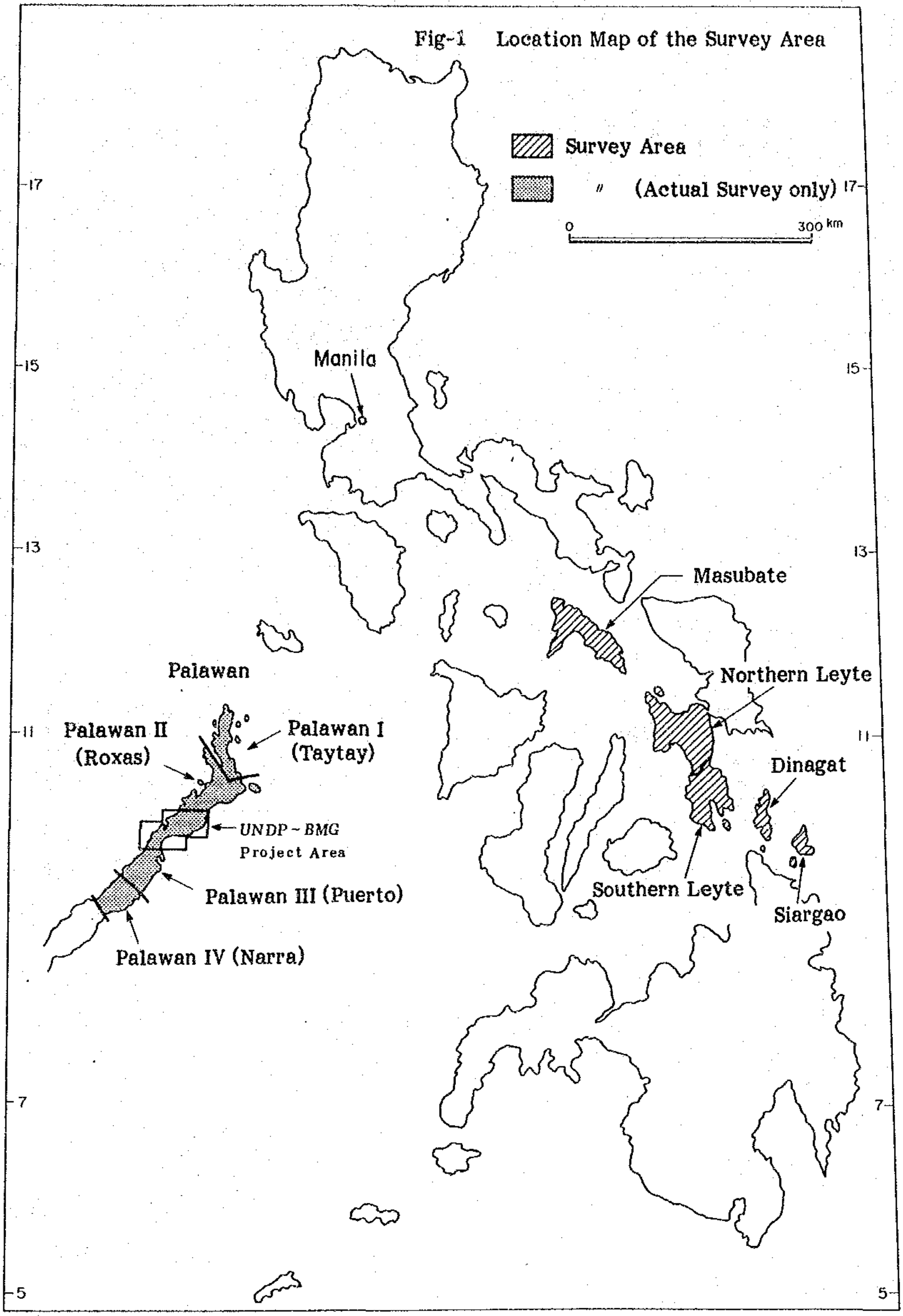
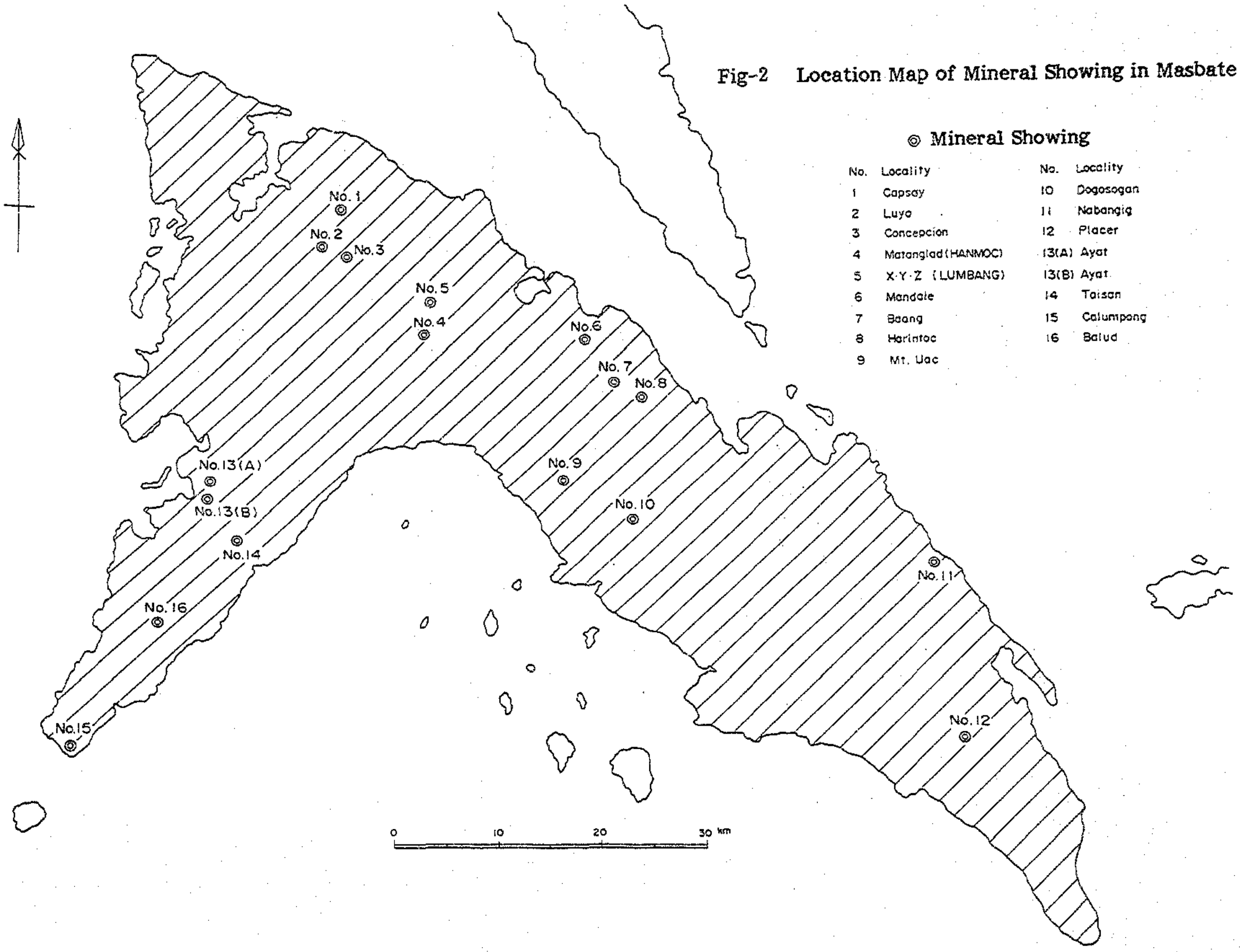


Fig-2 Location Map of Mineral Showing in Masbate



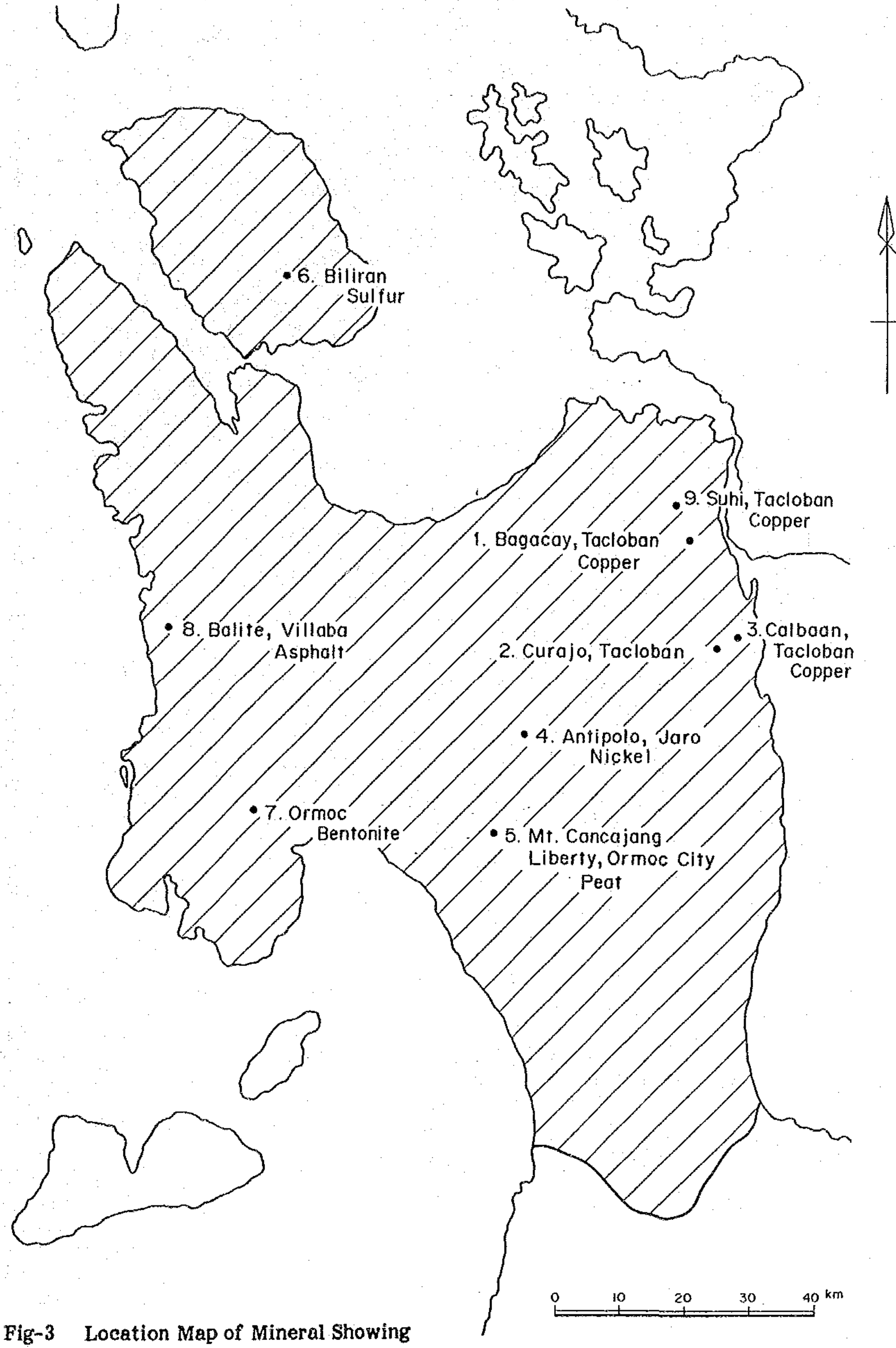



Fig-3 Location Map of Mineral Showing in Northern Leyte

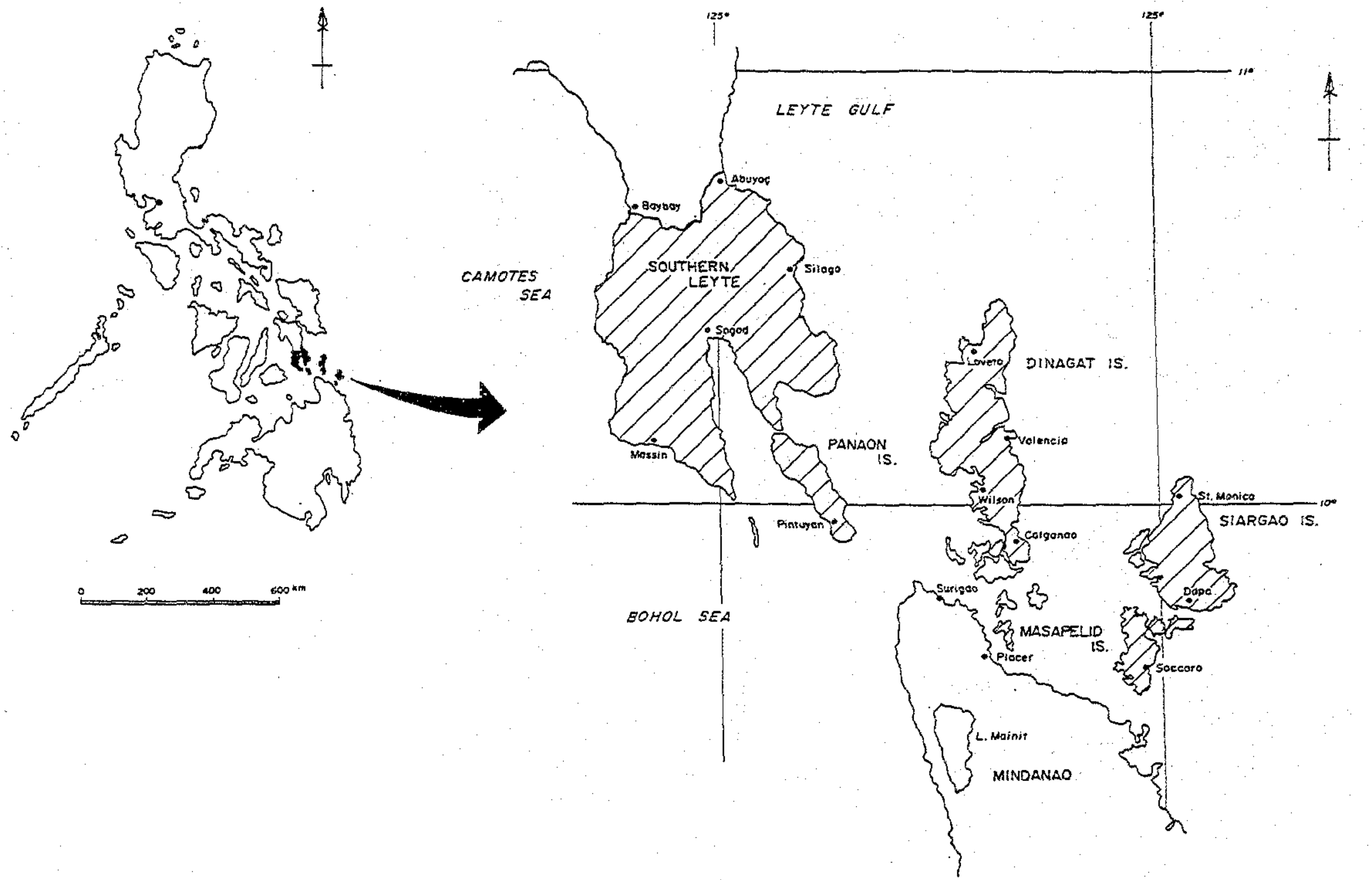



Fig-4 Location Map of Survey in Southern Leyte Dinagat · Siargao

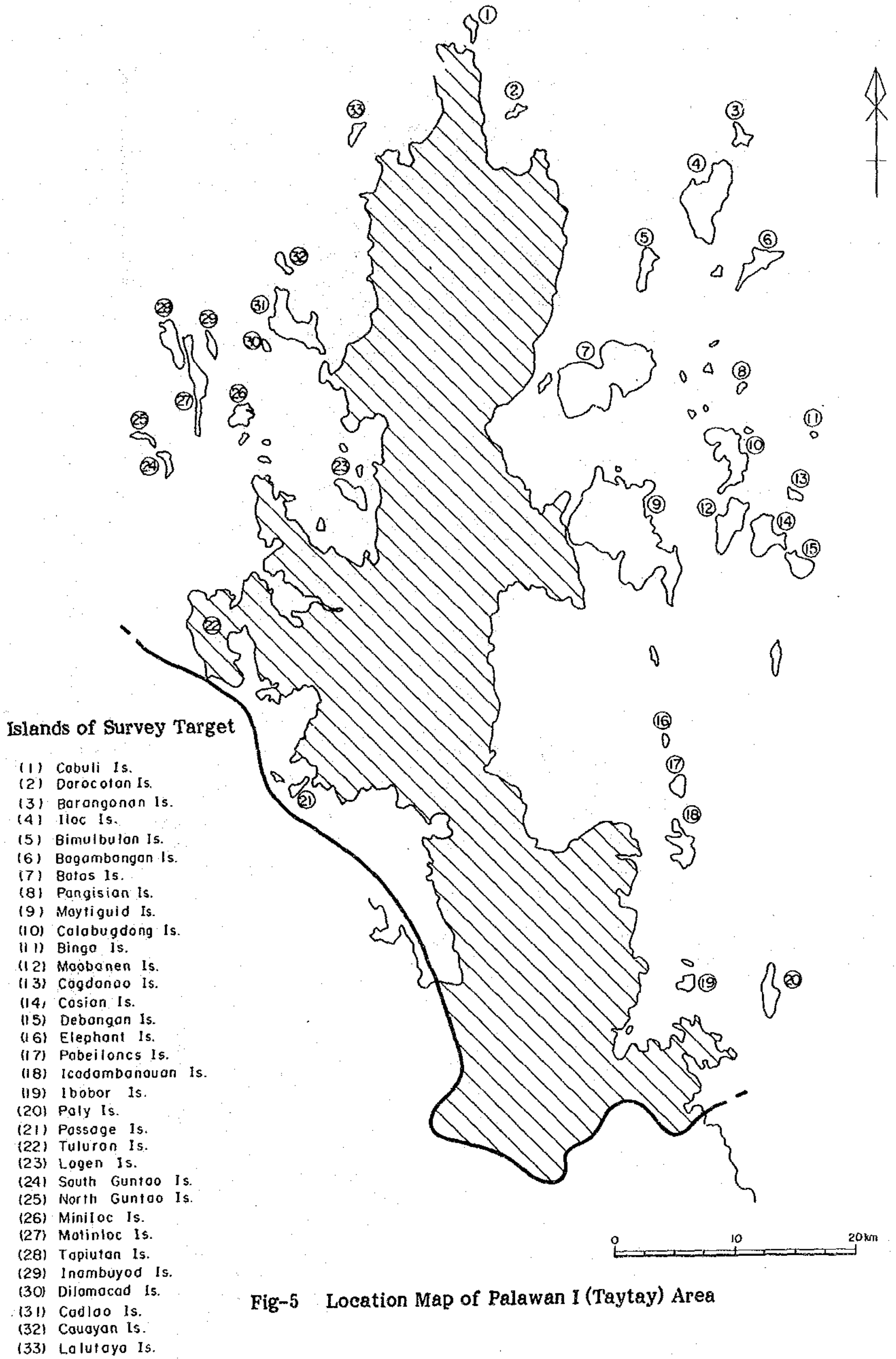



Fig-5 Location Map of Palawan I (Taytay) Area

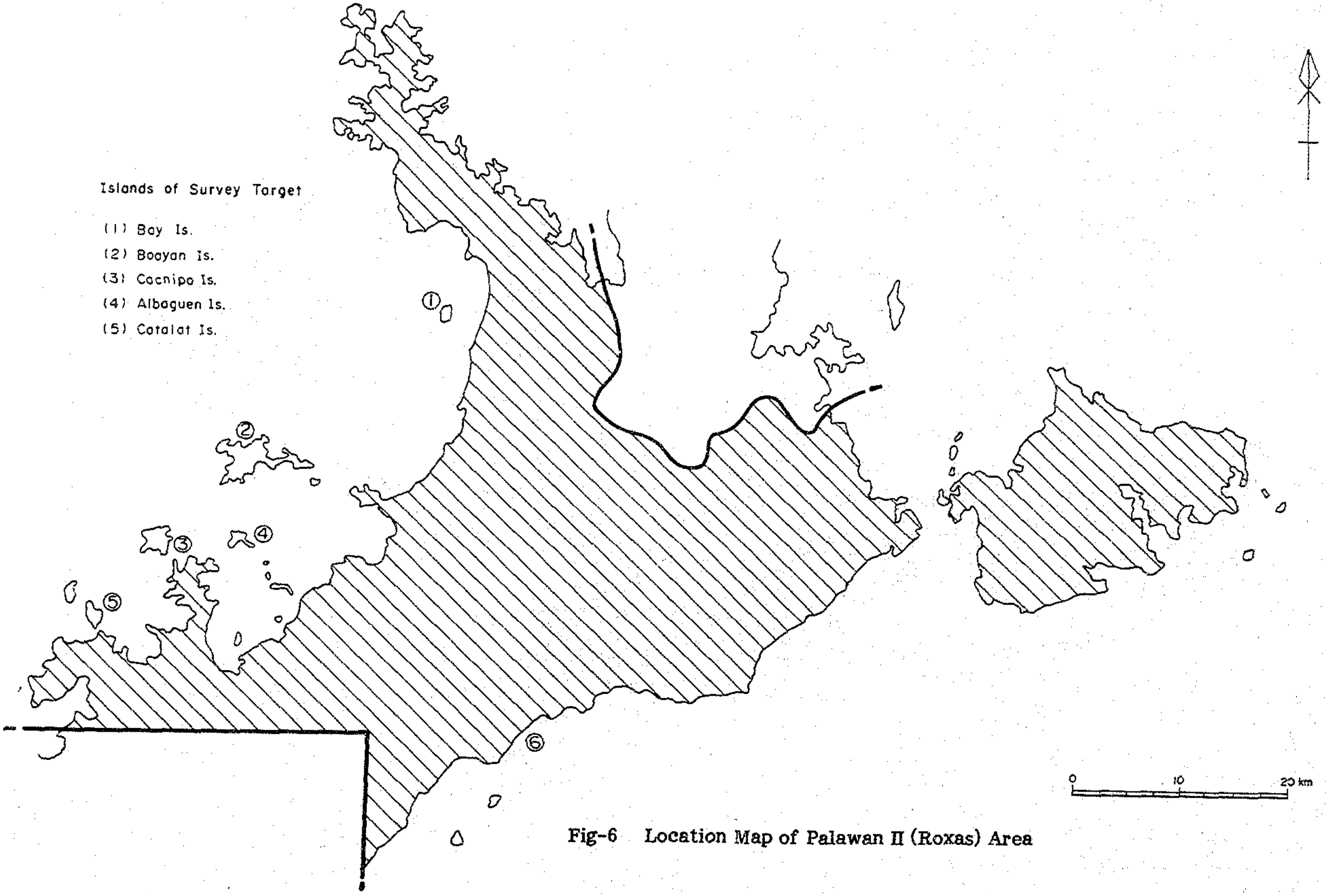



Fig-6 Location Map of Palawan II (Roxas) Area

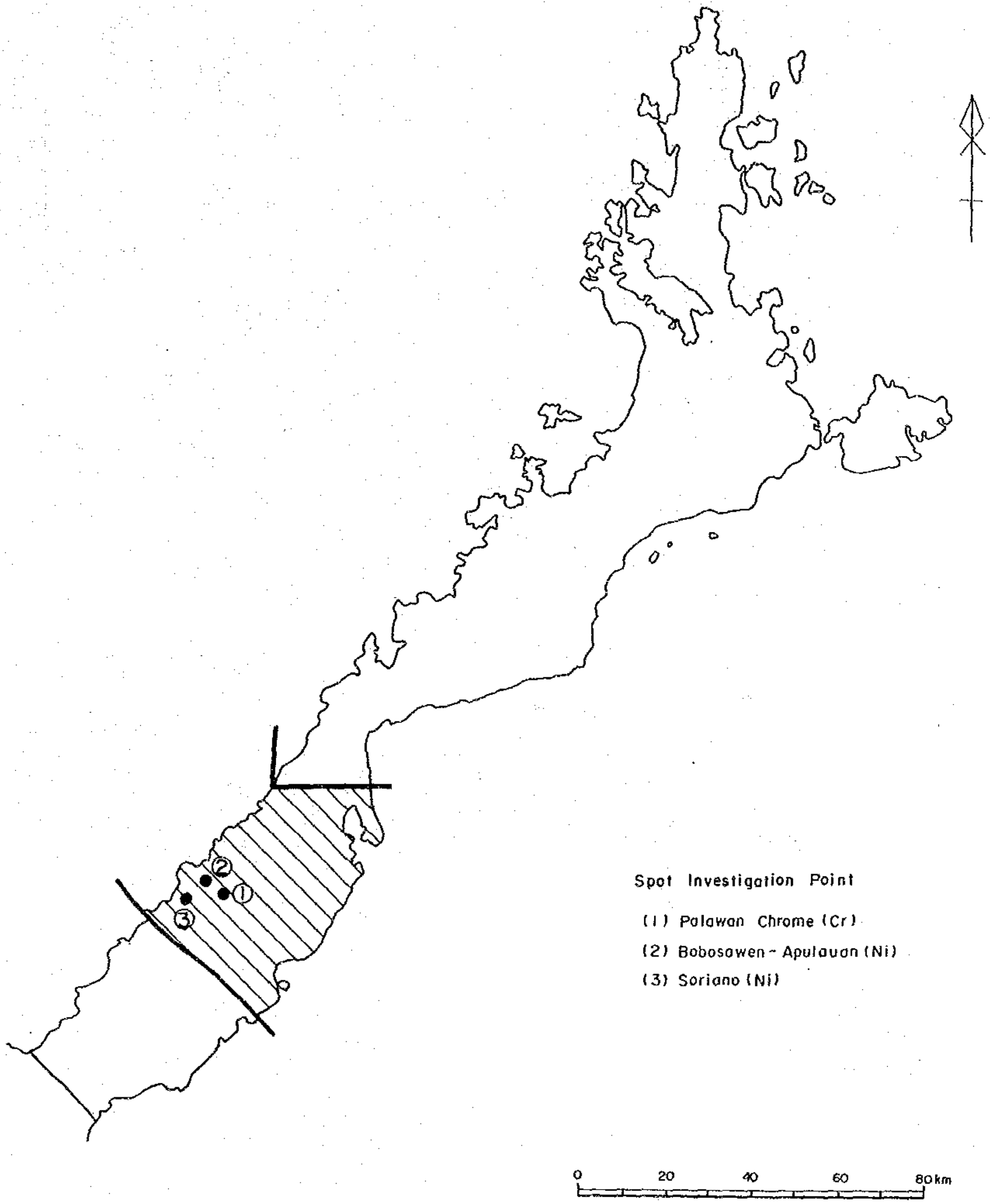



**Fig-7 Location Map of Palawan III (Puerto) Area**

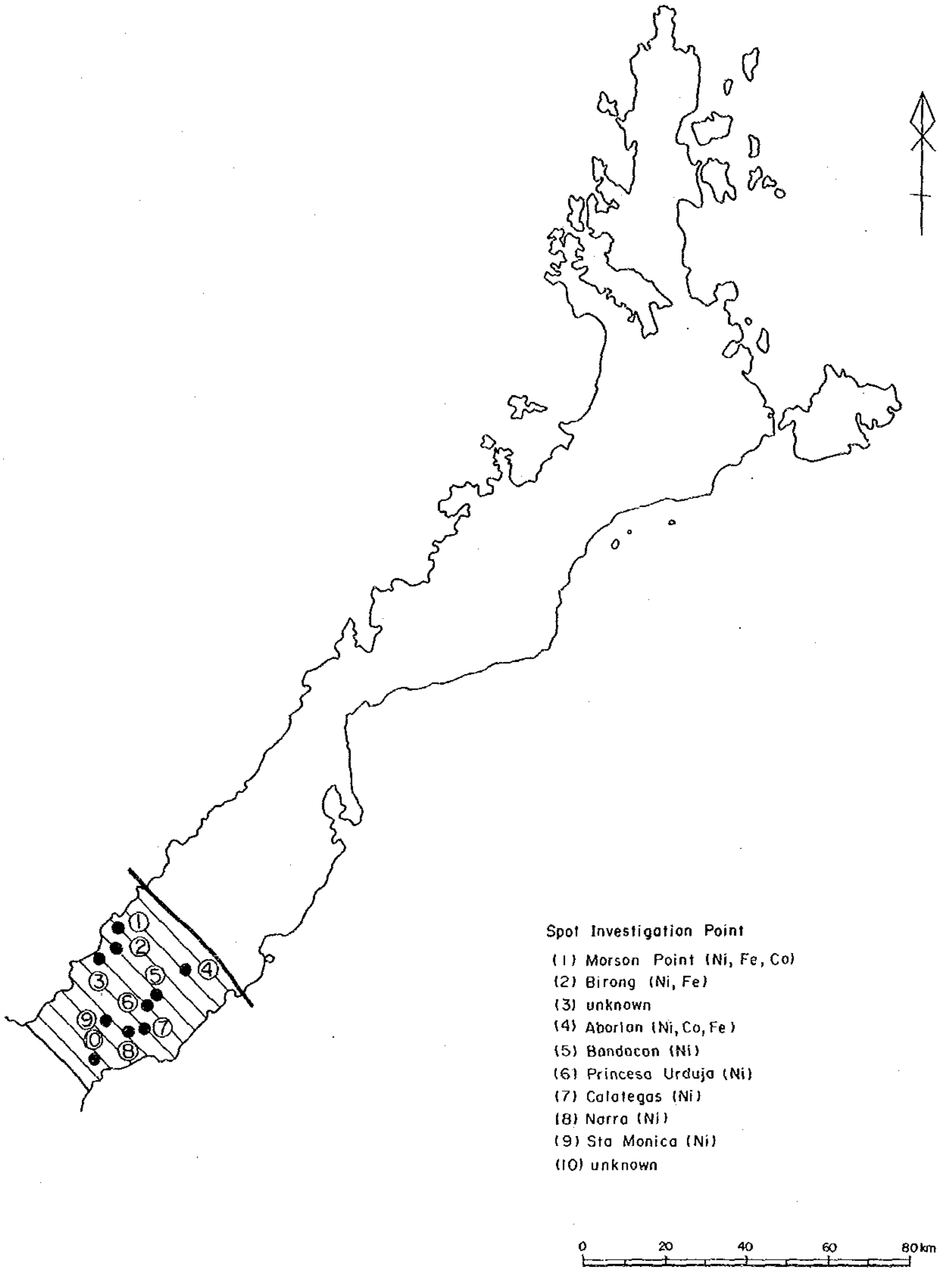



Fig-8 Location Map of Palawan IV (Narra) Area

# 1. INTRODUCTION

# 1 Introduction

## 1-1 Background and Objective of Survey

### 1-1-1 Background and Particulars

According to the Implementing Arrangement which was agreed upon between the Bureau of Mines and Geo-Sciences (BMG), Ministry of Natural Resources of Philippines and the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ) on September 26, 1984, the second stage field work were performed on the Masbate Area, the northern Leyte Area and the Southern Leyte, Dinagat, Siargao Area from 21st August 1985. As for Palawan I-IV Area, actual survey was started from 13th Jan. 1986.

### 1-1-2 Objective of Survey

The objectives of this survey are to explore and assess the mineral potential and the mineral inventory maps of the survey area by means of the synthesis on the result of geochemical analysis, many testings on various samples collected from the survey area, and the previous exploration data etc..

## 1-2 Contents of Survey

### 1-2-1 Field Work

The field work was carried out during 79 days from August 21, 1985 to November 7, 1985 in the Masbate Area, the Northern Leyte Area, and the Southern Leyte, Dinagat, Siargao Area.

In this work, stream sediment samples were collected at the rate of 1 sample per 1.0-+2.0 sq. km. along the main drainage and were microanalized on Cu, Pb, Zn, Ag, As, Hg, Co, Mn, Mo, Ni, and Cr. Moreover, pH and electric conductivity were measured at sampling points and heavy minerals collected by panning at junctions of main drainage were analyzed on Au, Ag, and Ga. Also the survey on geological structure and known mineral showings of these areas were carried out.

The details of collected samples are as follows:

1) Masbate Area.

| | |
|---|---|
| Survey Area | 3,251 sq. km. |
| Stream sediment samples | 2,281 |
| Duplicate samples | 67 |
| Heavy mineral samples | 179 |
| Spot survey point | 16 |
| Heavy mineral samples for spot survey | 99 |
| Petrographical thin sections | 30 |
| Ore polished sections | 15 |
| Whole rock analysis samples | 5 |
| Ore assay samples | 15 |
| X-ray diffraction analysis samples | 20 |
| K-Ar dating samples | 2 |
| Palaeontological samples | 20 |

2) Northern Leyte Area

| | |
|---|---|
| Survey area | 4,810 sq. km. |
| Stream sediment samples | 3,054 |
| Duplicate samples | 67 |
| Heavy mineral samples | 122 |
| Spot survey point | 9 |
| Heavy mineral samples for spot survey | 10 |
| Petrographical thin sections | 35 |
| Ore polished sections | 10 |
| Whole rock analysis samples | 5 |
| Ore assay samples | 10 |
| X-ray diffraction analysis samples | 20 |
| K-Ar dating samples | 3 |
| Palaeontological samples | 20 |

3) Southern Leyte, Dinagat, Siargao Area

| | |
|---|---|
| Survey area | 3,473 sq. km. |
| Stream sediment samples | 3,343 |
| Duplicate samples | 75 |
| Heavy mineral samples | 218 |
| Spot survey point | 14 |
| Heavy mineral samples for spot survey | 80 |
| Petrographical thin sections | 40 |
| Ore polished sections | 20 |
| Whole rock analysis samples | 10 |
| Ore assay samples | 20 |
| X-ray diffraction samples | 20 |
| K-Ar dating samples | 4 |
| Palaeontological samples | 20 |

4) Palawan I (Taytay) Area

| | |
|---|---|
| Survey area | 1,310 sq. km. |
| Stream sediment samples | 640 |
| Duplicate samples | 10 |
| Heavy mineral samples | 40 |
| Spot survey point | 33 |
| Petrographical thin sections | 20 |
| Ore polished sections | 10 |
| Whole rock analysis samples | 5 |
| Ore assay samples | 10 |
| X-ray diffraction samples | 10 |
| K-Ar dating samples | 3 |
| Palaeontological samples | 10 |

Palawan II (Roxas) Area

| | |
|---|---|
| Survey area | 2,080 sq. km. |
| Stream sediment samples | 1,050 |
| Duplicate samples | 20 |
| Heavy mineral samples | 80 |
| Spot survey point | 6 |
| Petrographical thin sections | 20 |
| Ore polished sections | 10 |
| Whole rock analysis samples | 5 |
| Ore assay samples | 10 |
| X-ray diffraction analysis samples | 10 |
| K-Ar dating samples | 3 |
| Palaeontological samples | 10 |

Palawan III (Puerto) Area

| | |
|---|---|
| Survey area | 1,330 sq. km. |
| Stream sediment samples | 790 |
| Duplicate samples | 15 |
| Heavy mineral samples | 50 |
| Spot survey point | 3 |
| Spot survey panning samples | 9 |
| Petrographical thin sections | 15 |
| Ore polished sections | 20 |
| Whole rock analysis samples | 5 |
| Ore assay samples | 20 |
| X-ray diffraction analysis samples | 10 |
| K-Ar dating samples | 2 |
| Palaeontological samples | 5 |

Palawan IV (Narra) Area

| | |
|---|---|
| Survey area | 1,170 sq. km. |
| Stream sediment samples | 770 |
| Duplicate samples | 15 |
| Heavy mineral samples | 50 |
| Spot survey point | 10 |
| Spot survey heavy mineral samples | 30 |
| Petrographical thin sections | 15 |
| Ore polished sections | 20 |
| Whole rock analysis samples | 5 |
| Ore assay samples | 20 |
| X-ray diffraction analysis samples | 10 |
| K-Ar dating samples | 2 |
| Palaeontological samples | 5 |

### 1-2-2 Synthetic Analysis

Statistical treatment on the assay results of stream sediment and heavy minerals, microscope observation of thin and polished sections, X-ray diffraction testing, while rock analysis, ore assay, K-Ar dating, and micro-fossils identification were carried out after the field work.

Consequently, the objectives of this survey were performed by means of the synthesis on the result of those analysis.

(Index map and spot investigation Fig. 1, Fig. 2 and Fig. 3)

## 1-3 Member and Itinerary of Survey Mission

### 1-3-1 Constitution of Survey Team

Participants in planning and negotiation, and survey member for the second fiscal year are listed as follows:

A. Planning and Negotiation

| | |
|---|---|
| Japanese Panel | |
| Makoto Ishida | MMAJ |
| Michihisa Shimoda | MMAJ |
| Jiro Osako | MMAJ |
| Yasuo Endo | MMAJ |
| Philippine Panel | |
| Juanito C. Fernadez | BMG |
| Guillermo R. Balce | BMG |
| Romeo L. Almeda | BMG |
| Noel V. Ferrer | BMG |

B. Field Work

| | | |
|---|---|---|
| Japanese member | | |
| Project manager | Yoshikazu Okubo | OMRD |
| " " | Akira Yatsuji | OMRD (For Palawan Area) |

| | | |
|---|---|---|
| Masbate Area | | |
| Leader | Makoto Kitami | Nikko Exploration & Development Co., Ltd. |
| | Fukio Kayukawa | " |
| | Takashi Isaka | " |
| Northern Leyte Area | | |
| Leader | Masakazu Kawai | Sumiko Consultants Co., Ltd. |
| | Takashi Tanno | " |
| | Hirotaka Nishimoto | " |
| Southern Leyte; Dinagat; Siargao Area | | |
| Leader | Yoshihiro Watanabe | Dowa Engineering Co., Ltd. |
| | Shigehisa Fujiwara | " |
| | Souichiro Tanaka | " |
| Palawan I (Taytay) Area | | |
| Leader | Katsuji Fukumoto | Mitsui Mineral Development Engineering Co., Ltd. |
| | Yuukichi Tagami | " |
| | Keishi Nakajima | " |

| | | |
|---|---|---|
| Palawan II (Roxas) Area | | |
| Leader | Shinichi Doi | Mitsui Mineral Development Engineering Co., Ltd. |
| | Minoru Kamezawa | " |
| | Ryohei Otsubo | " |
| Palawan III (Puerto) Area | | |
| Leader | Akio Shida | Nittetsu Mining Consultants Co., Ltd. |
| | Hiromitsu Nozawa | " |
| | Koji Uchiyama | " |
| Palawan IV (Narra) Area | | |
| Leader | Hiroshi Fuchimoto | Bishimetal Exploration Co., Ltd. |
| | Hiroshi Takahashi | " |
| | Shinji Naito | " |

| | | |
|---|---|---|
| Chemical Analyst | Ryuichi Ishizawa | OMRD |
| Philippine member | | |
| Project manager | Romeo L. Almeda | BMG |
| Assistant manager | Noel V. Ferrer | BMG |
| Analysis manager | Edwin G. Domingo | BMG |
| Masbate Area | | |
| Leader | Alvin Matos | BMG |
| Sub-leader | Fidel Zepeda | BMG |
| Sub-leader | Eleazar Mantaring | BMG |
| Northern Leyte Area | | |
| Leader | Alnulfo Cabantog | BMG |
| Sub-leader | Pedro Rovillos | BMG |
| Sub-leader | Ray Quebral | BMG |
| Southern Leyte; Dinagat; Siargao Area | | |
| Leader | Wilfredo Diegor | BMG |
| Sub-leader | Benjamin Cadawan | BMG |
| Sub-leader | Ulbano Palaganas | BMG |
| Palawan I (Taytay) Area | | |
| Leader | A. Cabantog | BMG |
| Sub-leader | E. Zepeda | BMG |
| Sub-leader | E. Mantaring | BMG |
| Palawan II (Roxas) Area | | |
| Leader | P. Rovillos Jr. | BMG |
| Sub-leader | F. Sajona | BMG |
| Sub-leader | E. Malaca | BMG |
| Palawan III (Puerto) Area | | |
| Leader | W. Diegor | BMG |
| Sub-leader | B. Cadawan | BMG |
| Sub-leader | E. Esguera | BMG |
| Palawan (Narra) Area | | |
| Leader | A. Matos | BMG |
| Sub-leader | L. Morales | BMG |
| Sub-leader | U. Palaganas | BMG |

Besides, about 30 BMG geologists engaged on the field work.

C. Constitution of field work party

One field work party was consisted of one Japanese geologist and 4 BMG geologists, in Masbate, northern Leyte and southern Leyte, Dinagat and Siargao Area, and each area was arranged 3 parties.

One geologic aid was arranged at each area for the implementation of drying and sieving samples collected and controling field materials at base camp.

Moreover, one party for sample preparing was arranged at PETROLAB to control samples. As for Palawan I-IV area, each party has one Japanese geologist and 3 BMG geologists.

D. Treatment of chemical analysis

Though the field work of three areas had need of micro-chemical analysis on about 7,500 samples collected of stream sediment (including duplicate samples) and about 650 samples of heavy minerals, micro-chemical analysis capacity of PETROLAB has still remained 2,000 samples per month. Therefore, PETROLAB was assigned to analyze 5,200 samples of stream sediment (10 elements analysis) collected from Masbate and Northern Leyte Area, and 650 samples of heavy minerals (3 elements analysis), by means of atomic absorption method. And 2,776 samples of stream sediments collected from the Southern Leyte, Dinagat, Siargao Area were requested to Chemex Lobs Ltd., Canada.

One Japanese chemist has stayed in PETROLAB for the purpose of checking analytical procedure from Oct. 1 to Dec. 20.

The working system of analysis was changed to irregular 2 shifts per day. (8:00-17:00, 12:00-20:00) As the result of this, all analysis had been finished up by Jan. 25 '86.

The analysis member for the above mentioned irregular 2 shifts per day consists of about 5 persons for decomposing samples, about 15 persons for operating ASS and about 5 persons for cleaning glass tools.

In Palawan I-IV area, chrome was selected as indicator, then analytical specialist stayed in PETROLAB to transfer analytical technique for chrome from 17th to 28th Feb. '86.

**1-3-2 Itinerary of Survey**

The survey work was carried out during 78 days from August 21 to November 7 for Masbate, Northern Leyte, Southern Leyte, Dinagat, Siargao Areas and 47 days from January 13 to February 28, 1986 for Palawan I-IV Areas.

Details of itinerary are as follows.

## Table-1 Itinerary List of Actual Survey

| | August | September | October | November | December | January | February |
|---|---|---|---|---|---|---|---|
| Arrangement with BMG | 8/21 8/27 | | 10/1 | 11/15 | | 1/13 1/18 | 2/25 2/28 |
| Field Survey of Masbate Area | 8/27 | | 10/6 | | | | |
| Field Survey of Northern Leyte Area | 8/27 | | 10/19 | | | | |
| Field Survey of Southern Leyte Dinagat · Siargao Area | 8/27 | | 10/31 | | | | |
| Field Survey Palawan I - IV Area | | | | | | 1/18 | 2/25 |
| Chemical Analysis in Petrolab | | 9/20 | | | 12/20 | | 2/17 2/28 |

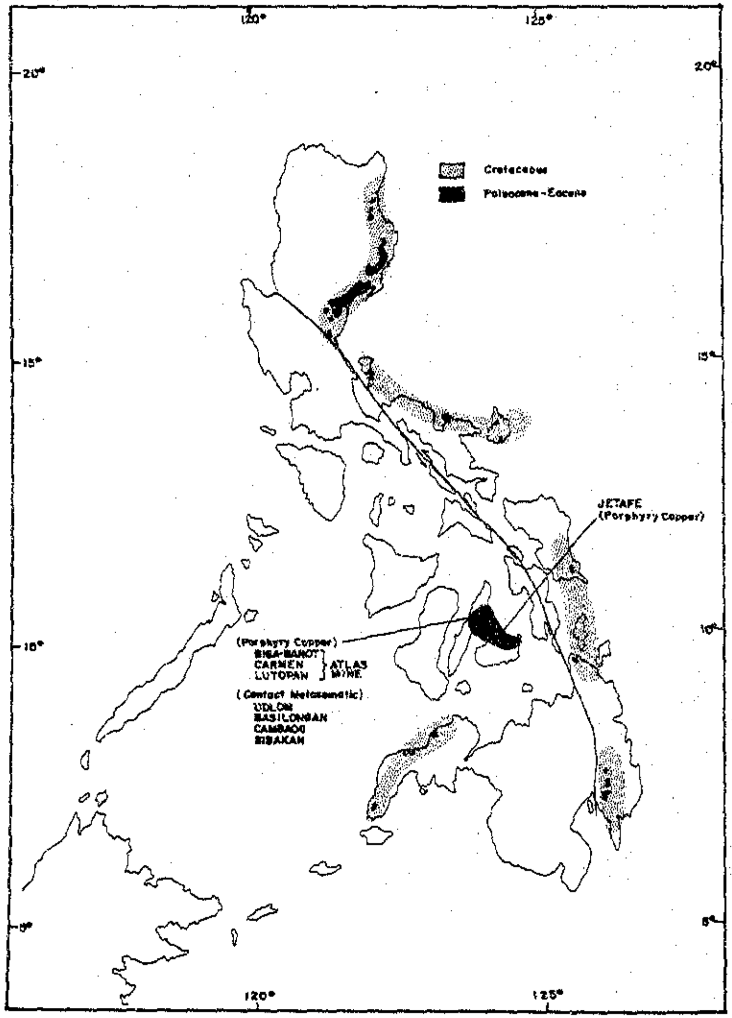



Fig-9 Cretaceous-Paleogene dioritic intrusives and associated copper deposits. (After A.S. Zanoria, 1984)

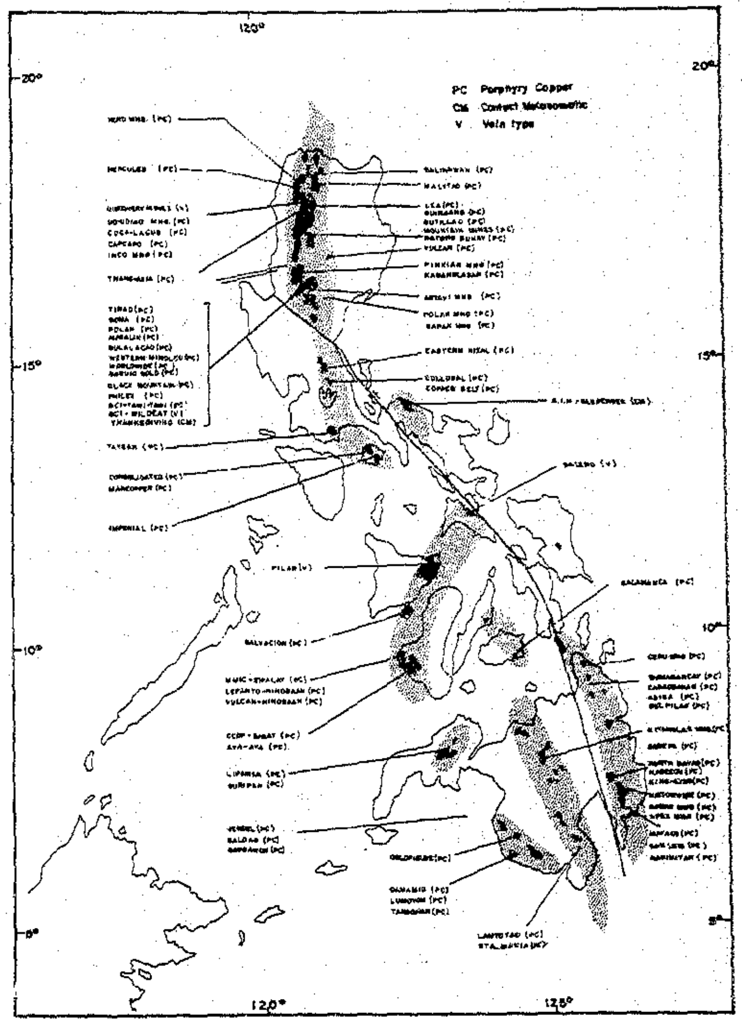



Fig-10 Oligocene-Miocene dioritic intrusives and associated copper deposits. (After A.S. Zanoria et al., 1984)

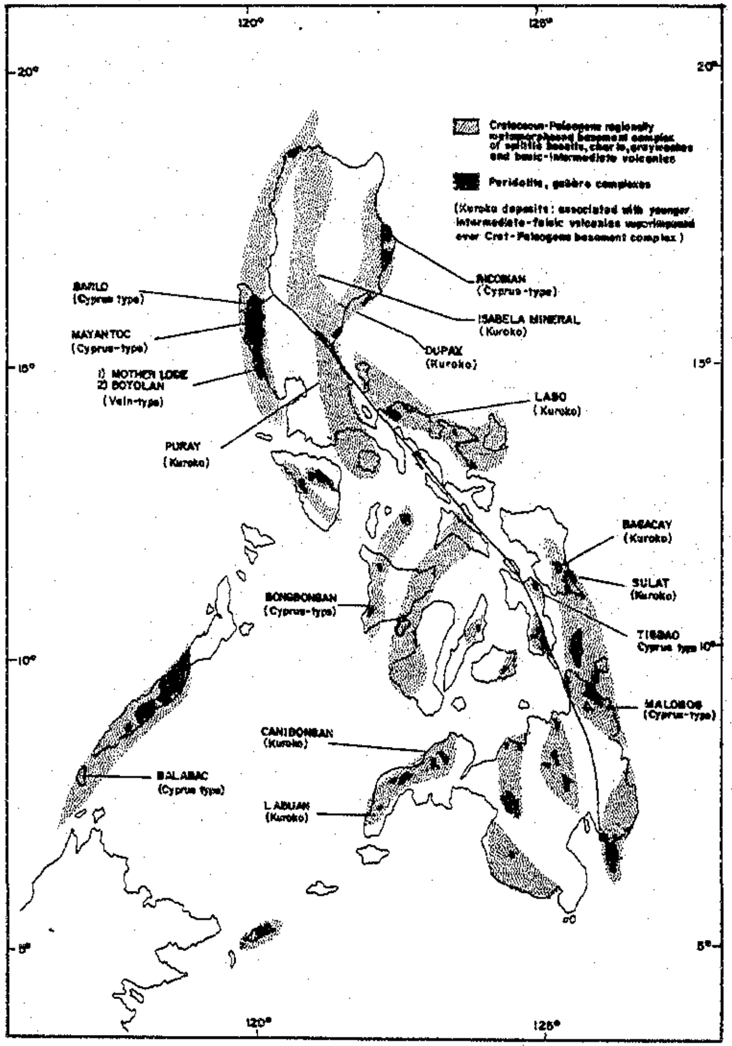



Fig-11 Ophiolitic terr.i anes
and associated copper deposits.
(After A.S. Zanoria, 1984)

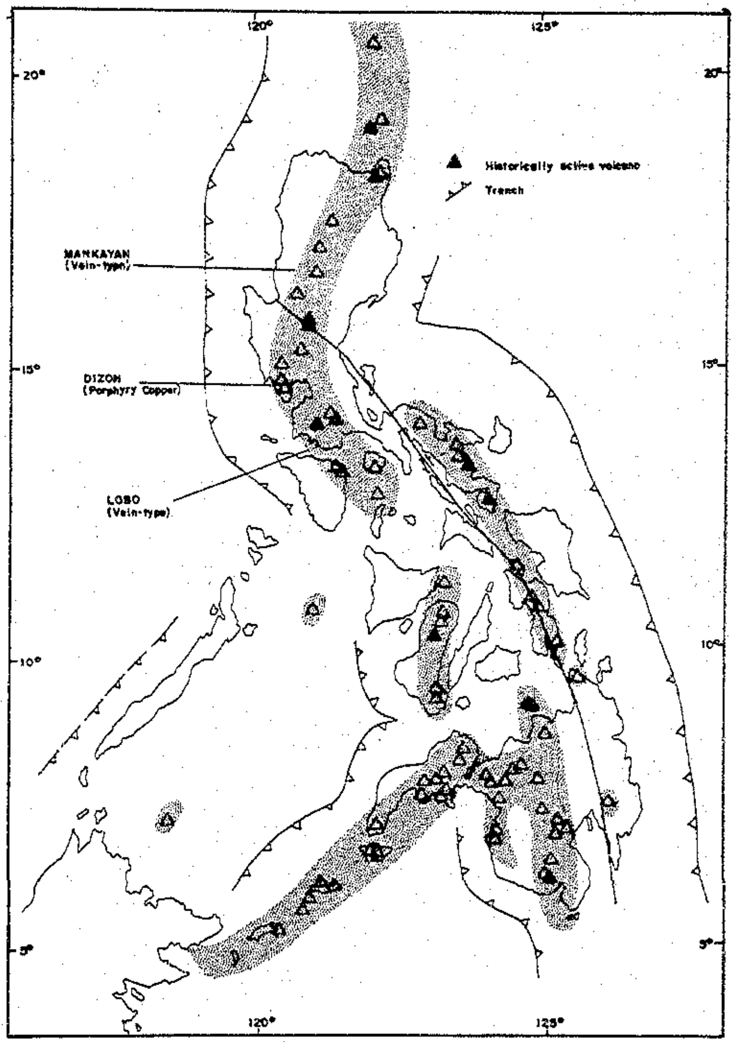



Fig-12 Pliocene-Recent volcanic centers
and associated copper deposits.
(After A.S. Zanoria, 1984)

# 2. GENERAL DESCRIPTION OF PHYSIOGRAPHY, GEOLOGY AND MINERAL

## 2 General Description of Physiography, Geology, and Mineral Deposits on Survey Area

### 2-1 Physiography and Geology

Three survey areas belong together to the Philippine Mobil Belt. Masbate, Leyte Area, situate in the Central Physiographic Province and Dinagat, Siargao Area locate in the Eastern Physiographic Province.

Central part of Masbate Island consists of Palaeocene diorite-granodiorite batholith belt which intruded in Cretaceous-Palaeocene metasediment. This relationship is similar to Guimalas Island and south-western part of Negros Island.

Those Cretaceous and Palaeogene formations were covered by Oligocene-Miocene volcanic clastics and limestone, then weakly folded and suffered intrusion of quartz diorite-porphyry of late Miocene. All of those formations were covered by late-Miocene--Recent formations.

Northeastern Leyte Island is consisted of foliated meta-volcanics, serpetinized peridotite and early-middle Miocene sedimentary rocks, and divided by block movement of thrust. The west side of this area is covered by unchanged marine-terrestrial late Miocene-Pleistocene sediments along central mountain range which has N-S direction.

Western Leyte Island is occupied by early-late Miocene sediments and volcanics, and have formed NW direction folding zone. Late Miocene volcanics are predominant at east side of Philippine fault which cut the folding zone with oblique angle.

In the southeastern Leyte, many small stocks of middle Miocene diorite and peridotite which cut by thrust and serpentinized have exposed. Pliocene-Pleistocene lava and volcanic clastics are covered without deformation. Andesitic volcanic corns distribute along the Philippine fault.

Dinagat and Siargao Area consist of thrust up ultramafic rocks, Cretaceous-Paleogene metasediments and basaltic metavolcanics which assumed as upper member of ophiolite formation, and Eocene serpentinized peridotite pebble bearing clastics and limestone are seen as uplifted terrain accompanied with Cretaceous-Paleogene formation and ultra-mafic rocks. Beside of this terrain, strong folded early and middle Miocene clastics and limestone constitute thrust-folded formation and have been intruded by middle-late Miocene quartz diorite, andesite and dacite. Pliocene-Pleistocene upper most formation which consist of undeformed andesitic volcanics-volcanic clastics, conglomerate and coral limestone cover all former rocks.

### 2-2 Tectonics

Cretaceous and Paleogene system which constitute middle of Masbate area uplifted as horst against Neogene system of northwest and southeast parts of this area. And northern part of this horst has been intruded by quartz-grano diorite with strong confusion of strata, the boundaries of this basement and Neogene system are NE direction of northwestern patrt and NS direction of southeastern part, and some parts of them are fault. This horst structure occupied northern part of the batholith belt which mentioned former chapter. Along the north-east seashore of Masbate Island NW tectonic line is assumed, which has parallel direction to Philippine fault, and strikes of Neogene formation in this part have showed same direction.

Leyte Island is cut by Philippine fault longitudinally, and in NE part of this island Cretaceous-Palaeogene schitosed metasediments is exposed accompanying with ophiolite.

In the west side of Philippine fault, early Miocene series which folded with NW axis covered broad area, and in NW peninsula, middle-late Miocene series covered former series with unconformity. In coast region Plio-Pleistocene series are distributed.

Some parts of Philippine fault became the pass ways of magma and geothermal fluid. In Dinagat Is. thrust-like movement is assumed between metamorphosed rocks and ultramafic rocks, and south western part is uplifted as step according to the influence of NW assumed faults. Foldings have same tendency as above mentioned structure NW-SE synclinal structure is considered between Loreto and Mabini.

In Siargao Is. along the valley which elongate from Espelansa to north-eastward synclinal structure is assumed.

## 2-3 Ore Deposits

In Masbate area, gold-silver, copper, manganese and phosphate mineralization are known, the types of ore deposits are as follows: gold-silver and copper deposits are hydrothermal vein type which formed from Palaeogene to Neogene Period and accompanied quartz-grano diorite activity. Manganese deposits are syngenetic sedimentary deposits which accompanied Cretaceous-Palaeogene chart formation.

In Northern Leyte area, copper, nickel, native sulphur, peat, bentonite and rock asphalt deposits are investigated. Many copper deposits are belonging to stratabound massive sulphide deposit which occur in Tacloban copper deposit zone accompanied to ophiolite. Some of copper deposits are hydrothermal vein type. Nickel deposit is epithermal vein and native sulphur is exhalation deposit accompanied Quarternary volcano.

In southern Leyte area, vein type gold, silver and copper deposits, stratabound manganese deposit, fissure filling manganese mineralization, and residual nickeliferous laterite deposit are investigated. Many argeliferous quartz veins are recornized in vein type deposits.

In Dinagat, Siargao area, ortho-magmatic chromite deposits and gold quartz veins are recognized. Chromite deposit is accompanied dunite and pyroxene peridotite (hartzburgite) and the later type is to be small scale.

# 3. RESULTS OF GEOLOGICAL SURVEYS AND INVESTIGATION ORE DEPOSITS

## 3 Results of Geological Surveys and Investigation of Ore Deposits

### 3-1 Geology and Mineral Deposits of Masbate Area

#### 3-1-1 General Summary

Masbate Island has belonged to Region V administrative district, and is the seat of central province city. The population of the island reaches 490,000 and main industry are cattle breading, coconuts plantation, fishery and mining.

There are three traffic means from Manila, air way, sea rout and sea-land mixing rout. Many people used to take air way (daily flight, about 1 hour for one way). However, heavy cargo used regular sea liner connected between Manila and Masbate. Sea-land mixing rout is not regular, but the conbination of Manila-Sorsogon land way and Sorsogon-Masbate sea rout is very common.

Main inland traffic of Masbate Is. is only National Highway which pass along northeast coast line. Other roads are bad condition and suspended in many places after rain.

Between Masbate city and Manila, other main city, telegram, telephone and telex are available but there are no means of communication between town to town in this island.

Geographical situations of this island are as follows.

| | |
|---|---|
| Broadness | 3,300 sq. km |
| Hightness | 0-697 m (Highest Conical Peak.) |
| Temperature | Max. 31.6, Min. 24.5 centigrade |
| Annual Precipitation | 1,857.3 mm |

#### 3-1-2 Succession of Each Formation

The basement rocks of Masbate Is. consist of patial metamorphosed Cretaceous-Palaeogene Series (KPG). Neogene Series Which consist of mainly sandstone and mudstone in lower part ($N_1$), mainly andesite limestone sandstone and mudstone in upper part (M, $N_2$), have overlain the basal formation. Neogene-Quarternary Series which consist of siltstone, marl and limestone have overlain all.

As for intrusive rocks, dioritic rocks distribute with various scales in north-middle part of the area and andesitic volcanic rocks usually formed lava flow but sometimes observed as intrusive rock.

<u>Cretaceous-Palaeogene Systems (KPG)</u>

This Systems consist of metasediments and metavolcanics. Metasediments contain slate, hard shale, sandstone and limestone. Slate and hard shale are black to greenish black colored flinty rocks developing minute cracks and being fragile in outcrops.

Sandstone show centi-meter alternation with shale in sometimes and partially tuffaceous silt stone are recognized. As the results of weak metamorphism, these rocks change to hard and recrystallization. Limestone show two types. One is massive and apophyllitic and another is stratified, either of them are recrystallized.

Metavolcanics consist of basalt flow, andesite flow and tuff breccia of those. Lava flows are predominate. As the results of weak metamorphism, color minerals change to green and show deep green-dark blueish green color.

Fig-13 Schematic Columnar Section of Masbate Area

| Period | Epoch | Sediments | | Intrusives | |
|---|---|---|---|---|---|
| Quaternary | Holocene | Qal | Recent River and Coastal Deposits, Coral Reef. | | |
| Quaternary | Pleistocene | NQS2 | Unconsolidated Tuffaceous Sand and Silt. | | |
| Quaternary | Pleistocene | NQS1 | Conglomeratic Fossiliferous and Loose Sponge-like Limestone. | | |
| Quaternary | Pleistocene | N2-3 | Andesitic Lava and Tuffbreccia. | An | Hornblend Andesite. |
| Neogene Tertially | Pliocene | N2-2 | Polous and Fossiliferous Limestone. | D | Hornblend Diorite. |
| Neogene Tertially | Miocene | N2-1 | Conglomerate, Sandstone, Siltstone. | | |
| Neogene Tertially | Miocene | N1 | Alternation of Mudstone, Siltstone, Sandstone and Conglomerate. | | |
| | Oligocene ∫ Cretaceous | KPG-4 | Meta-andesitic Volcanics with flow Breccia. | | |
| | Oligocene ∫ Cretaceous | KPG-3 | Meta-basalt Volcanics with flow Breccia. | GB | Hornblend Gabbro Coarse Grained. |
| | Oligocene ∫ Cretaceous | KPG-2 | Meta-sediments (Slate, Shale, Sandstone, Siltstone etc.) | | |
| | Oligocene ∫ Cretaceous | KPG-1 | Recrystalline Limestone. | | |

These Cretaceous-Palaogene Systems seems to stratify from buttom to top as metasediments (slate, sand stone, lime stone,), metabasaltic rocks metaandesitic rocks.

Distribution area shows anti-triangle shape connecting Aroroy, Magdaleno, Pulandula Point, Buri Point in north-middle part of Masbate Is.

Microscopical observation results.

The sample from west coast of Carogo Is. (sample No. LC61091385) shows the appearance of fair coarst grain two-pyroxene andesite which has porphyritic texture. Some parts of groudmass alter to sericite, and quartz zeolite veinlets observe in places.

Fossil identification results.

From the KPG siltstone sample northeast of Milagros (south coast Masbate Is.) microfossils of nanno-plankton are found out and the age is estimated to be Eocene-Oligocene.

The KPG metaandesite age determination in Carogo Is. (west coast Masbate Is.) which belong Palaeogene System is estimated to be 22.6 $\pm$ 1.1 m.y. (Lower Miocene) by K-Ar Method.

Neogene Series ($N_1$)

This Series consist of alternatives of stratified mudstone, siltstone, sandstone and conglomerate and small scale of andestitic or basaltic rocks. These volcanic rocks are abundant near metaandesitic rocks in lower part, some of them have stock shape. Conglomerate consist of andesitic rocks, and often show aglomerate appearance.

Distribution of this series have north-south trend and east dip and elongate band like shape along east side of Cretaceous-Palaeogene Systems exposed area.

Microscopical observation results.

The thin section of N-1 conglomerate sample (B04098502) which locate 4 km northwest of Mandaon is observed that the conglomerate consists of mainly andesitic rounded pebbles, small grains of silicious rock and quartz matrix.

These andesitic pebbles was weakly chloritized.

Fossil identification results.

From the shale sample east mountains of Mandaon (west coast Masbate Is.) microfossils of nanno-plankton are found out and the age is estimated to be Lower Miocene (CNla zone).

Neogene Series (M, $N_2$)

In northwestern part of Masbate Area, this series consist of mainly conglomeratic rocks which contain abundantly andesite, on the other hand in southeastern part of the Area, limestone predominated sediments are observed. Northwestern conglomerate contain many gravels (10-30 cm) of andesite, and matrix consist of coarse sandy material. Local limestone layer is observed general strike of this formation is about NE-SW and dip is low angle (10-20) to NW, some flexure are recognized but general structure is monoclinal. Southeastern limestone contain sandstone and mudstone etc. This limestone show pale yellow-yellow color, have many cavity and abundant fossils, and constitute main part of $N_2$. Sandstone consist of gray graybrown coarse particle, aggregation of limestone particle are also observed. Mudstone are black and soft and have abundant micro fossils. The limestone which situated in west and northwest of Masbate City show massive appearance, contain large scale fossils in sometimes, some of them interbed pale-brown muddy limestone.

Microscope observation results.

The thin section of limestone samples (C0929020) which locate at 6 km south-east of Palanas is observed that the limestone is aggregation of lenticular and ellipsoid calcite having spherulitic texture, and contain many spherical fossils (diatom or radiolaria?) under 0.3 mm in diameter. Small amount of quartz and iron minerals are contained.

Fossil identification results.

From the $N_1$ mudstone and limestone samples southern part of Masbate Is. micro fossils of nanno-plankton are found out and the age is estimated to be Middle Miocene (CN4 Zone).

Neogene-Quarternary Series (NQa)

This series distribute northwestern area of Masbate Is. and around Kagbertan. The former consist of limestone and the later consist of siltstone. Limestone have gravel like appearance containing the fossils of shell or snail or pinkish loose sponge like. These limestone generally incline to east or to south with low angle. Siltstone are blueish-gray and loose, compeatency are almost invisible. In this point they distinguish to former sediments. They interbed marl locally. This limestone seems to originate Quarternary sediment judged by it's facies.

Fossil identification results.

From the NQs siltstone sample southern part Masbate Is. micro-fossils of nanno-plankton are found out and the age is estimated to be upper Miocene (CN9 Zone).

### 3-1-3 Intrusive Rocks

Many dioritic intrusive bodies distribute in northern part of Masbate Is. (Especially Aroroy, Bolneo Area) and Barn area, South of Mobo. Generally in the northern part, grano-diorite or quartz-diorite predominate and hornblend-diorite in the southern part. Sometimes these marginal zone show gabbroic facies. Besides these, hornblende andesite intrusive bodies develop in Aroroy-Nabungslan Area. They change to lava flow sometimes. In Umabey-Tatap area, same kind of andesitic volcanic rocks have broad distribution.

Microscopic observation results.

The thin section of diorite sample (A091101) which locate at southern Bolneo in northeastern coast is observed that this rock show holocrystalline equigranular texture accompanying hornblende, biotite in common and sphane partially. Chlorite and epidote are observed as alternation products.

The diorite K-Ar age is $7.1 \pm 0.5$ m.y. (Upper Miocene).

### 3-1-4 Geological Structure

The geological structure of Masbate Is. have been controlled by the dioritic batholith intrusion which would intrude in Cretaceous-Palaeogene Systems at Palaeocene Period and uplifted these. According to this movement Masbate Is. devides three tectonic regions (Central zone, Northwestern zone, Southwestern zone), hereinafter the features of each region describe.

Central tectonic zone

The Cretaceous-Palaeogene Systems which expose around several dioritic intrusive bodies in northeastern coast from Aroroy to Mobo are of its lower member metasediments and considerable confusion in strata are observed. This will be evidence that the area has occupied central part of horst type uplifted basal formation. On the contrary the Cretaceous-Palaeogene Systems in southwestern part distribute generally in flat and in southeastern part dips change from NE (west side) to E (east side).

The graben which elongate from Masbate City to Milagros locate the boundary between confused zone and NE inclined zone, and is assumed as hidden-crop of hinge fault because the horizon of the difference on both side of the graben increase to southwestern side.

Northwestern tectonic zone

This zone locate northwestern part of Masbate Is. where distribute andesitic conglomerate ($N_2$) and northern limestone (NQs). The gently flexure are observed in andesitic conglomerate, but they incline generally to northwest with low angle (10-20 degree). Limestone incline to east or south with low angle. Many andesitic intrusive bodies are observed near the boundary $N_2$ and KPG.

Southwestern tectonic zone

This zone locate east side area of the connecting line Uson Bay (north coast) and Kawayan (south coast), and predominated limestone, sandstone, mudstone ($N_2$), and siltstone (NQs) are observed.

As the results of Philippine Fault influence the structure of northeast coast have NW strike and NE or SW dip shutter zone, and in southside of above mentioned rocks are observed as flat distribution with wavy flexure.

### 3-1-5 Mineral Showing Survey

In this survey 16 mineral showings are confirmed. Ore kind division are gold 8, copper 2, manganese 6. These location are shown Fig. 2 and data sheets of these are shown in appendics.
Gold copper deposits situate in northern part of Masbate Is. All of them are vein type and country rocks obtain hydrothermal alternation. Around these mineral showing used to accompany placer old pit. Actual panning operation are going in some places. As for copper minerals, evaluation is only as accessory mineral of gold. Actual operating mine is only Atlas Co,. Aroroy Mine which has mined massive disseminated ore body in silicified zone.

Mineral showings which investigate in this survey have large scale of argillization in some cases, but silicification not so predominate as Aroroy Mine.

## Table-2 Abstruct of Mineral Showing Survey Results in Masbate Area

Evaluation Grade
B; High necessity for following survey
C; Having room for following survey
D; Low necessity for following survey
E; Needless for following survey

| No. | Name | Type of Mineral Deposit | Kind of Ore | Country Rocks | Grade | Abstruct |
|---|---|---|---|---|---|---|
| 1 | Capsay | Gold bearing Silicified massive deposit. | Au | Quartz Porphyry (?) | D | Main Alteration is Argillization. Not expectable. |
| 2 | Luya | " | Au | Hornblende Andesite | D | Outcrops are sporadic. Scale is smaller for future development. |
| 3 | Conception | " | Au | Metaandesite Hornblende andesite | C | Strong silicification zone which has 4 km long is recognized. Ore grade; Au 0.14 g/t, Ag 1.7 g/t |
| 4 | Matanglad (Manahoc) | Epithermal vein type deposit | Cu | Andesitic Porphyry | D | Few Cu-minerals are observed in outcrop, Ore grade; Au 0.07 g/t, Ag 142.9 g/t, Cu 61.63%, Pb 0.01%, Zn 0.01% |
| 5 | X.Y.Z. (Lumbang) | " | Au | Sandstone, Shale | D | Poor ability of development of scale and state of mineralization. |
| 6 | Mandale | Network-vein type deposit | Au | Metabasalt | C | Mineralization zone has 200 m width, silicification and argillization are visible. |
| 7 | Baang | Vein type disseminated deposit | Au | Hornblende andesite | E | Small scale mineralization and weak alteration. |
| 8 | Marintoc | Hydrothermal vein type deposit | Au | " | C | Main alteration is silicification, many limonite boulders are observed along Marintoc River and slope. Ore grade; Au 0.07 g/t, Ag 2.3 g/t |
| 9 | Mt. Uac | Vein type deposit | Au, Cu, Pb | Basalt | D | Small scales of outcrops, mineralization and alteration. |
| 10 | Dogosongan | Hydrothermal vein type deposit | Au | Andesite | B | Gold bearing Qtz-vein in silicified andesite. Ore grade; Au 0.21 g/t, Ag 14.5 g/t, Cu 2.15%, Pb 0.46%, Zn 8.86% |
| 11 | Nabangig | Sedimentary Manganese deposit | Mn | Conglomerate | E | Poor ability of development due to small scale. |
| 12 | Placer | Unknown | | | | No information for mineralization exploration and mining. |
| 13 | Ayat | Sedimentary manganese deposit | Mn | Shale, Chert | E | High grade ore is almost mine out. |
| 14 | Taisan | " | Mn | Chert | E | " |
| 15 | Calumpang | " | Mn | Sandstone, Chert | E | Showing is small and unexpectable. |
| 16 | Balud | " | Mn | Chert | E | " |

No. 3 Comcepcion, No. 6 Mandale, No. 8 Marintoc and No. 10 Dogosongan have large scale alteration, especially Dogosongan has 3 m width disseminated zone and gold blebs are recognized by naked eye. So necessity of following survey is high (Evaluation grade B).

Results of laboratory study for the gold-copper ore.

Grade of ore

| Showing No. | Au gr/t | Ag gr/t | Cu % | Pb % | Zn % | |
|---|---|---|---|---|---|---|
| 3. Conception | 0.14 | 1.7 | | | | quartz,chlorite> sercite, py. |
| 6. Mandale | 0.07 | 0.5 | | | | quartz> chlorite,sercite, py. |
| 8. Marintoc | 0.07 | 2.3 | | | | quartz,hematite,goetite |
| 4. Matanglad | 0.07 | 142.9 | 61.63 | 0.01 | 0.01 | kaoline, 2nd copper ore |
| 10. Dogosongan | 0.21 | 14.5 | 2.15 | 0.46 | 8.86 | quartz,chlorite,sericite, Ga, Sph. |

Manganese ore deposits distribute in southwestern and southeastern parts of Masbate Is. All of them are sedimentary orgin and the scales are too small, therefore they are not to become the target for following survey.

Results of laboratory study for manganese ore.

Grade of ore

| Showing No. | Mn % | Mode of occurence | X-ray analysis |
|---|---|---|---|
| 11. Nabangig | 47.3 | colloform | sericite calcite Mn-mineral |
| 13. Ayat | 72.0 | colloform vein type | |
| 15. Calumpong | 67.9 | colloform vein type | |

Assay results of panning sample at mineral showings.

Anomalous samples are shown in the following.

| Showing No. | Sample No. | Au gr/t | Ag gr/t | Ga ppm | Country rock |
|---|---|---|---|---|---|
| 1. Capsay | A 076 H | 25 | 1.3 | 6.2 | intrusive andesite |
| 3. Conception | A 042 H | 25 | 2.3 | 7.0 | metaandesite |
| Conception | A 076 H | 25 | 1.3 | 6.2 | Alluvium |
| 7. Baang | A 108 H | 13 | 2.7 | 6.6 | diorite |
| Baang | A 109 H | 150 | 21.5 | 14.6 | diorite |
| Baang | A 110 H | 42 | 0.7 | 6.8 | diorite |

Abstruct results of mineral showing survey are shown in Table 2.

## 3-2 Geology and Mineral Deposits of Northern Leyte

### 3-2-1 General Summary

The extent of Northern Leyte Area is covering from Biliren Is. in north to Abuyog-Baybay Highway in south. This area belong to region VIII. The population of this area is about 900,000. Main industries are agriculture, forestry, cattle breeding, fishery, etc. Airway and highway (partial ferry) are available from Manila. Between Manila-Tacloban has 2 flight in each day, oneway flight needs 1.2 hours, while highway needs 27 hours. In the Leyte Is. main high ways are arranged and many coastal road are available but inland road arrangements are not enough.

Communication systems from Tacloban to other main city and abroad are available, but inland communication system arrangements are not yet.

Southern Tacloban plain and rice field have affair for Systosimiasis, therefore rubber boots wearing is necessary for field survey.

Geographycal situations in Northern Leyte area are as follows.

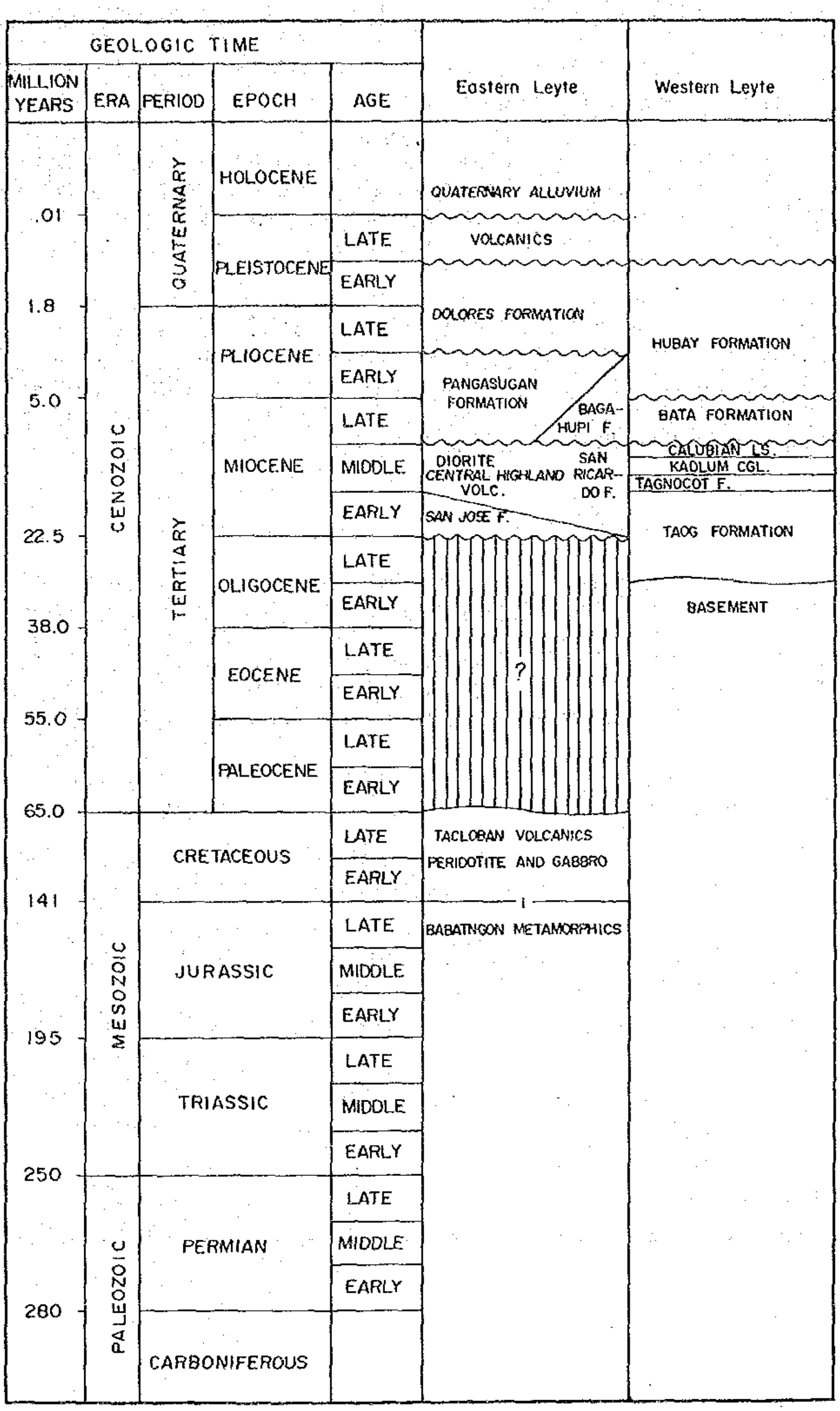
| | |
|---|---|
| Broadness | 5,160 sq. km |
| Hightness | 0 - 1,300 m (Highest peak Mt. Mandewen) |
| Temperature | Max. 31.2 Min. 23.1 cetigrade |
| Annual precipitation | 4,000 mm |

### 3-2-2 Succession of Each Formation

This area has devided into two geological provinces by Philippine Fault, in the east part lacking of lower and upper Miocene Formation and Plio-Pleistocene Formation, on the contrary in the west part lacking of middle Pliocene and Pleistocene Formation. Jurassic, Cretaceous, Palaeogene systems are recognize only eastern part.

Typical columnar section of Northern Leyte Area is shown in Fig. 14.

Fig-14 STRATIGRAPHY OF LEYTE



Serpentine, gabbro, Tacloban volcanics, diorite, Central-highland volcanics, northwest volcanics and Quarternary volcanics are intrusive rocks in this area. These intrusive rocks observe often east side of Philippine Fault, and volcanics have formed sometimes lava flow.

Jurassic-Cretaceous-Palaeogene Systems

Babatngon Schist which metamorphosed from probably Jurrasic sediments and volcanics distribute over Bugho (Northeast Mountain Range.), Palo to Near Babatngon and as several isolated small scale outcrops, they consist of weak metamorphosed crystalline schist, gneiss and phyllite and lower formation is altered to green schist facies.

Microscopic observation results

The sample of footwall chlorite schist in Suhi Deposit (AVE-03 061085) is shown foliated structure, considered altered from fine layerd rock consisting of basic pyroclastics and calcareous sandstond, rock forming minerals are fine grain epidote, fibrous chlorite and quartz. The hanging wall sericite quartz schist sample in Suhi Deposit consist of mainly fine quartz grains (0.02 mm size) and needle sericite and iron mineral (hematite?).

Lower Miocene Series

Taog Formation; This series consist of conglomerate, sandstone, shale and thin layer of shaly limestone which have vertical or steep dip and show clearly bedding plane. Coal layer accompany with shale. Conglomerate and sandstone show brown color. Rounded volcanics and quartz gravels with chert are observed along some horizon. They expose highland of Western Ormoc City with extent N-S 37 km and E-W 5-10 km, and have strong folding and cut by fault in places, basaltic small stocks of North-west Volcanics intrued, in central part.

Lower-Middle Miocene Series

Tagnocot Formation; This formation have dominantly massive shale which show poor bedded and is accompanied by thin layers of conglomerate and sandstone.

This formation distribute from north side of Taog Formation to west side of Northwestern Peninsula with the extent NS 18 km and Ew 5-8 km, besides above band shape distribution it is observed west side Taog Formation.

San Jose Formation; This formation consist of alternation of hard and weak metamorphosed conglomerate, sandstone, shale, fine tuff and volcanices.

Conglomerate consists of fragments of andesite and limestone cemented by tuffuceous and calcareous sandy materials.

Sandstone and shale are calcareous and interbeds with andesitic lava flows at upper and lower parts of the section.

Isolated lens shape outcrop which elongate 7 km in NW is observed at northern part of San Jose.

Fossil identification results

Middle-Upper Miocene Series

Kadium Conglomerate; This conglomerate is poorly bedded and poorly sorted and sometimes interbed with thin layers of shale and sandstone. Rounded andesite gravels and fragments of chert, siliceous shale, quartz are cemented by brown coarse sandy materials. The outcrops are observed at east side of North-west Peninsula with Kalvian Limestone.

San Ricaldo Formation; This Formation consist of conglomerate, sandstone, shale and lava flow which inclined with steep dip. Thin layers of massive limestone which have been intruded by andesitic dyke is also observed. The outcrops are observed intermittently 9 km distance in the west side of Babatngon northeast coarst and also west side hill of Tacloban.

Upper Miocene Series

Calubian Limestone; This limestone is mainly coralline, porous marlish and is white color. Weathering portion are corroded and developing cave. Fossils are generaly poor. It is distributed at west side of Taog Formation in west-highland of Ormoc City as NNE elongated band shape and also in lens shape at around Kadium Conglomerate in east side Northwest Pninsula.

Lower Pliocene Series

Bata Formation; This formation consist of mainly pale colored shale and sandstone, and is accompanied with lenticular conglomerate and thin layer of marly limestone.

Shale is tuffaceous, bentonitic and sometimes calcareous. Sandstone is calcareous and contains large fossils. Conglomerate shows lenticular shape and consist of andesite gravel and clayish cemented material. Limestone divides to upper part of fossilifers shale and lower parts of calcareous sandstone.

This formation show broad distribution around Miocene Series in western highland of Ormoc City, and distribute also in Northwest Peninsula and east side of it.

Bagahupi Formation; this formation consists of low inclined conglomerate, sandstone and marlish tuffaceous shale. Conglomerate consists of sub-angular gravels of andesite, basalt, serpentine, schist, gabbro, small amount limestone cemented by sandy and clayey materials. Sandstone is coarse grained and arcoarsic and well bedded. Shale is marly and tuffaceous and interbedded with thin layer of fine tuff. This formation distribute in northwest of Tacloban City to northeastern coast of Leyte Is. and broad extent (5 km - 9 km) of Northwest San-Miguel City, located west side Babatngan Metamorphic Rocks.

Fossils identification results.
Sample of Bata Formation (NF 225-1R) at 7 km southeast of Palompon in west coast has fossil of foraminifera; Globorotalia tumida (s.l.), so this formation is considered to belong after Pliocene Series.

From the Bata formation samples at western and southwestern Ormoc City, micro fossils of nanno-plankton are found out and the age is estimated to be upper Miocene (CN9 Zone).

Upper Pliocene Series

Pangasugan Formation: This formation consist of mainly poor sorting and bedded massive conglomerate which is accompanied with coarse sandstone and tuffuceous shale lens in places. Conglomerate consists of angular and sub-angular fragments of andesite and fine sandy and partial tuffaceous materials. Andesitic agglomerate, tuff breccia, pumice tuff, crystalline tuff are also observed as volcanic clastics.

Sandstone and shale are observed in upper horizon.

It show elongated distribution along Philippine Fault from southwest coast of Biliran Is. to SE direction. The formation also covers central mountain range in 12 km width near Baybay.

Fossil identification results.

From the Pangassugan Formation sample near southern limit of this area, micro fossils of nanno-plankton are found out and the age is estimated upper Miocene, therefore this formation may correlate more older age.

Upper Pliocene - Pleistocene Series

Hubay Formation; This formation predominates in limestone which is accompanied with conglomerate, sandstone, shale in lower horizon. Limestone is porous, coralline, poorly bedded and massive (partialy marly). Sandstone and shale are calcareous and partialy tuffaceous and sometimes crossbeds. The formation distributes intermittently around Neogene System from west side of Ormoc to Northwest Peninsula.

Pleistocene Series

Dolores Formation; This formation consists of andesitic volcanic clastics and low angle well bedded conglomerate, sandstone, shale, limestone. It is sometimes accompanied with thin layer of calcareous tuffaceous shale and sandy muddy and white colored limestone lens. Conglomerate consists of mainly sub-angular fragments of andesite and sandy, tuffaceous cementing material but competency is not enough. It is distributed both side of central mountain range of Middle Leyte Is., especially around Mt. Robie and Mt. Janagdam. It seems to be basement of volcanic clastics of recent volcano.

Fossil identification results.

From the Dolores Formation sample at south of Northwestern Peninsula, microfossils of nanno-plankton are found out and the age is estimated upper-middle Pleistocene (CN-146 Zone).

Quarternary Volcanics; This volcanic rocks distribute from Central Billiran Is. along Philippine fault (NW-SE) intermittently, and constitute isolated peaks as Mt. Robie and Mt. Janagdam etc. consisting of hornblende pyroxene andesite, sometimes porphyritic appearance with trachytic groundmass. Rock forming minerals are andesine-labradorite, hornblende, pyroxene, magnetite, pyrite and apatite.

Microscope observation results.

The sample of western Billiran Is. belonging to this formation (NG003R) consist of phenocrysts of plagioclase (probably andesine), augite, olvine and iron mineral and intergranular groundmass. Appearance is fresh andesite but some olivines are altered to iddingsite and serpentine showing pseudomorph of olivine.

Alluvium; It consists of unconsolidated recent flood plain sediments distributed in flood plain and estuary of major drainage system. Beach sand and coral reef also belong to this division.

**3-2-3 Intrusive Rocks**

Serpentinized Peridotite; This rock was intruded in northeast part of Babatngon Metamorphic Rocks in northeastern Leyte, consisting of mainly serpentinized massive middle-coarse grained hartzburgite and shows pale green to dark green. Other rock forming minerals are serpentinite, olivine, augite, enstatite, labradorite, chlorite, magnetite, clay minerals. These minerals show allotrio-morphic texture as the results of alternation.

The intrusion period is considered to be Lower Cretaceous.

Microscopic observation results.

The sample of serpentinite Near Antipolo Mineral Showing consists of throughout serpentine and reriet mineral being cut by many later chlorite veinlets.

Gabbro-Diabase; These rocks are sporadically distributed about 30 km length along east side of Babatngon Metamorphic Rocks in North-Eastern Leyte Is.. Kinds of rock are generally middle-coarse grained gabbro which have allotrio-hipidiomorphic texture and ophitic texture. Rock forming minerals are mainly labradorite, augite, hornblende and as accessory minerals chlorite, bauslite, uralite, opaque iron minerals. Cataclastic textures are observed in some places. The intrusion period is considered Middle Cretaceous.

Microscopic observation results.

The sample (NC249R) collected at 10 km north-east of Tacloban shows holo-crystalline texture. It is consists of plagioclase (below 2 mm length), augite and hornblende accompanying apatite and iron mineral. Some parts of augite and hornblende are altered to foliated actinolite. The K-Ar age of this sample is 50.0 ± 3.9 m. y. (middle Eocene).

Tacloban Volcanics; This rocks is exposed along 9 km in the east side of Babatongon Metamorphic Rocks and accompanied Diorite. Basaltic and andesitic volcanics are dominant in the volcanics with subordinate amounts of chert, gray wacke and shale. Volcanic rocks contain fibrous aggregation of andesine, radial intergrowth of secondary chlorite and quartz with apatite.

The rocks partially crushed and the minerals re-arranged by the influence of Philippine Fault. This volcanics have mineralized of sulphide minerals. The intrusion period is considered Upper Cretaceous.

Microscope observation results.

The sample of this rock collected at 9 km north-east of Tacloban (ND223R) consists of mainly plagioclase (andesine - oligoclase) with augite and iron mineral. Chloritization is observed.

Central Highland Volcanics; This volcanics is distributed from Carigara Bay at Northern Leyte Is. to west side of Abuyog about 65 km length and consitutes basement of Central Mountain Range. It consists of porphyritic hornblende pyroxene andesite, agglomerate and flow breccia.

Appearance is gray- pale gray colored porphyritic rock.

The intrusion period is estimated to be Middle Miocene.

Microscope observation results.
The dasite sample from central highland (NK019R) consists of phenocryst of plagioclase (oligoclase - andesine), hornblende, biotite, augite, iron mineral, quarlz and potash feldspar and groundmass of plagioclase, pyroxene, iron minerals, silica minerals, glass and apatite. It has porphyritic appearance.

Diorite; This rock is exposed as small body intruded in Taog Formation at west highland of Ormoc City and as window type outcrops in Pangasgan Formation at west side of Central Mountain Range. It is middle-coasrse grained dark gray holocrystalline rock and partially banded. Weathering part shows graysh black color. The intrusion period is estimated to be Upper Miocene.

Microscope observation results
The sample of Pangasgan Formation at west side of central highland (NLR-4) consists of plagioclase (andesine- oligoclase), hornblende, potash feldspar, quartz, biotite and iron mineral accompanying apatite, epidote, zircon and chlorite. This rock is fresh but alteration minerals such as sericite, chlorite, epidot are seen partially. The K-Ar age of diorite in west side of Central Mountain Range is $20.9 \pm 2.3$ m.y. (Lower Miocene).

North-east Volcanics; This rock is observed as small intrusive bodies and basaltic lava in Neogene System at west highland of Ormoc City. The texture is porphyritic and amygdaloidal and partially inter-granular. Rock forming minerals are calcareous plagioclace 50-60%, clinopyroxene 40-45% and Olivine. Pillow structure is general. The intrusion period is estimated to be Pliocene-Pleistocene.

Microscope observation results.
The sample from west side of highland of Ormoc (NG008R) is metabasalt which phenocrysts consist of mainly plagioclase (labradorite-bytowrite) accompanying angite, serpentine, iron mineral and apatite. Intergranular texture is observed. Phenocrysts and groundmass are altered to serpentine showing green color.

### 3-2-4 Geological Structure

Philippine Fault pass through the area in NNW- SSE direction. This fault is estimated as oblique side slip fault, and it's activity has prolonged from Palaeogene to Recent. As the results of this activity, strong block movements have originated, many small faults and linearments have developed and some of them have become to be passways for magma intrusion and geothermal.

The basal formation in eastern Leyte Is. has thrust up toward west by above mentioned NNW-SSE movement and are associated with ophiolite. Neogene Sedimentary Rocks in Northeast Pninsula is folded generally along the NNW-SSE axis.

### 3-2-5 Mineral Showing Survey

Mineral showings which have confirmed on this survey are 9 places. Kinds of ore are copper 4, nickel 1, native sulpher 1, peat 1, natural asphalt 1 and bentonite 1. These locations are shown in Fig. 3 and details and data sheets are shown in appendix of last volume.

Massive sulphide deposits are too small scale for exploration target. Native sulpher, peat, natural asphalt, vein type copper deposits are not profitable. Bentonite deposit is already in operation. Only vein type nickel deposit is remained as further exploration target.

The geothermal field at 13 km NE of Ormoc City is developed. Electricity plant is operating to supply electricity for Passal Smelter. This field underwent alternation zone of montmorillonite alunite and pyrite.

Results of laboratry work

o Bentonite crude ore; Sample of Ormoc Deposit (NES06R)

| | | | |
|---|---|---|---|
| Specification | 1 | absorption capacity of metylene blue | ; 97 m mol/100 gr |
| | 2 | swelling capacity | ; 6 ml/2 gr |
| | 3 | pH | ; 9 |

(Detail data is shown in appendix of end volume)

This bentonite ore consists of 70 - 75% Montmorillionite of Ca type and useful for caking material of casting sand.

o Natural asphalt; Sample of Balite showing (NBS002R(A))

Specification: 1. water content (1.0%), 2. Inorganic material 64.8%, 3. Volatile compornent 34.8%, 4. Fixed carbon 0.4%, 5. Total sulphur 0.5%, 6. Total calorific value 1,290 kcal/kg. Analysis of matrix material shows high volatility and calorific value. As purity is low as asphalt, utility value seems to low.

Peat;

| | Original Base | Anhydrous Base |
|---|---|---|
| Water Content | 12.0% | --- |
| Inorganic Material | 46.4% | 52.7% |
| Volatile Compornent | 27.9% | 31.7% |
| Fixed Carbon | 13.7% | 15.6% |
| Total Sulphur | 0.40% | 0.45% |
| Total Caloric Value | 2,140 cal/gr | 2,430 cal/gr |

Results of X-ray, chemical and polished section analysis are shown in abstruct table and data sheets of mineral showing in appendix (end of the volume).

## Table-3 Abstruct of Mineral Showing Survey in Northern Leyte Area

| No. | Name | Type of Mineralization | Kind of Ore | Country Rocks | Grade | Abstruct | Results of Laboratory Work |
|---|---|---|---|---|---|---|---|
| 1 | Bagacay | Stratabond Massive Sulphide | Cu | Basalt Lava | D | Thickness 0.5 m, max. elongation 4 m. continuity is not so good. | Ore assay; (AVC-020-061085)<br>Au g/t Ag g/t Cu % Pb ppm Zn %<br>0.005 0.6 0.02 40 0.01 |
| 2 | Curajo | " | Cu | Basalt Lava<br>Metasediments | D | Thickness 0.03-2.0 m, Cu; 0.41%, Au; 0.75%, Zn; 0.20%, Ag; 3.67 gr, 6 holes drilling in 1979 - 1980. | Ore assay; (K100502, K100607)<br>0.035 1.1 0.02 77 0.01<br>0.065 5.4 10.7 227 0.73 |
| 3 | Caibaan | " | Cu | " | D | Massive and disseminated ore boy cut by fault is recognized at upper adit. | Ore assay; (K100903)<br>0.02 25.78 1.64 83 0.21 |
| 4 | Antipolo | Epithermal Vein | Ni | Serpenitized Peridotite | C | Vein Grade 0.2-0.7% Ni Renaldite (secondary Uranium mineral) assume to exist in alternation zone | Ore assay; (K100706)<br>Total Ni; 6480 ppm, slicate Ni; 80 ppm, Altered mineral; crystobarite, tridymite accompanying renardite (secondary U mineral) |
| 5 | Liberty | Peat | Peat | Sediments | D | 1.0-2.0 m thick, not profitable | |
| 6 | Biliran | Native Sulphur | S | Quarternary Andesite | E | Proven ore 320 ton, S; 30%<br>Altered zone consists of montmolironite and quartz. | |
| 7 | Ormoc | Hydrothermal Clay Deposit | Montmolironite | Sediments | D | Actually operating | |
| 8 | Balite (Villalaba) | Natural Asphalt | Natural asphalt | Sediments | D | Along the anticline axis. | |
| 9 | Suhi | Epithermal Vein | Cu | Crystalline Schist | D | Vein width; 2.0 m<br>Py, Cp, Mar, Qz disseminated zone | Ore assay; (AVC-04-101085)<br>Au g/t Ag g/t Cu % Pb ppm Zn %<br>0.015 9.3 10.4 240 0.39 |

Evaluation grade

C; Having room for following survey

D; Low necessity for following survey

E; Needless for following survey.

TABLE

Ore assay results of mineral showing (Northern Leyte Area).

| Mineral showing | Sample No. | Au (gr/t) | Ag (gr/t) | Cu (%) | Pb (ppm) | Zn (%) | Ni (ppm) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Total | Silicate |
| Bagacay | AVC-2 061085 | 0.005 | 0.6 | 0.02 | 40 | -0.01 | | |
| Curajo | K100502 | 0.035 | 1.1 | 0.02 | 77 | 0.02 | | |
| " | K100607 | 0.065 | 5.4 | 10.7 | 227 | 0.73 | | |
| Caibaan | K100901 | 0.005 | -0.2 | 0.02 | 28 | -0.01 | | |
| " | K100903 | 0.020 | 25.7 | 1.64 | 183 | 0.21 | | |
| Antipolo | K100706 | 0.055 | 0.5 | 0.04 | | | 6,480 | 80 |
| " | K100707 | 0.050 | -0.2 | -0.01 | | | 1,320 | 5 |
| Suhi | AVC-03 101085 | 0.005 | 0.6 | 0.25 | 65 | 0.02 | | |
| " | AVC-04 101085 | 0.015 | 9.3 | 10.4 | 240 | 0.39 | | |
| Camonsi (palompon) | NFS095R | 0.035 | -0.2 | 0.02 | 37 | 0.01 | | |

## 3-3 Geology and Mineral Deposits of Southern Leyte, Dinagat and Siargao Area

### 3-3-1 General Summary

The extent of Sourthern Leyte Area covers south from Abuyog-Babay highway and Panaon Island. This area belongs to Region VIII, having 400,000 population. Main industries are agriculture, forestry, cattle breeding, fishery etc. Pan philippine Highway is arranged between Tacloban- Abuyog-Sogod-Liloan. Besides of it, Southern Leyte coast road is available, but inland roads are not developed yet. It takes two and half hours from Tacloban to Sogod.

The extent of Dinagat, Siargao Ares is Islands of Dinagat, Siargao, Bucas Grande, Esat Bucas and Masapelid. This area belong to Region X. Daily shipping service connects between Surigao City (central city of this Region) and each islands taking 2 hours from Surigao City to South Dinagat, 9 hours to North Dinagat and 4 hours to South Siargao. Except Siargao Is. inland roads are not developed and survey works depended on foot in many places. Main industries are agriculture, forestry and fishery. In northern Dinagat Is. nickeliferous laterite mines have actual operation and in Masapelid Is. actual gold mines are working. Geographical situations in these Area are as follows.

| | Southern Leyte Area | Dinagat, siargao Area |
|---|---|---|
| Broadness | 2,563 sq. km | 910 sq. km |
| Highest Peak | 918 m (Mt. Nacolod) | 1,000 m (Mt. Redondo) |
| Average temp (annual) | 26.5 Centigrade | 27.0 Centigrade |
| Precipitation (annual) | 1,900 mm | 4,200 mm |

### 3-3-2 Succession of each formation

#### 3-3-2-1 Southern Leyte Area

Metagabbro, gabbro (BC), ultramafic volcanics accompanied chart (Kpg), and serpentinized ultramafic rocks (SP) have occupied in lower horizons of this area. Miocene Formation which consists of mainly basaltic and andesitic volcanic rocks ($ChV_1 \cdot ChV_2$) and sediments ($N_1$) have unconformably overlain those basements.

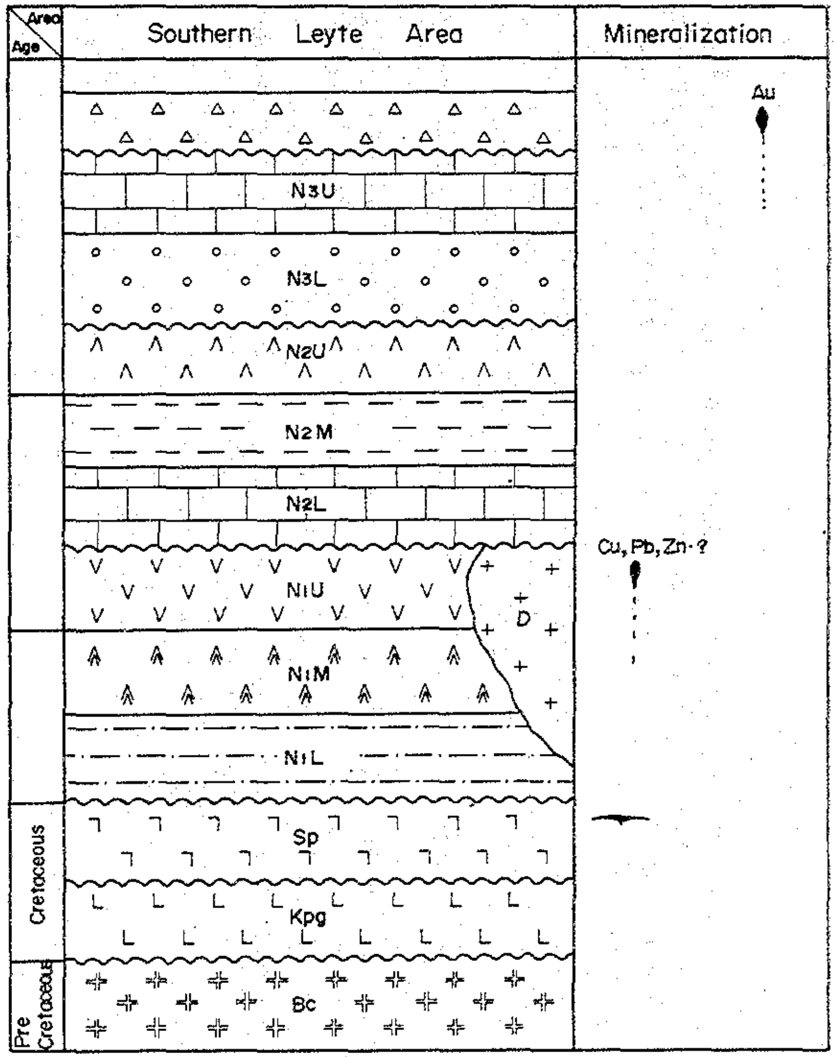
Upper Miocene-Pliocene formation which consists of sedimentary rocks with some andesitic volcanic rocks have covered Miocene Formation. Upper Pliocene-Pleistocene Formation consisting of mainly sedimentary rocks has overlain all former formations and is covered by Qv Formation consisting of andesitic volcanic rocks and alluvial sediments have covered over all.

Typical columnar Section is shown in Fig. 15.

<u>Metagabbro . gabbro (BC)</u>

Locality; Outcropping in small scale at the central part of Bato Quadraangle.

Fig. 15 Schematic Columnar Section of Southern Leyte Area




Legend

- 9 : Coral reef, Conglomerate, Sandstone
- V : Andesite cones, Lava Flow, Flow Breccia
- $N_3U$ : Calcarenite, Coralline Limestone, Limy Mudstone
- $N_3L$ : Conglomarate, Sandstone
- $N_2V$ : Andesite Tuft, Breccia
- $N_2M$ : Sandstone, Shale, Conglomerate, Mudstone
- $N_2L$ : Coralline Limestone, Calcarente
- $ChV_2$ : Andestic Lava, Breccia, Basalt Lava
- $ChV_1$ : Basalt Lava
- $N_1$ : Sandstone, Mudstone, Conglomerate
- SP : Serpentiniged Peridotito - Pyroyene Peridotite, *Diabase*
- kpg : Chert, Mudstone, Shales, Basalt, Diabase
- BC : Schistose Gabbro
- D : Diorite

Rock facies; This formation shows dark-green color and has chloritized. It is sheared partially and shows schistose structure but metamorphysm is generally low grade, green schist facies. Apparent layered structures are found in some places. Leucocratic parts are often observed.

Original date; Cretaceous Period.

Ultramafic Volcanics ·Sediments. (Kpg)

Locality; This formation is observed in southeastern and eastern parts of Bato Quadrangle.

Rock facies; Basaltic and andesitic lava show dark greenish gray and are fine grained in many cases. Chrolitized and epidotized pyroxene, weak altered plagioclase are recognized. Pillow lava is partially observed.

Shale and chert show red color and are silicious. These sediments generally overlie basaltic andesitic lava containing thin leyer of sediments.

Original Date; Cretaceous- Palaeogene Period

Ultramafic Rocks (Sp)

This formation consists of periodotite and later gabbro.

Locality; This formation is observed in southwestern part of the area accompanying Kpg and distribute along the Philippine Fault and it's branched fault.

Rock facies; Peridotite shows grayish violet-gray color and almostly serpentinized.

Microscopic observation: The sample from 7 km east of Cajagnan (R021) is olivine gabbro and shows clearly polysynthetic twinning. The samples which exposes near Maboi in southeastern Peninsula (N121, Q252) is serpentinized lherzolite to hartzbargite.

Original Date; Palaeogene Period

Miocene Formation

This formation can be divided into three menbers, the lower which consists of mainly sediments, the middle of basaltic volcanics ($ChV_2$) and the upper of andesitic volcanics ($ChV_1$) covering unconformable former ultramafic rocks. Original age is considered to be Miocene.

Locality; This is distributed mainly over Bato and Maasin Quadrangle area.

Rock facies; This formation consists of mainly bluish gray to gray colored sandstone and mudstone accompanying basaltic volcanic clastics. Thin layer of pillow lava is observed. The formation is correlated to Taog Formation in Northrn Leyte.

Fossils identification results; Micro-fossils of nanno-plankton of sample from this formation 10 km north west Sogod are identified to be Middle-Miocene to Lower-Pliocene.

Microscopic observation; The samples from 8 km north of Sogod and from west side of Pannon (S110, R165) are hyalopilitic two pyroxene andesite which are 2.48 ± 0.12 m.y. and 1.44 ± 0.07 m.y. dating age by K-Ar method, therefore some upper Pliocene andesite assume to misclassify whithin this formation.

Middle Member ($ChV_1$)

Locality; This is distributed in southwestern part of Plaridel Quadrangle and in small part of Bato Quadrangle.

Rock facies; Basaltic lava shows gray to grayish-red and is massive, brecciated or pillow like appearance and consists of fine grain idiomorphic pyroxene and small amount plagiclace, lack of phenocrysts in places.

Upper Member ($ChV_2$)

Locality; This is mainly distributed in Abuyog, Hilongos, Hingatungan, Hinundayan, Cavalian and San Francisco Quadrangles.

Rock Facies; This member consists of mainly dark-gray and gray andesitic lava and tuff breccia. Lava is brecciated and porphyritic texture in many places. It consists of hornblende andesite and biotite-hornblende andesite which contains fine to middle grained idiomorphic or semi-idiomorphic hornblende and fine biotite phenocryst. Lava grades into sandstone and mudstone intercalating conglomerate in near Bato Area.

*Fossils determination results; The sample from 20 km north of Sogod contains micro* fossils of nanno-plankton (CN-9 Zone) correlating to Upper Miocene.

Upper Miocene - Pliocene Formation (N-2)

*This Formation* unconformably overlies Miocene andesitic volcanics. It can be divided into three members namely the lower member of mainly limestone, the middle of shale to conglomerate sediments and the upper of mainly andesitic volcanics.

Lower Member;

Locality; The member is distributed as small scale outcrops all over the area especially in central portion of Bato Quadrangle.

Rock facies; Consisting gray to milky-gray coral massive limestone, pertially interbedding calcareous sandstone and siltstone, correlating to Calubian formation in Northern layte.

Fossils identification; The sample from east side of Southwest Peninsula contains micro-fossils nanno-plankton (CN-10.11 Zone) denoting Lower Pliocene.

The sample (N020) at 16 km west of San Ishidolo in Southeastern Peninsula yields upper Pliocene foraminifera fossils; Globoratalia tumida tumida, G. tumida flexuosa, G. ungulata, Sphaeroidinella dehiscens, Pulleniatina praecursor and P. obliquiloculata.

Middle Member;

Locality; The member is distributed over southwest of Plaridel, west of Hilongos and south of San Francisco Quadrangles.

*Rock Facies; Consisting of calcareous mudstone, shale, sandstone* and thin layer of conglomerate with andesitic materials. They seems to be tarbidite.

Fossil identification; The sample from 11 km west of Sogod yields micro- fossils of nanno- plankton (CN-9 Zone) denoting to Upper Miocene.

The sample (R099) from east coast of Southwest Peninsula yields upper Miocene foraminifera; Globorotalia crassaformis, G. tosaensis and G. inflat Spheroidinella deficiens.

The sample (T086) from 6 km west of Sogod yields upper Pliocene foraminifera fossil; Globorotalia tosaensis, G. classaformis, G. inflata, Pulleniatina obliquiloculata and Neogloboquadrina dutertri.

Upper Member;

Locality; The member is distributed over southeast of Sogod and Cabalian in NNW-SSE direction.

Rock facies; Consisting of gray to dark gray andesitic tuff and tuff breccia intercalating brecciated lava. Corrlating to Pangasugan formation in Northern Leyte.

Original age determination; The member unconformably overlies N1.

Upper Pliocene-Pleistocene Formation (N-3)

This formation is divided into two members, lower consisting mainly of fluviatile sediments and upper of mainly limestones.

Lower Member; This is distributed in Sogod, Cabalian and Hingatungan Quadrangles.

Rock facies; Consisting of gray to dark-gray weakly consolidated conglomerate with unclear beddings. Gravels are mainly andesitic rocks and matrix is clayey and sandy material. This is considered to be fluvil sediments. The member is correlated to Bubay formation in Northern Leyte.

Upper Member; Distributing over southwest of Hilongos, Bato and Maasin Quadrangles.

Rock facies; Consisting of grayish calcareous sandstone and mudstone containing fragments of shell, coral and limestone.

Fossil identification; The sample of middle west coast of this formation yields micro-fossils of nanno-plankton (CN-11 Zone) denoting Lower Pliocene.

The sample of this member (T018) at 11 km NE of Hilongos yields foraminifera fossils of Globorotalia tumida tumida, G. Tumida flexosa and G. ungulata which is considered to denote upper Pliocene.

Pliestocene Volcanics (Qv)

The volcanics is distributed along Philippine Fault as a cone like shape.

Locality; This is distributed in Cabalian and San Francisco Quadranles.

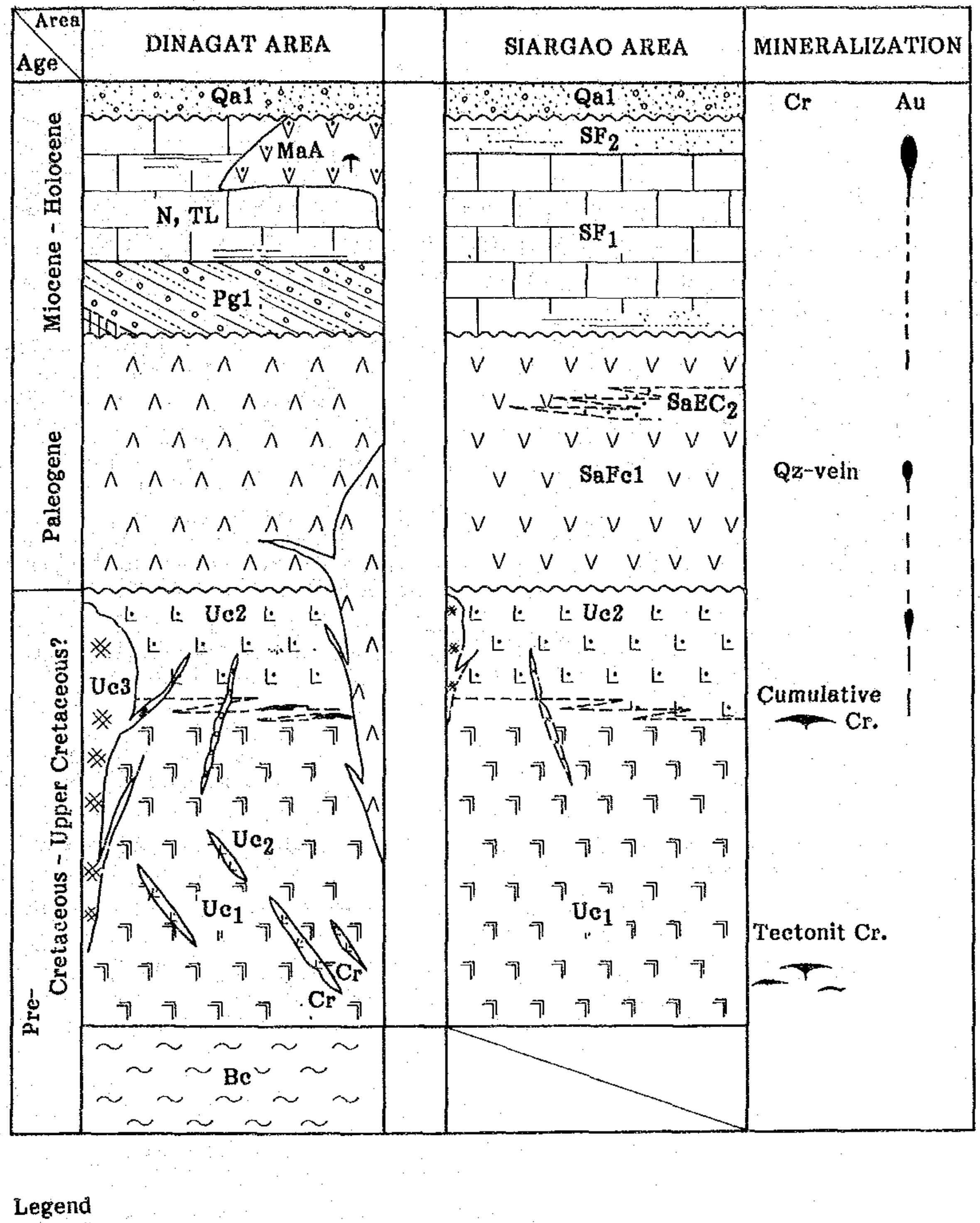
Rock facies; This consists of gray to grayish white andesite lava and andesitic breccia which contain considerable amount of plagioclase and hornblende phenocrysts. Biotite hornblende andesite is also observed.

Original age determination; K-Ar age of rock in southern part of Southeastern Peninsula (P160) is determined to be 0.2 ± 0.1 m.y. (Quarternary). The microscopic character of the sample is hyalopilitic hornblende andesite.

### 3-3-2-2 Dinagat · Siargao Area

Dinagat · Siargao Area is underlain by metamorphic rocks (BC), ultramafic complex (UC), green igneous rocks (K), Sabao formation (SaFc), Siargao limestone (SF), Dinagat limestone (N), Masapelid limestone (TL), andesitic rocks (MaA) and allvium (Qal) in an ascending order.

Fig. 16 Schematic Columnar Section of Dinagat・Siargao Area




Legend

| | | | | |
|---|---|---|---|---|
| Pgl | Conglomerate, Sandstone, Mudstone, chert | | | |
| SaFc2 | Tafaceous Sandstone, Siltstone | | | |
| SaFc1 | Basalt, Andesite, Diabase - Dolerite | | | |
| K | Basalt, Diabase - Dolerite | | | |
| Uc3 | Micro Gabbro, Pyroxenite | | Qal | Conglo, sand, silt, peat |
| Uc2 | Dunite | | MaA | Andesite |
| Uc1 | Pyroxene Peridotite | | N, TL | Limestone, Siltstone |
| BC | Amphibolite, Green SHist | | SaEC2 | Limestone, Siltstone |

Schematic columnar section shows in Fig. 16.

Metamorphic Rocks (BC)

This rocks is distributed in southern part of Dinagat Is. and shows schistose structure.

Locality; Southern Dinagat Is. area from San Jose through Dinagat to Caglanao.

Rock facies; Consisting of green schist, pelitic schist, acidic schist and schistose Gabbro - hornblende schist.

Green schist is composed mainly of chlorite, epidote and hornblende and considered to be basic igneous rock origin. But the sample of near Caglanao (SF-35) is assumed to be altered from intermediate tuff containing thin layer of quartz grain in places (SF 39). Pelitic schist is composed of chlorite and graphite and alternates with segregation quartz.

Acidic schist showing white to grayish green color is composed of sericite - muscovite, plagioclase, quartz and chlorite. It is considered to be acidic igneous rock origin. Schistose gabbro - hornblende schist consist of hornblende, plagioclase and show dark green color. These rocks are observed at road cutting between Kajanao to Dinagat. These metamorhic rocks are highly folded therefore the dip and strike of schistosity plane are varied. Then detail survey are necessary to clearify geological structure.

Original date; Considering to be Pre-Cretaceous Period but unclear yet. (Ariate, E.Z. and Socrates, A. J. 1976 etc,) These rocks lies in thrust fault contact along ultramafic complex (UC).

Ultramafic Complex (UC)

These rocks is consisted of ultramafic rocks and concerned igneous rocks and are observed in Dinagat and Bucas Grande Is.

Locality; Exposing in almost all part of Dinagat Is. and north part of Bucas Grande Is. up to Socolo and Santa Cruz.

Rock facies; These rocks is composed of pyroxene peridotite (harzburgite), dunite, pyroxinite, gabbro - diabase and anorthosite.

The complex is mainly composed of massive pyroxene peridotite (UC-1) showing dark green black colored and containing 10 - 30% pyroxene phenocryst (dia. 1-4 mm).

Bastite - antigorite alteration began around pyroxene crystals. Olivine is serpentinized in places Dunite (UC-2) occupy mainly north side of Loreto in Dinagat Is. and west side of Bucas Grande and show dark green and black color. The weathering part is turned to brownish yellow. Dunite is composed of almostly olivine accompanying frequently chromite. Serpentinization is observed, it construct the country rock of chromite deposits at Talisay Mine and Redondo Mine. Micro crystals of magnetite which have been differentiated by serpentinization are observed in microscope.

At the boundary zone between UC-1 and UC-2 (northeast of Loreto, Dinagat Is.) alternating beds of pyroxene peridotite and dunite is developing to be considered "cumulate structure". Strikes of the rocks are NW trend and dips are 45-65 degree to west.

Pyroxenite occur dark green colored as dyke shape under 1 m width in many cases. Pyroxene ratio change from 100% to 70-80% and the remained parts are formed by olivine.

Gabbro (UC-3) construct mainly fine grained (under 2 mm in dia.) pyroxene and plagioclase, olivine visible in rare case. In many cases this rock intrudes into UC-1 and UC-2 as dykes few meter width. At near Malinao, north of Dinagat Is. Medium grain stock shape body of gabbro is observed and troctolite and norite appearance rocks are also observed.

Anorthosite occurs as leucocratic dykes under 1 meter width in many cases.

Original age; K-Ar age of UC-1 sample (Y-23-2) which include in UC-2 at northern Dinagat Is. is 84.8 + 4.2 m.y. (Middle Cretaceous Period).

According to Ariate, E.A. & Socrates, J.A. (1976) the original age is estimated also to be Cretaceous Period.

Green Igneous Rocks (K)

This rock is observed in Dinagat Is. as greenish rocks.

Locality; The outcrops have NW-SE trend and is observed in Loreto - Mabini, southwest of Marinao, southeast of Arbol - San Jose.

Rock facies; Appearance is green to grayish green. Rocks are composed of chloritized, fine grain massive andesitic - basaltic or doleritic - diabasic rock. Generally mafic minerals (pyroxene) are chloritized, plagioclases are become white cloudy and weak pyritization is observed in some places.

Original age; This rock is correlated to Eocene by Ariate, E.Z. & Socrates, J.A. (1976).

Sabao Formation (SaFc)

This is named by Fernandez, H.F.. The green rocks distributed in East Bucas and Masapelid Is. contains also in this formation.

Locality; The distributions are observed at near Sabao (St. Monica), San Benito and northeastern Espelansa in northern part of Siargao Is. with NE-SW trend, and also at east Bucas Is. and northeast end of Masapelid Is..

Rock facies; Lower parts is consisted of basaltic pillow lava, it's clastics, dolerite - diabase (intrusive rock?) and dasitic - andesitic pyroclastics. Upper parts is consisted of predominate sediments as siltstone sandstone etc, in Siargao Is.. Fernadez, H.F. has recognized weldedtuff below andesitic pyroclastics.

Basalts show green to grayish green color, fine grained and pillow structure in many cases, therefore is considered as submarine eruption, and shows chilled margin of variolitic texture. Chlorite occurs in gas pore (W9711).

Dolerite - diabase show green colored and is fine or medium grained and massive occuring as the shape of sill and dyke and accompanying strong chloritization and weak pyritization.

Dasitic - andesitic pyroclastics show gray to greenish gray color accompanying lapilli blocks of lower horizon sediments and basalt. The glassy material considered as essential shows green - bluish green colored lenticular and irregular shape.

Sedimentary rocks are gray to greenish gray colored, well bedded tuffaceous and calcareous containing fossils of foraminifera and sagarites.

In East Bucas Is. this formation consists of chloritized doleritic - diabasic rocks accompanied pyrite and quartz veins. Plagioclase phenocrysts are recognized but that of mafic minerals are unclear for the influence of alteration. In Masapelid Is. this formation consists of mainly green colored, massive, porous basaltic lava accompanying same pyroclastics. This volcanics are chloritized and argillized accompanying calcite veinlets.

Original age; Fernandez (1966) has correlated to earier Palaeogene Period. Report of Geological Maps (1/50,000) have estimated to Eocene as same as stage of green igneous rocks (K).

Sedimentary Rocks (Pgl)

This formation is the sedimentary rocks which distribute in Dinagat and Masapelid Is.

Locality; The distribution is observed at around Mabini, eastern Arbol (Blood), eastern San Loque, northern Wilson etc.

Rock facies; Consisting of conglomerate, sandstone, silt - mudstone, chert etc, and their alternating beds.

Conglomerate observes mainly in the part of basement, show gray color and well bedded structure containing medium size gravel of ultramafic rocks.

Sandstone shows gray - bluish gray color and well sorted. Materials are supplied from ultramafic rocks.

Siltstone - sandstone show gray - dark gray color and clear bedding.

Chert is observed at eastern Albor, show grayish red color and fine grained.

Original date; Ariate, E.Z. & Socrates, J.A. (1976) have correlated to Eocene. These rocks unconformably overlies ultramafic rocks at near Mabini, north coast of Wilson and northeast ridge of Dagbaboy with unconformity.

Limestones

Sargao limestone (SF), Dinagat limestone (N), Masapelid limestone. This formation contain Siargao Is. Dinagat Is. Bucas Grande Is. Masapelid Is. in each islands.

Locality; Distributions are observed in main part of Siargao Is. near Loreto, Arbol - San Loque of Dinagat Is. southern part of Bucas Grande Is. and northwestern coast of Masapelid Is..

Rock facies; This formation consists of mainly limestone accompanying siltstone and sandstone.

Limestones (SF-1, N, TL,) show graywhite colored, massive-stratified, marly-porous, colitic, sandy appearances and accompanying a lot of fossils.

Siltstone - sandstone (SF-2) show grayish white color and is softy and carcaleous.

Fossils identification; Micro-fossils in southern Bucas Grande Is. are correlated to Upper Oligocene (nanno-plankton CP-190 zone).

Original date; Fernandez, H.F. (1966) and Report of Geological Map "Dapa" 1/50,000 have correlated to Miocene - Pliocene.

Andesitic Rocks (MaA)

This formation is altered andesitic rocks which distribute in Masapelid Is..

Locality; Extent of outcrop is 6 km N-S and 1.5 km E-W in eastern Masapelid.

Rock facies; Showing grayish white to yellow-grayish brown color. Argillized, softy, fine-porphrytic, massive appearance containing argillized plagioclase and hornblende in rare, accompanyed pyrite dissemination and veinlet.

Original date; These rocks can correlate to Mabuhay Andesite of "Taganaan" 1/50,000 Quadrangle, so the activity is considered at Upper Miocene. The country rock of Cangmod Mine is belonging to this andesitic rocks.

Alluvium Formation (Qal)

This formation distribute along rivers and plane consisting of gravel, sand, silt and thin layer of organic material.

### 3-3-3 Intrusive Rock

Dioritic Rocks ($N_1$)

This diorite intrude in andesitic volcanics (N-1). Limestone (N-2) unconformably overlies the east side of the diorite.

Locality; Distributions are observed in Sogod and Plaridel Quadrangles. Small outcrops are also seen in Sogod Quadrangle.

Rock facies; The rock is pale gray colored medium-coarse grained holocrystalline rocks. Phenocrysts of hornblende, plagioclase and biotite are observed. Argillization, silicification and pyrite impregnation are recognized near the boundary with N-1.

The sample of northeast coast in Panaon Is. (Q210) has porphyritic texture. Plagioclase and hornblende are altered to sericite and chlorite.

The metadiabase intrusive mass which has 5 km diameter is observed 17 km NW of Sogod, it shows subophitic texture in microscope (sample No. T028).

### 3-3-4 Geological Structure

#### 3-3-4-1 Geological Structure of Southern Leyte Area

In this area, geological structures are strong controlled by Philippine Fault which passes longitudinally through this area. Many pallarel faults and strong shaered zones develop along the fault.

Main fault is left side slip fault called Philippine Rift Zone accompanying parallel N - NW fault. NE direction faults are also seen in some places. This side slip fault cut Tertiary Volcanics and Sediments. Andesite eruption and serpentine diabill type intrusion are considered to occur along the fault. Block shape subsiedence taking place according to activity of this fault caused to form Sogod Bay.

At the southern part of the area, Kpg, UC, BC Formations scattered along thrust previous to Philippine Fault.

N-S structure have controlled folding structure in this area. Generally at east side of Philippine Fault, west dipped monoclinal structure predominate. On the contrary anticline and syncline of NS axis are observed in the west side, especially dome structure is observed around area of diorite in south Plaridel Quadrangle.

#### 3-3-4-2 Geological Structure of Dinagat · Siargao Area

Geotectonic position of this area is located at 12 - 150 km west of Philippine trench and 30 - 70 km east of Philippine Fault. NNW-NW and NE trends predominate in the area.

Fault; NW trend fault is assumed to be at Tobahon-Malinao, Arbol and north part of Wilson by linearments. All of them are considered to be south side lifted up, therefore older formation is considered exposing in southern part. Same NW to NNW fault is assumed to be Siargao and Bucas Grande Is.

NE fault series are observed at northeastern Loreto in northern Dinagat Is.. This fault causes dislocation of chromite deposits at Talisay, Masdang and Redond. Bountary between metamorphic rocks and ultramafic rocks is assumed to be thrust. (Ariate, E.Z. and Socrates, J.A. 1976)

Foldings; The syncline structure with NW - SE axis is considered between Loreto and Mabini in Dinagat Is.. Syncline structure is assumed to be along the NE direction valley at Esperansa in Siargao Is..

Small fold structure develop in metamorphic rock. Small scale drag folding is observed limestone reagion.

### 3-3-5 Mineral Showing Survey

#### 3-3-5-1 Southern Leyte Area

8 showings are investigated in this area.

(a) Vein type doposits

1. Pulta 2. Mt. Bagacy 3. Sogod 4. Anilao 5. Pinotan

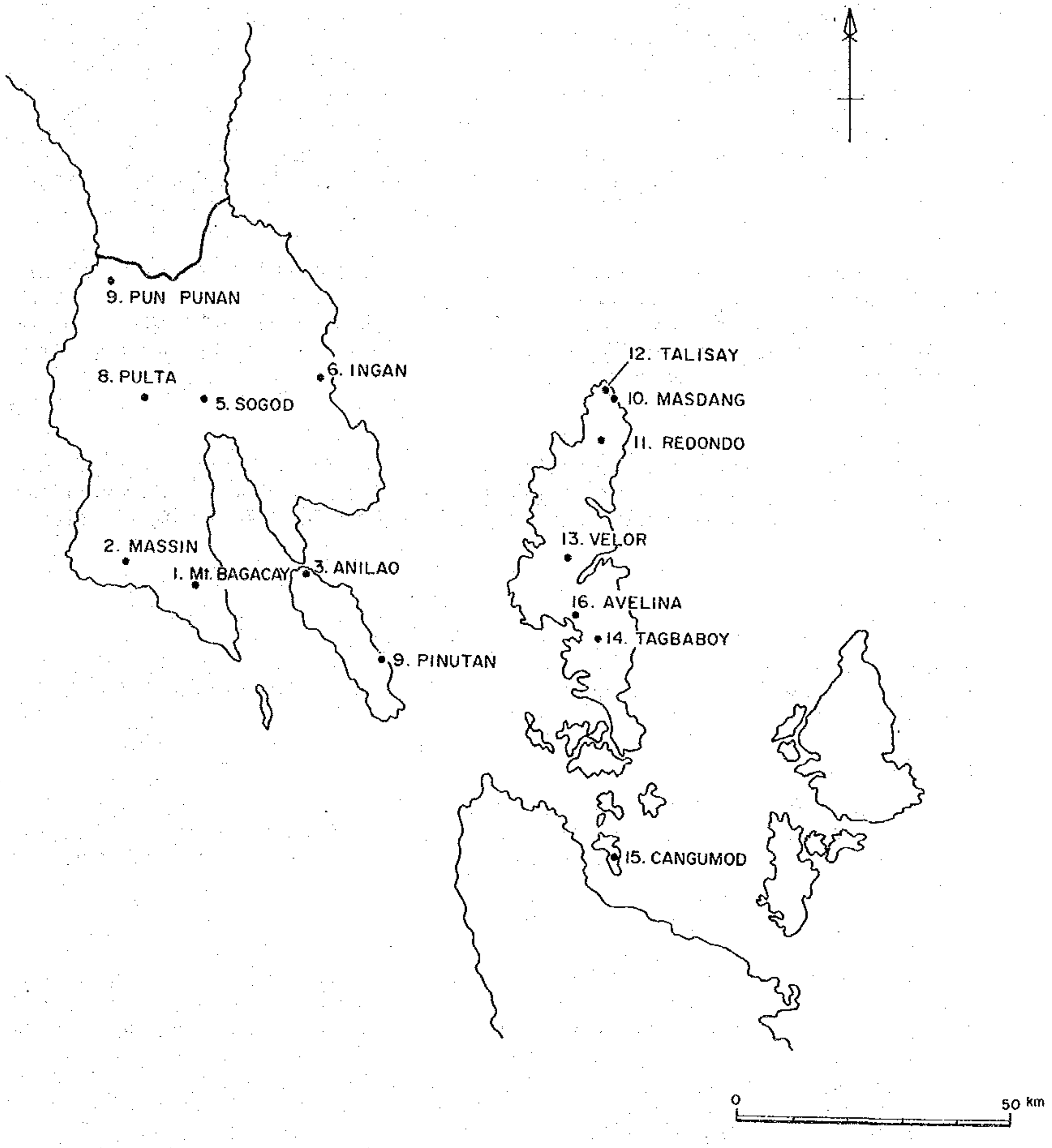



Fig-17 Location Map of Mineral Showing in Southern Leyte · Dinagat · Siargao

(b) Manganese deposits assumed to be sedimentary origin and observed in sheared zone.

6. Punpunan 7. Ingan

(c) Nickel deposit in residual laterite

8. Massin

Others. Tigbawan

1. Pulta

This mineral showing is belong to the mineralization zone accompanying dioritic intrusive rock near Inopakan west side of the area. Mineralization zone is stockwork ore deposition in argillized diorite body which has 0.5 - 1.0 cm width pyrite quartz veins. Mineralization of under 10 m width is recognized in outcrop but alteration zone is considered to extend widely.

2. Mt. Bagacay

This mineral showing is belong to the mineralization zone accompanying basaltic sheared zone near Maltibog, east side Massin Quadrangle. Sulphide dissemination exists in basalt which has partial sheared. Chalcopyrite and malachite are recognized.

3. Sogod

This mineral showing is located in 7 km north of Sogod. Mineralization zone is observed in sheared and argillized andesitic volcanics. Silicification and pyrite dissemination are observed in some places. Small amount of bornite and chalcopyrite are recognized.

4. Anilao

This mineral showing is located in northern part of Panawan Is., east side of San Fransisco Quadrangle. Mineralization is hematite dissemination in altered basic rock. The relation to andesitic intrusive rock at near part is not clear but contact part is chloritized.

5. Pinotan

This mineral showing is located in the boundary area between San Fransisco and Pintuyan Quadrangle. Broad silisification and argillitization are observed along NW-SE fault and actual exploration works in adit are carried out by Benguet Corporation. Country rocks are andesitic pyroclastics and lava which have strong silicification and argillitization. Vein width; 50 - 80 cm, proven length in strike side; 100 - 450 m, proven length in dip side; 100 m, crude ore assay; 6 gr/ton, general strike is EW, dip is 25 - 80 degree to N. In adit diorite is recognized. Pyrite disseminated quartz vein is recognized.

6. Punpunan

This mineral showing is located in Baybay in Plarider Quadrangle. Manganese deposit is seated in andesitic pyroclastic rock with nodule or layer shape. In present some manganese ore blocks remain in the pit.

7. Ingan

This mineral showing is located in west part of Hindayan Quadrangle. Mineralization is pyrite dissemination in sheared argillitized zone. Some manganese mineral is accompanied by this zone.

8. Massin

This mineral showing is located in southern part of Bato Quadrangle. 5 - 30 cm nickeliferous laterite layer covers upper part of basic rocks which consists serpentinized peridotite and later gabbro.

Others; Tigbawan

This mineral showing is located in eastern part of Bato Quadraangle. Mineralization zone is ferruginaus lateritic soil which develop upper part of basalt and red chert belonging to Kpg Formation.

**3-3-5-2 Dinagat and Siargao Area**

7 mineral showings (6 in Dinagat Is., 1 in Masapelid Is.) are investigated.

(a) Orthomagmatic chromite deposits in Dinagat Is.

Chromite ore in dunite.
1. Talisay 2. Masdang 3. Redond

Chromite ore in pyroxene peridotite
4. Velor 5. Avelina 6. Tagbaboy

(b) Vein type gold deposit

7. Cangumod

Others.

1. Talisay

This mineral showing is located in north most part of Dinagat Is. Actual operation is carrying out by Acoje Mining Company, INC.

Ore body is platy, striking N 80°E to EW, dipping 90° to 75°W, maximum thickness 80 cm and alternating with dunite. Several faults which have NNE, NE and NW strikes cut the ore body in some places but the ore body considered to continue at least 60 m in strike side. Country rocks (dunite) are serpentinized and accompanied talc etc..

2. Masadang

This mineral showing is located in north east end of Dinagat Is.. Actual operation is carrying out by Acoje Mining Company, INC. Ore send from Port of Masdang to Cagayan de Oro etc. by tanker. Mineralization has N 70°W strike, and 90°-70° dip, and 2 m thickness. Ore grade is low because ore is disseminated type (strata form), proven elongation is 100 m in strike side but sometimes cut by NE and NW faults and dislocated. Country rocks (dunite) are serpentinized. Another dunite and anorthite dykes which intrude in later age are recognized.

3. Rdond

This mineral showing is located in west side of Mt. Redond (1,000 m height) and altitude is 750 - 900 m. Mining road pass from Loreto to mine site. Actual operation is carrying out by Malayan Wood Product, INC. in big scale.

Strike of ore body is EW and dip is 30° - 70° to S. Thickness of ore body is assumed to be over 15 m. High grade layer is alternated with dunite to show cumulate structure. Ore body is cut by NNW and NNE faults in sometimes. Proven elongation is 30 m in strike side, dip side continuity is also proved by drilling. Country rock dunite is serpentinized and shows black to dark green appearance. Garnierite is accompanied by this ore body.

4. Velor

This mineral showing is located in 2 km south of San Jose in central Dinagat Is. Actual operation is carrying out by Velor Mining Co.,. Unpaved road is arranged from Arbol to Velor, and ore is transported to Port Arbol by truck.

Total amount of mined ore is considered already 10,000 tons from this deposit. Ore body is cut by fine grain gabbro dykes and is caught in this dyke. Therefore the continuity and scale of ore are not clear. At least two orebody (north and south) are considered to exist in NW - SE direction based on old pit shape. Ore is massive, coarse grained and disseminated. Grade is comparably low in many cases. Country rocks (dunite and fine gabbro) have weak hydrothermal alternation. Bluish green serpentinite (in peridotite), pyrite and chlorite (in gabbro) are recognized.

5. Avelina

This mineral showing is located in 6 km SSE side of Velor mine, 150 m altitude. NS 40 m and EW 30 m extent were already explored by Malayan Wood Product, INC. Ore deposit is accompanied by the dunite intruding in pyroxene peridotite or catched by tectonite. Ore bodies have 0.5 - 2.0 m lenticular shape, NW and NE trends dipping 35° - 65° to north several of ore are observed in present. Ore is massive and disseminated and grade is comparably high.

6. Tagbaboy (Doniahelen)

Two old trenches in this showing are observed at 7 km ENE side of Wilson and 40 -50 m hight of mountain slope.

Northern trench (Tagbaboy 1) has the extent NS 20 m and EW 2 - 10 m. Disseminated - massive ore body (several cm thickness) is observed in serpentinized dunite. Several tons of mainly disseminated ore is stocked near the trench.

Southern trench (Tagbaboy 2) has the extent elongated 50 m in NNE direction and 5 - 10 m in width, and ore body is observed in serpentinized dunite.

The ore body has N20°W strike and 25°S dip, consisting of high grade lenticular ore (5 - 10 cm thickness) accompanied disseminated ore in hanging wall. Several tons of ore is stocked at down stream side of the trench, which is assumed to mine from the trench.

(b) Vein type deposit (Gold)

7. Cangumod

This mineral showing is located in southeastern part of Masapelid Is. where is a famous actual mine in the Dinagat, Siargao Area.

Country rocks is hydrothermal altered and argillitized andesitic rock.

Ore deposit is quartz vein in adnesite accompanying native-gold, pyrite, chalcopyrite, bornite, galena and sphalerite (Abarquez o. etal 1980) but in present many adits and shafts are drowned so details is not clear.

Actual operation is carrying out to mine the gold bearing pyrite veilets.

Others

As for chromite deposite several old trenches exist at northeast side of Loreto and around Arbol to Wilson. Gold showings are known in places at northern part of Dinagat Is., east side Arbol, east side Mabini, south side Velor mine and southeast side Wilson etc. In these places people say that panning carried out in old age and quartz vein bearing bolders accompanying pyrite, sphalerite and chalcopyrite are observed near these places.

Another gold mine, Cangumod exist at northwest coast of Masapelid Is. but details is unknown.

Abstruct of surveyed mineral showings in Southern Leyte, Dinagat and Siargao Area is in Table-4.

Details of each mineral showings are shown in skeches and data sheets editing at the end of volume appendics.

Table-4 Abstruct of Mineral Showing Survey in Southern Leyte • Dinagat • Siargao Area

| No. | Name of Showing | Type of Ore Deposit | Kind of Ore | Country Rocks | Rank | Reference | Sample Grade |
|---|---|---|---|---|---|---|---|
| 1 | Mt. Bagacay (Lambonao) | Hydrothermal alternation | Copper | Andesite Basalt Pyroclastics | D | Contact of intrusive rocks is known, ore body has lenticular shape, dissemination observed. | Au; tr Ag; 1g/t Cu; 0.01%<br>Pb; 0.01% Zn; 0.03% |
| 2 | Massin | Residual Soil | Nickel | Serpentinized Periodotite | E | Ore body enclose lateritic clay, small scale. | Au; tr Ag; 1g/t Cu; 0.01%<br>Pb; 0.23% Zn; 0.01% |
| 3 | Anilao | Disseminated ore | Pyrite Hematite | Metabasic rocks | E | Dissemination in serpentinized Peridotite. | Au; 1.8 g/t Ag; 25 g/t Cu; 4.65%<br>Pb; 0.02% Zn; 0.02% |
| 5 | Sogod | Vein type deposit | Chalcopyrite Bornite | Biotite andesite | E | Small scale vein accompanying strong silicification & pyritization. | Au 0.1 g/t Ag; 2 g/t Cu; 0.01%<br>Pb; 0.05% Zn; 0.02% |
| 6 | Ingan | Vein type deposit, partial dissemination | Pyrite | Plagioclase andesite | C | Strong argillitized, sulfide bearing quartz veinlet and dissemination accompanying manganese gossan. | Au 0.1 g/t Ag; 1g/t Cu; -0.01%<br>Pb; 0.01% Zn; -0.01% |
| 7 | Pinat-an | Gold bearing vein type deposit | Gold | " | E | Gold accompany argillitization and pyritization, sphalerite, galena, bornite visible. | Au g/t Ag g/t Cu % Pb % Zn %<br>1; tr 5 0.07 0.06 0.01<br>2; 0.4 2 -0.01 0.03 0.07 |
| 8 | Pangagan | Residual manganese deposit | Mn | Andesitic pyroclastics pyroclastics | E | Mined out. | Mn Fe P S $SiO_2$<br>57.28 0.08 0.07 0.07 0.88(%) |
| 9 | Pula | Massive sulfide | Pyrite | Diorite | E | Country rock is strongly argillitized | |
| 10 | Masdang | Orthomagmatic deposit | Chromite | Dunite | B | Accompanying dunite which intrude in serpentinized dunite. | $Cr_2O_3$ $Al_2O_3$ FeO MgO $SiO_2$<br>36.78 8.72 10.97 22.33 17.49(%) |
| 11 | Redond | " | " | " | B | " | 47.56 11.49 13.25 19.62 7.96(%) |
| 12 | Talisay | " | " | " | B | " | 41.01 8.83 11.29 20.20 12.00(%) |
| 13 | Velor | " | " | " | C | Accompanying micro gabbro, dip side exploration is necessary. | 28.82 13.05 11.33 23.11 18.38(%) |
| 14 | Tagbaboy (1) | " | " | " | D | Accompanying dunite which intrude in serpentinized dunite | 35.64 11.90 12.83 21.58 14.20(%) |
| | Tagbaboy (2) | " | " | " | " | " | 50.05 8.74 16.29 15.37 9.07(%) |
| 15 | Cangumod | Gold bearing pyrite vein | Gold | Andesite | C | Gold bearing pyrite vein in andesite accompanying sphalerite. | Sample Au g/t Ag g/t Cu% Pb% Zn%<br>sf-37 -0.01 1 0.02 0.01 0.02<br>sf-38 10.8 6 0.03 0.01 -0.01 |
| 16 | Avelina | Orthomagmatic deposit | Chromite | Dunite | C | Accompanying dunite which intrude in serpentinized dunite. | $Cr_2O_3$ $Al_2O_3$ FeO MgO Zn<br>45.99 11.84 13.46 17.81 6.65(%) |

Evaluation Grade: B: High necessary for following survey
C: Having room for following survey
D: Low necessity for following survey
E: Needless for following survey

# 4. GEOCHEMICAL SURVEY

## 4 Geochemical Survey

### 4-1 Survey Method

Geochemical survey was undertaken mainly to analyze the microchemical contents of elements of stream sediment samples.

Likewise analysis for microchemical contents of heavy mineral samples was also carried out. Sampling error was checked by taking duplicated samples from same place of original sampling point at approximately every 50 stream sediment samples collected.

Geochemical samples for Masbate area and Northern Leyte Area were analyzed by the Breau of Mines and Geo-Sciences analitical laboratory (herein after called PETROLAB) by atomic absorption method.

While samples for Southern Leyte, Dinagat and Siargao Area only heavy mineral sampels was analyzed herein, and the rests were analyzed by Chemex Co., in Canada using the same method.

Processing of geochemical data was done by Overseas Mineral Resources Development Co., Ltd. (hereinafter called OMRD) for all areas.

Analyzing method is univeriate and multivariate analysis of the data.

#### 4-1-1 Sample Location

Sampling was carried out along active channels of streams. Density of sampling is approximately 1 stream sediment sample for every 1 to 2 square kms. Sampling points are pre-determined in a 1/50,000 scale prior to the start of the survey.

#### 4-1-2 Sampling method

Samples collected are wet sieved by stainless sieve to 30 mesh fraction in situ by which they amounted to about 500 grams. They are washed thoughly to remove dirty and clay fractions before they are placed in properly maked kraft bag water resistant. An accompanying data seet card (Fig 9) is being filled up to record observations when sample was taken the following items, location, grid coordinates, features of the stream, pH, Eh, topography etc. Samples are transported to base camp for drying and sieving to -80 mesh.

Likewise heavy mineral samples were collected using wooden pans at pre-determined sampling points. 50 grams of heavy mineral fractions are collected from each point and placed in plastic tube and then sended to laboratory through base camp. As same as stream sediments, a corresponding data sheet form is filled up to describe the place where the sample was taken from. Southern Leyte·Dinagat and Siargao Area stream sediment samples were sun-dried and were sieved to -80 mesh by stainless sieve. The -80 mesh material were put in kraft paper bag and were sent to Chemex Laboratory in Canada. Masbate and northern Leyte sampels were dried at each base camps sieving to -80 mesh, then put in kraft paper bags and were sent to PETROLAB.

#### 4-1-3 Method of Indoor Testing

1) Adjustment method of analitical samples

## Fig-18 Field Data Sheet of Geochemical Survey

AREA:

| SAMPLE NO. | SAMPLE TYPE | EASTING | NORTHING | S T R E A M | | | | | | B A N K | | SEDIMENT OR SOIL SIZE | ORGANIC MATTER | PRECIPITATE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ord. | Width-m | Depth cm | Flow | PH | EH | Type | Ht-m | | | |
| 1 5 | 6 | 7 10 | 11 14 | 15 | 16 17 | 18 20 | 21 | 22 23 | 24 25 | 26 | 27 28 | 29 | 30 | 31 |
| | | | | | | | | | | | | | | |

| CONTAMINATION | MINERALIZATION | ALTERATION | ROCK TYPE | OTHER SAMPLES |
|---|---|---|---|---|
| 32 | 33 | 34 | 35 36 | 37 |
| | | | | |

REMARKS:

CODES:

Cols.1-5 Sample number.

Col.6 Sample type. Enter one of the following codes:
- 1-stream sediments
- 2-soil
- 3-rock
- 4-heavy mineral concentrate (note original concentrate panned under REMARKS column)
- 5-duplicate sample (corresponding to preceeding sample number)

Cols.7-14 Coordinates.

Col.15 Stream order.

Cols.16-17 Stream width(m). Enter width of active channel; (enter 99 if > 99).

Cols.18-20 Water depth (cm).

Col.21 Flow. Enter one of the following codes:
- 0-dry
- 1-stagnant
- 2-slow
- 3-moderate
- 4-fast
- 5-artificial

Cols.22-23 PH. Leave blank if not recorded: if measurement is 6.4 enter 64.

Cols.24-25 Conductivity ($\mu S / cm$)

Col.26 Bank type:
- 1-colluvial
- 2-alluvial
- 3-scree
- 4-bedrock
- 5-colluvial and bedrock

Cols.27-28 Bank height(m).

Col.29 Sediment or soil size. Record grain size of material sampled (whether sediment or soil) using one of following codes:
- 1-coarse
- 2-medium (sandy)
- 3-fine (silty)
- 4-clayey

Col.30 Organic matter. Note presence and amount (abundant, moderate, minor). Use code 1 if present and 0 if absent.

Col.31 Precipitates. Note precipitates present, using codes:
- 0-absent or not detected
- 1-iron (red or brown stains)
- 2-manganese (black stains)
- 3-sulphur (yellow stains)
- 4-carbonate
- 5-other (specify)

Col.32 Contamination. Note presence and type. Use code 1 if present and 0 if absent.

Col.33 Mineralization. Note presence and type (sketch on reverse). Use code 1 if present and 0 if absent.

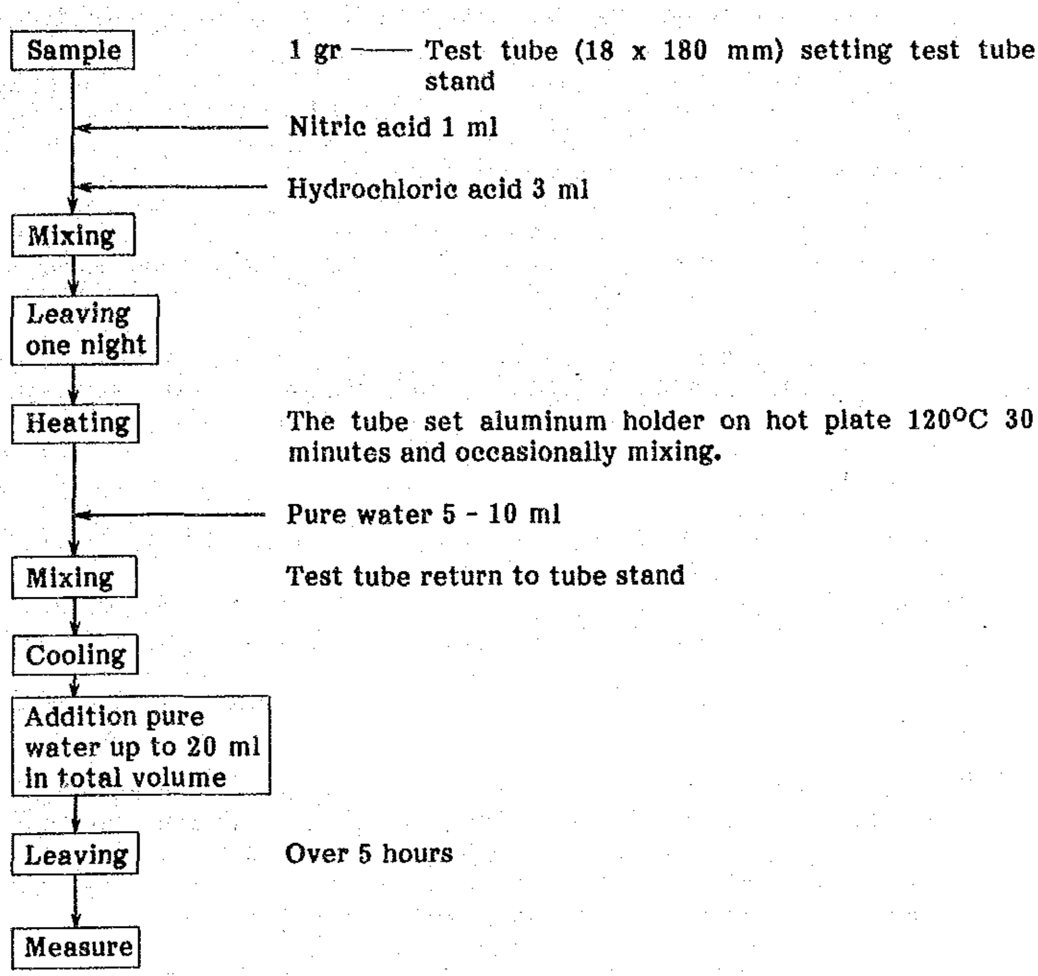
Col.34 Alteration. Note presence and type. Use code 1 if present and 0 if absent.

Cols.35-36 Rock type. Use one of the codes given on the reverse.

Col.37 Other samples. Note other samples collected at the same site. Use one of the following codes:
- 0-none
- 1-stream sediment
- 2-soil
- 3-rock
- 4-heavy mineral concentrate
- 5-duplicate
- 6-several types (specify)

Remarks. Enter any other pertinent information about the sampling locality

Fig-19 Flow Chart of Stream Sediment Preparation




| Element | Measuring Method | Flame | Wave Length (mm) |
|---|---|---|---|
| Ag | Direct Atomic Absorption | Air-$C_2H_2$ | 328.1 |
| Cu | " | " | 324.7 |
| Mn | " | " | 403.3 |
| Pb | " | " | 217.0 |
| Zn | " | " | 213.7 |
| Mo | " | $N_2O$-$C_2H_2$ | 313.0 |
| Hg | Reduction vapor - A.A.S. | Flameless | 253.7 |
| As | Hydration - A.A.S. | " | 197.4 |

Stream sediment and heavy mineral samples which are sent to PETROLAB are divided into 20 gram for analitical samples and the rest amount for spare samples.

At analytical laboratory one gram of stream sediment samples and 10 grams of heavy mineral samples use for AAS analysis and the rest are stocked as spare sample.

2) Microchemical analitical methods (Foot note 1)

After weighing all samples were analized by atomic absorption method according to the attached flow chart (Fig 10) in PETROLAB. Chamex Laboratory in Canada did the analysis by same procedure.

Elements analyzed were Ag, Cu, Pb, Zn, As, Hg, Mo, Mn, Co (9) in Masbata Area Ag, Cu, Pb, Zn, As, Hg, Mo, Ni, Co, Mn (10) in Northern Leyte and Southern Leyte Area.

For Dinagat and Siargao area elements analyzed were Ag, Cu, Pb, Zn, Co, Mn, Ni, Cr, As, Hg (10).

Heavy mineral samples were analyzed Au, Ag, and Ga (3) in all Areas. The detection limits of those elements are shown in Table 8.
In PETROLAB 3 sets of atomic absorption spectrometer were utilized. One of which is flameless type. (model GTA-95 while other two AS-1475, maker; Varian Tectron Co.,)

Foot note 1

This analysis method is direct aqua-regina extraction from under 80 mesh sampels unless further grinding, therefore, some amount of indication elements which include in quartz grain etc., have possibility to remain after extaction. But geochemical survey requires not absolute contents but comparable value in each samples, so such convenience method is accepted in geochemical survey.

Table 5 Detection Limit of AAS of Both Laboratory

| Laboratory | Cu | Pb | Zn | Ag | Ni | Co | Mn | As | Hg | Mo | Ba |
|---|---|---|---|---|---|---|---|---|---|---|---|
| PETROLAB | 2 | 10 | 2 | 1 | 3 | 3 | 50 | 0.5 | 0.04 | 2 | - |
| CHEMEX | 2 | 1 | 1 | 0.1 | 1 | 1 | 5 | 0.5 | 0.005 | 1 | 10 |

The check of analitical results were made between both laboratory (PETROLAB and Chemex Co.,) by 50 Samples, the differences among them recognize as negligible small.

3) The method of statistical analysis for geochemical results

The statistical analysis for geochemical results were carried out in all the areas. In each area univariate and multivariate analitical method was applied to each population group using the proceudre by C. Lepeltier (1969).

Procedure of analysis are as follows.

Computer was used for calculations.

Previous Procedure of data

(1) Determination of lithological population

Country rocks which predominate in sampling area are divided into some lithological populations in reference to tendency of microchemical component of the rocks.
(generally 8 - 12 population in one area)

(2) Making data file

Data file are made on sample number, analitical results in each lithological population and elements.

(3) Checking dispersion for results of microchemical analysis between original and duplicated samples.

Univariate Analysis

(1) The result data are rearranged to put in order of value in each population and element.

(2) Mean, threshold, standard deviation, maximum, minimum, dispersion etc., statistical values are calculated.

(3) Histograms for each pupulation and elements were made.

(4) Log normal data tables were made for each pupulation and elements.

(5) 95% level student (t), and Snedecor (F) certification for dispersion of data were carried out between different population. If data dispersion range among some populations was same, those populations were consolidated.

(6) Drawing cumulative frequency curve for each population and elements.

(7) Making the list to pick up anomalous data.

(8) Correlative coefficients between all populations and elements were calculated.

Multivariate Analysis (Factor Analysis)

(1) Determination of Factor and Inference of Eactor Loadings.

(2) Calculation of Factor Scores.

(3) Drawing Distribution Maps of Factor Scores

Note 2: Factor analysis has been developed as the statistical method to condense many various informations to small amount of potential factors and applied to broad field at the same sence of other multivariate analysis methods in recent days. This method has some similarity to Principal component analysis method, but the purpose of former method is to explain correlation of various informations by using potential factors (in this case mineralizations) on the other hand the later is to explain dispersion of various informations by using small number of principal components.

## 4-2 Geochemical Survey in Masbata Area

### 4-2-1 Basic statistical data

1) Statistical data for each lithological code

Stream sediments in Masbate Area are divided into following lighological code according to the geochemical feature of country rocks.

| Lithological Code | Contents | Sample Number |
|---|---|---|
| R | Allvium sediments | 166 |
| NQS | Pliocene - Pleistocene sediments | 162 |
| NQL | " limestone | 86 |
| N2A | Neogene andesitic volcanics | 78 |
| N2L | " limestone | 166 |
| N2S | Neogene upper sedimentary rocks | 365 |
| N1S | Neogene lower " | 96 |
| KPA | Metaandesitic volcanics | 449 |
| KPB | Metabasaltic volcanics | 305 |
| KPS | Metasedimentary rocks | 224 |
| KPl | Recrystalline limestone | 16 |
| INR | Dioritic rocks | 104 |
| | | 2,217 |
| | Duplicate samples | 57 |

Statistical data for each lithological code are shown in following tables. (These values are calculated by logalismic base and transferred to natural values.)

2) Histogram

Frequency dispersion histograms for each detective element in each lithological code are made by logarithmic scale with 1/2 standard deviation unit (shown in Appendix-5).

Each histogram features for each element are as follows.

Cu; Histogram of copper for each lithological code shows normal logarithmic dispersion except KPA code. Samples are not enough in number in the high grade range of code R and in the low range of code NQL, NIS and KPL.

## Lithological code NQS; Pliocene - Pleistocene Sediments

Number of Sample 162 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 25 | 5 | 0.5 | 37 | 38 | 18 | 693 | 1.7 | 6.0 | 20.0 | |
| $1\sigma$ value | 37 | 5.4 | - | 52 | 56 | 26 | 1,160 | 3.2 | 10.2 | 21.8 | |
| $1.5\sigma$ value | 46 | 5.7 | - | 63 | 67 | 31 | 1,500 | 4.3 | 13.3 | 22.6 | This value estimate as threshold |
| $2\sigma$ value | 56 | 5.9 | - | 76 | 81 | 38 | 1,940 | 5.9 | 17.4 | 23.5 | |
| Maximum | 58 | 10 | 0.5 | 73 | 92 | 50 | 4,100 | 6.0 | 95.0 | 40.0 | |
| Minimum | 7 | 5 | 0.5 | 13 | 16 | 7.0 | 180 | 1.0 | 1.3 | 20.0 | |

## Lithological code NQL; Quarternary Limestone

Number of Sample 86 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 24 | 5.1 | 0.5 | 42 | 23 | 16 | 578 | 1.7 | 3.9 | 21.0 | |
| $1\sigma$ value | 36 | 5.5 | - | 70 | 35 | 27 | 1,172 | 4.0 | 7.9 | 27.5 | |
| $1.5\sigma$ value | 44 | 6.3 | - | 91 | 44 | 35 | 1,669 | 6.1 | 11.3 | 21.2 | This value estimate as threshold |
| $2\sigma$ value | 54 | 6.7 | - | 118 | 55 | 46 | 2,378 | 9.2 | 16.1 | 35.4 | |
| Maximum | 52 | 13.0 | 0.5 | 187 | 63 | 43 | 2,000 | 10.0 | 10.0 | 84.0 | |
| Minimum | 5 | 5.0 | 0.5 | 7 | 9 | 1.5 | 25 | 1.0 | 0.25 | 20.0 | |

## Lithological code $N_2A$; Neogene andestic Volcanic Rocks

Number of Sample 78 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 75 | 5.0 | 0.5 | 87 | 18 | 28 | 1,073 | 1.1 | 1.7 | 21.6 | |
| $1\sigma$ value | 130 | 5.6 | - | 153 | 26 | 40 | 1,851 | 1.3 | 3.7 | 29.1 | |
| $1.5\sigma$ value | 172 | 5.9 | - | 202 | 30 | 48 | 2,431 | 1.5 | 5.4 | 33.8 | This value estimate as threshold |
| $2\sigma$ value | 226 | 6.2 | - | 268 | 36 | 57 | 3,193 | 1.6 | 7.9 | 39.2 | |
| Maximum | 154 | 12.0 | 0.5 | 280 | 58 | 72 | 2,420 | 4.0 | 9.8 | 130.0 | |
| Minimum | 8 | 5.0 | 0.5 | 22 | 9 | 10 | 280 | 1.0 | 0.25 | 20.0 | |

(2) Calculation of Factor Scores.

(3) Drawing Distribution Maps of Factor Scores

Note 2: Factor analysis has been developed as the statistical method to condense many various informations to small amount of potential factors and applied to broad field at the same sence of other multivariate analysis methods in recent days. This method has some similarity to Principal component analysis method, but the purpose of former method is to explain correlation of various informations by using potential factors (in this case mineralizations) on the other hand the later is to explain dispersion of various informations by using small number of principal components.

## 4-2 Geochemical Survey in Masbata Area

### 4-2-1 Basic statistical data

1) Statistical data for each lithological code

Stream sediments in Masbate Area are divided into following lighological code according to the geochemical feature of country rocks.

| Lithological Code | Contents | Sample Number |
|---|---|---|
| R | Allvium sediments | 166 |
| NQS | Pliocene - Pleistocene sediments | 162 |
| NQL | " limestone | 86 |
| N2A | Neogene andesitic volcanics | 78 |
| N2L | " limestone | 166 |
| N2S | Neogene upper sedimentary rocks | 365 |
| N1S | Neogene lower " | 96 |
| KPA | Metaandesitic volcanics | 449 |
| KPB | Metabasaltic volcanics | 305 |
| KPS | Metasedimentary rocks | 224 |
| KPI | Recrystalline limestone | 16 |
| INR | Dioritic rocks | 104 |
| | | 2,217 |
| | Duplicate samples | 57 |

Statistical data for each lithological code are shown in following tables. (These values are calculated by logalismic base and transferred to natural values.)

2) Histogram

Frequency dispersion histograms for each detective element in each lithological code are made by logarithmic scale with 1/2 standard deviation unit (shown in Appendix-5).

Each histogram features for each element are as follows.

Cu; Histogram of copper for each lithological code shows normal logarithmic dispersion except KPA code. Samples are not enough in number in the high grade range of code R and in the low range of code NQL, NIS and KPL.

## Lithological code NQS; Pliocene - Pleistocene Sediments

Number of Sample 162 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 25 | 5 | 0.5 | 37 | 38 | 18 | 693 | 1.7 | 6.0 | 20.0 | |
| 1σ value | 37 | 5.4 | - | 52 | 56 | 26 | 1,160 | 3.2 | 10.2 | 21.8 | |
| 1.5σ value | 46 | 5.7 | - | 63 | 67 | 31 | 1,500 | 4.3 | 13.3 | 22.6 | This value estimate as threshold |
| 2σ value | 56 | 5.9 | - | 76 | 81 | 38 | 1,940 | 5.9 | 17.4 | 23.5 | |
| Maximum | 58 | 10 | 0.5 | 73 | 92 | 50 | 4,100 | 6.0 | 95.0 | 40.0 | |
| Minimum | 7 | 5 | 0.5 | 13 | 16 | 7.0 | 180 | 1.0 | 1.3 | 20.0 | |

## Lithological code NQL; Quarternary Limestone

Number of Sample 86 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 24 | 5.1 | 0.5 | 42 | 23 | 16 | 578 | 1.7 | 3.9 | 21.0 | |
| 1σ value | 36 | 5.5 | - | 70 | 35 | 27 | 1,172 | 4.0 | 7.9 | 27.5 | |
| 1.5σ value | 44 | 6.3 | - | 91 | 44 | 35 | 1,669 | 6.1 | 11.3 | 21.2 | This value estimate as threshold |
| 2σ value | 54 | 6.7 | - | 118 | 55 | 46 | 2,378 | 9.2 | 16.1 | 35.4 | |
| Maximum | 52 | 13.0 | 0.5 | 187 | 63 | 43 | 2,000 | 10.0 | 10.0 | 84.0 | |
| Minimum | 5 | 5.0 | 0.5 | 7 | 9 | 1.5 | 25 | 1.0 | 0.25 | 20.0 | |

## Lithological code $N_2A$; Neogene andestic Volcanic Rocks

Number of Sample 78 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 75 | 5.0 | 0.5 | 87 | 18 | 28 | 1,073 | 1.1 | 1.7 | 21.6 | |
| 1σ value | 130 | 5.6 | - | 153 | 26 | 40 | 1,851 | 1.3 | 3.7 | 29.1 | |
| 1.5σ value | 172 | 5.9 | - | 202 | 30 | 48 | 2,431 | 1.5 | 5.4 | 33.8 | This value estimate as threshold |
| 2σ value | 226 | 6.2 | - | 268 | 36 | 57 | 3,193 | 1.6 | 7.9 | 39.2 | |
| Maximum | 154 | 12.0 | 0.5 | 280 | 58 | 72 | 2,420 | 4.0 | 9.8 | 130.0 | |
| Minimum | 8 | 5.0 | 0.5 | 22 | 9 | 10 | 280 | 1.0 | 0.25 | 20.0 | |

## Lithological code $N_2L$; Neogene Limestones

Number of Sample 166 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 23 | 5.4 | 0.5 | 32 | 29 | 14 | 449 | 1.6 | 4.5 | 20.2 | |
| $1\sigma$ value | 51 | 7.9 | - | 66 | 51 | 26 | 1,077 | 3.3 | 8.7 | 21.7 | |
| $1.5\sigma$ value | 76 | 9.6 | - | 95 | 67 | 36 | 1,669 | 4.7 | 12.1 | 22.6 | This value estimate as threshold |
| $2\sigma$ value | 114 | 11.5 | - | 136 | 88 | 50 | 2,585 | 6.7 | 16.7 | 23.5 | |
| Maximum | 95 | 76.0 | 0.5 | 390 | 99 | 46 | 3,700 | 7.0 | 14.0 | 40.0 | |
| Minimum | 3 | 5.0 | 0.5 | 7 | 7 | 1.5 | 25 | 1.0 | 0.25 | 20.0 | |

## Lithological code $N_2S$; Neogene Upper Sedimentary Rocks

Number of Sample 365 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 45 | 5.0 | 0.50 | 69 | 21 | 28 | 940 | 1.1 | 1.6 | 20.1 | |
| $1\sigma$ value | 74 | 5.6 | 0.52 | 117 | 34 | 42 | 1,312 | 1.7 | 5.1 | 21.8 | |
| $1.5\sigma$ value | 95 | 5.9 | 0.53 | 152 | 43 | 51 | 1,791 | 2.1 | 9.1 | 22.7 | This value estimate as threshold |
| $2\sigma$ value | 122 | 6.1 | 0.54 | 199 | 55 | 63 | 2,221 | 2.5 | 16.3 | 23.6 | |
| Maximum | 3,344 | 12.0 | 1.00 | 290 | 95 | 70 | 2,600 | 8.0 | 15.0 | 63.0 | |
| Minimum | 13 | 5.0 | 0.50 | 8 | 5 | 10 | 320 | 1.0 | 0.25 | 20.0 | |

## Lithological code $N_1S$; Neogene Lower Sedimentary Rocks

Number of Sample 96 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 61 | 5.2 | 0.51 | 56 | 19 | 25 | 910 | 1.0 | 2.9 | 22.0 | |
| $1\sigma$ value | 78 | 6.2 | 0.58 | 83 | 24 | 33 | 1,331 | - | 5.2 | 29.5 | |
| $1.5\sigma$ value | 88 | 6.8 | 0.62 | 102 | 27 | 37 | 1,610 | - | 6.9 | 34.2 | This value estimate as threshold |
| $2\sigma$ value | 99 | 7.4 | 0.67 | 125 | 30 | 43 | 1,947 | - | 9.2 | 39.7 | |
| Maximum | 136 | 20.0 | 2.00 | 143 | 35 | 62 | 2,100 | 1.0 | 9.3 | 100.0 | |
| Minimum | 29 | 5.0 | 0.50 | 22 | 8 | 14 | 120 | 1.0 | 0.25 | 20.0 | |

## Lithological code KPA; Meta-Andesite Volcanics

Number of Sample 449 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 69 | 6.6 | 0.52 | 72 | 17 | 21 | 960 | 1.1 | 2.0 | 24.4 | |
| 1σ value | 167 | 14.5 | 0.73 | 124 | 29 | 30 | 1,449 | 1.5 | 5.7 | 51.0 | |
| 1.5σ value | 236 | 21.4 | 0.87 | 163 | 37 | 35 | 1,781 | 1.7 | 9.8 | 73.9 | This value estimate as threshold |
| 2σ value | 355 | 31.7 | 1.02 | 214 | 47 | 42 | 2,189 | 2.0 | 16.9 | 106.9 | |
| Maximum | 9,300 | 710 | 19.00 | 340 | 125 | 74 | 3,500 | 10.0 | 82.0 | 4,600 | |
| Minimum | 11 | 11 | 0.50 | 14 | 3 | 4 | 93 | 1.0 | 0.25 | 20 | |

## Lithological code KPB; Meta-Basaltic Volcanics

Number of Sample 305 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 51 | 5.3 | 0.5 | 72 | 26 | 27 | 1,171 | 1.1 | 1.3 | 20.2 | |
| 1σ value | 81 | 7.3 | - | 110 | 48 | 38 | 1,709 | 1.4 | 4.3 | 23.0 | |
| 1.5σ value | 102 | 8.5 | - | 136 | 65 | 46 | 2,065 | 1.5 | 7.6 | 24.6 | This value estimate as threshold |
| 2σ value | 128 | 9.9 | - | 168 | 88 | 54 | 2,496 | 1.7 | 13.7 | 26.2 | |
| Maximum | 154 | 65 | 0.5 | 260 | 206 | 98 | 3,900 | 7.0 | 61,0 | 110.0 | |
| Minimum | 11 | 4 | 0.5 | 20 | 3 | 9 | 380 | 1.0 | 0.25 | 20.0 | |

## Lithological code KPS; Meta-Sedimentary Rocks

Number of Sample 224 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 42 | 5.2 | 0.5 | 72 | 23 | 26 | 1,088 | 1.1 | 1.4 | 20.3 | |
| 1σ value | 70 | 6.6 | - | 111 | 46 | 40 | 1,7373 | 1.4 | 3.8 | 23.2 | |
| 1.5σ value | 90 | 7.4 | - | 137 | 65 | 50 | 2,143 | 1.6 | 6.2 | 24.8 | This value estimate as threshold |
| 2σ value | 116 | 8.3 | - | 170 | 91 | 63 | 2,771 | 1.9 | 10.4 | 26.4 | |
| Maximum | 210 | 27.0 | 0.5 | 270 | 210 | 99 | 3,200 | 6.0 | 20.0 | 65.0 | |
| Minimum | 7 | 5.0 | 0.5 | 9 | 3 | 3 | 94 | 1.0 | 0.25 | 20.0 | |

Lithological code KPL; Recrystalline Limestone

Number of Sample 16 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 49 | 6.0 | 0.5 | 57 | 23 | 25 | 874 | 1.0 | 2.9 | 20.0 | |
| 1σ value | 83 | 9.0 | - | 90 | 39 | 38 | 1,640 | - | 5.0 | - | |
| 1.5σ value | 107 | 11.1 | - | 112 | 51 | 47 | 2,248 | - | 6.6 | - | This value estimate as threshold |
| 2σ value | 140 | 13.5 | - | 141 | 67 | 59 | 3,079 | - | 8.6 | - | |
| Maximum | 114 | 15.0 | 0.5 | 101 | 114 | 98 | 3,500 | 1.0 | 7.2 | 20.0 | |
| Minimum | 12 | 5.0 | .5 | 17 | 12 | 11 | 150 | 1.0 | 0.9 | 20.0 | |

Lithological code INR; Dioritic Rocks

Number of Sample 104 (Unit; ppm except Hg)

| | Cu | Pb | Ag | Zn | Ni | Co | Mn | Mo | As | Hg(ppb) | Remark |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 52 | 5.4 | 0.5 | 40 | 10 | 14 | 527 | 1.1 | 0.9 | 21.1 | |
| 1σ value | 90 | 7.1 | - | 73 | 19 | 24 | 923 | 1.5 | 3.1 | 28.0 | |
| 1.5σ value | 118 | 8.2 | - | 98 | 26 | 31 | 1,222 | 1.8 | 5.8 | 32.3 | This value estimate as threshold |
| 2σ value | 156 | 9.4 | - | 132 | 35 | 40 | 1,618 | 2.2 | 10.8 | 37.3 | |
| Maximum | 198 | 20.0 | 0.5 | 360 | 39 | 30 | 1,940 | 12.0 | 36.0 | 150.0 | |
| Minimum | 13 | 5.0 | 0.5 | 13 | 3 | 1.5 | 50 | 1.0 | 0.25 | 20.0 | |

2) Histogram

Frequency dispersion histograms for each detective element in each lithological code are made by logarithmic scale with 1/2 standard deviation unit (shown in Appendix-5).

Each histogram features for each element are as follows.

Cu; Histogram of copper for each lithological code shows normal logarithmic dispersion except KPA code. Samples are not enough in number in the high grade range of code R and in the low range of code NQL, NIS and KPL.

Histogram of KPA is skewed to right by reason that anomalous value including maximum value 9,300 ppm are excess in number.

Pb·Ag; Pb·Ag contents are almostly under the detection limit. Therefore all Pb·Ag histograms have not shown normal logarithmic dispersion.
Maximum value sample (710 ppm Pb, 19 ppm Ag) are included in KPA code.

Zn; Histogram of Zn for each lithological code shows normal logarithmic dispersion except KPA code. Low grade side dispensions are not enough in NQL and KPL codes.
In KPA code many anomalies including maximum value (840 ppm Zn) are located in high grade side. This seems just reason the histogram out of normal logarithmic dispersion.

Ni; Histogram of Ni for each lithological code shows normal logarithmic dispersion except N2S code. Dispersion of high grade side is not enough in KPL code.
In N2S code, the lack of both side dispersion are observed. This seems main reason out of normal logarithmic dispersion. Maximum value (210 ppm Ni) include in KPS code.

Co; Histogram of Co for each lithological code shows normal logarithmic dispersion except NQL, N2S, KPS codes. Generally low grade side dispersions are not enough, especially this tendency is strong in NQL, N2S and KPS.
Maximum value (99 ppm Co) includes in KPS code.

Mn; Histogram of Mn for each lithological code shows normal logarithmic dispersion except N2L, KPA., KPS. Generally low grade side dispersion is not enough, especially above mentioned excepted codes. Maximum value (4100 ppm; Mn) is included in NQS code.

Mo; Mo content of samples is almostly under detection limit. Therefore Mo histogram have not shown normal logarithmic dispersion.
Maximum value sample (12 ppm; Mo) is included in INR code.

As; Histogram of As for each lithological code shows normal logarithmic dispersion except N2A, N2S, KPA codes. Generally low grade side dispersion is not enough. Same tendencies are observed in N2A, KPA codes while N2S code is insufficient dispersion in high grade side.
Maximum value sample (95 ppb As) is included in KPA code.

Hg; Hg content of samples is almostly under detection limit. Therefore Hg histogram is not shown normal logarithmic dispersion to any lithological code.
Maximum value sample (4,600 ppb Hg) is included in KPA code.

3) Cumulative frequency curve

Cumulative frequency curves corresponding to above mentioned histograms are shown in appendics-5.
They have transition point between mean value + 0.5 $\sigma$ to mean value + 2 $\sigma$ in many codes, this have justified estimation mean + 1.5 $\sigma$ value as threshold value.
The feature of the curve for each element is as follows.

Cu; Transition point of the curve is observed between mean + 1 $\sigma$ value and mean + 2 $\sigma$ value on codes of R, N2S, N1S, KPA, KPS, INR.
The point is considered to be threshold value of mineralization anomaly.

Pb.Ag; Pb.Ag content of almost samples are under detetion limit. Therefore transition point is not clear.

Zn; On the code R, NQL, KPS, INR, transition point is observed at mean +2 $\sigma$ value while on the code N2A, N2L, N1S, KPA, this is located at mean + 1.5 $\sigma$ value. They are considered to be threshold value of mineralization anomaly.

Ni; On codes R. INR, transition point is not clear, but on other codes this is observed between mean + 1 $\sigma$ value and mean + 2 $\sigma$ value.
These values are considered to be threshold value of mineralization anomaly.

Co; On codes NQL, INR, transition point is not clear, but on other codes, this is observed between mean + 1 $\sigma$ value and mean + 2 $\sigma$ value. These values are considered to be threshold value of mineralization anomaly.

Mn; On codes R, N2A, transition point is not clear, but on other codes, this is observed between mean + 0.5 $\sigma$ value and mean + 2 $\sigma$ value. These values are considered to be threshold values of mineralization anomaly

Mo.Hg; The greater part of Mo, Hg content of samples is almostly under detective limits. Therefore transition point of these elements is not clear.

As; On codes R, NQL, N2L, N2S, KPL, transition point is not clear, but on other codes, this is observed between mean + 1.5 $\sigma$ value and mean + 2 $\sigma$ value. These values are considered to be threshold values of mineralization anomaly.

4) Correlation coefficient

Correlation coefficient between elements for all samples are shown in Table .
High correlation are observed between Cu and Zn, Ag and Hg, Zn and Co, Zn and Mn, Co and Mn.

The correlation coefficient tables between elements in each lithological code are shown in appendics-6.

ALL DATA

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cu | 1.000 | | | | | | | | | |
| Pb | .358 | 1.000 | | | | | | | | |
| Ag | .355 | .355 | 1.000 | | | | | | | |
| Zn | .541 | .277 | .056 | 1.000 | | | | | | |
| Ni | .042 | .007 | -.013 | .148 | 1.000 | | | | | |
| Co | .426 | -.006 | -.016 | .648 | .377 | 1.000 | | | | |
| Mn | .433 | .022 | -.014 | .675 | .218 | .816 | 1.000 | | | |
| Mo | -.189 | .017 | -.025 | -.167 | .200 | -.237 | -.272 | 1.000 | | |
| As | .158 | .118 | .033 | -.128 | .306 | -.132 | -.105 | .293 | 1.000 | |
| Hg | .389 | .441 | .694 | .089 | -.047 | -.042 | -.025 | -.024 | .081 | 1.000 |

Table-6 Correlation Coefficient between Each Detective Elements in Masbate Area

5) Multivariate analysis (Factor analysis)

i) Determination of Factor Number

The relations between detective elements and factors extracted by factor analysis of Masbate Area are as follows.

| Factor | Elements |
|---|---|
| 1st Factor; | Co · Mn · Zn |
| 2nd Factor; | Hg · Ag · Cu |
| 3rd Factor; | As · Ni · Mo |

These factors are used for the analysis for the reason that detective elements with the exception of Pb are included in the above mentioned elements and that Pb content is almostly under the detection limit. Factor contribution of 1st to 3rd factor is about 70%.

Table 7 Result of Factor Analysis in Masbate Area

Factor Loadings

| | 1st Factor | 2nd Factor | 3rd Factor |
|---|---|---|---|
| Cu | 0.542 | 0.475 | 0.055 |
| Pb | 0.084 | 0.511 | 0.088 |
| Ag | 0.000 | 0.772 | -0.014 |
| Zn | 0.766 | 0.113 | -0.088 |
| Ni | 0.323 | -0.042 | 0.560 |
| Co | 0.881 | -0.038 | 0.067 |
| Mn | 0.877 | -0.028 | -0.047 |
| Mo | -0.276 | -0.033 | 0.459 |
| As | -0.135 | 0.090 | 0.567 |
| Hg | -0.007 | 0.792 | -0.003 |

ii) Calculation of factor score

Factor score of each sample is obtained by totaling each element value multiplied factor weight.

Then factor score is classified by a class.

Table-8

FACTOR WEIGHTS

| VARIABLES | 1 | 2 | 3 |
|---|---|---|---|
| Cu | .166 | .196 | .090 |
| Pb | .001 | .147 | .091 |
| Ag | -.034 | .382 | -.047 |
| Zn | .189 | -.032 | -.187 |
| Ni | .115 | .011 | .363 |
| Co | .318 | -.049 | .197 |
| Mn | .373 | -.045 | -.088 |
| Mo | -.039 | -.005 | .291 |
| As | -.076 | -.019 | .342 |
| Hg | -.032 | .387 | -.026 |

Table-9 Statistical Values of Factor Score in Masbate Area

| | 1st Factor | 2nd Factor | 3rd Factor |
|---|---|---|---|
| $\bar{x}$ | 0 | 0 | 0 |
| 1 Value | 0.949 | 0.876 | 0.761 |
| 1.5 Value | 1.424 | 1.313 | 1.141 |
| 2 Value | 1.898 | 1.751 | 1.5213 |
| Maximum | 2.473 | 17.028 | 2.296 |
| Minimum | -5.462 | -0.634 | -2.253 |

### 4.2.2 Analysis for Heavy Mineral Samples

1) Analytical Method

206 heavy mineral samples are collected in Masbate Area. Statistical analysis is carried out on microchemical analysis results of these. These samples were taken from down side of junction of streams. They were reduced from 3 kg to 50 gram by panning in each places. On these samples microchemical analysis for Au, Ag and Ga were carried out by atomic absorption method as same as of stream sediment samples. The results of this are shown in Appendics-8.

According to the assumption that these data have shown logarithmic normal dispersion, mean value and standard deviation are calculated, and the data are classified by threshold value (1.5 value).

These statistical values are shown in Table 10.

Table-10 Statistical Values on Geochemical Analysis of Heavy Mineral Samples in Masbate Area

| | $\bar{x}$ Value | $1\sigma$ Value | $1.5\sigma$ Value | $2\sigma$ Value | Maxi-mum | Mini-mum |
|---|---|---|---|---|---|---|
| Au (ppb) | 1,355 | 5,412 | 10,815 | 21,614 | 38,000 | 5 |
| Ag (ppb) | 489 | 3,634 | 9,805 | 26,465 | 42,400 | 50 |
| Ga (ppm) | 8.2 | 13.2 | 16.7 | 21.2 | 28.8 | 1 |

2) Identification of constituent minerals of heavy mineral samples

Constituent minerals are classified by biocular microscope on random 20 specimens. Magnetite is recognized as main constituent minerals. Details is shown in Table 11.

Table-11 Constituent Minerals of Heavy Mineral Samples in Masbate Area

| Order | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Mineral name | Magnetite | Hornblende | Quartz | Feldspar | Pyroxene | Zircon | Ilmerite | Hematite | Pyrite | Zeorite | Limonite |
| Constitution Range (%) | 75-15 | 25-5 | 25-5 | 25-5 | 15-0 | 15-2 | 10-0 | 15-0 | 15-0 | 15-0 | 5-Tr |
| Mean Constitution Ratio (%) | 45 | 13 | 12 | 11 | 5 | 4 | 3 | 3 | 2 | 2 | Tr |

### 4-2-3 Local Distribution of Anomalous Values

1) Univariate analysis for stream sediments (Ref; attached plate 7-1)

Anomalous values in each lithological code are classified in following limits.

These classified anomalous values have been plotted in 1:250,000 scale sample locality map with symbol , and . Distribution features of anomalous valves in each element are as follows.

| Analytical Value (Z) | Symbol |
|---|---|
| $1\sigma$ value $\leq$ Z $<$ $1.5\sigma$ value | ● |
| $1.5\sigma$ value $\leq$ Z $<$ $2\sigma$ value | ▲ |
| $2\sigma$ value $\leq$ Z | ■ |

Cu; Distribution anomalous values are restricted in Paleogene meta-andesitic Rocks (KPG4) and Pleistocene unconsolidated sand (N2-2). These anomalous values is accumulated mainly around diorite body south of Baleno and east side of Mt. Uac.

Pb; Accumulation of anomalous values is seen in east and south-west side of Mt. Uac. Strongly and scattered anomalous values are seen in southern Plestocene Area.

Ag; Anomalous values are accompanied with Cu, Pb anomalous zone in east side of Uac.

Zn; Anomalous Values are seen in Palaeogen meta-andesite and meta-basalt, Miocene sedimentary rocks and Pliocene limestone. High and middle anomalous values are accumulated in south of Baleno (northern Masbate), west side Madalidon (north-west Masbate), southwest side Mt. Uac. and south side Mt. Bagacay (southeast Masbate).

Ni; Anomalous value is distributed in Miocene Sediment in east coast of South-western Peninsula and in Pliocene, Pleistocene Sediment of south-east side of Masbate besides, in Plaraeogene Area. The high and middle anomalous values is accumulated around Mt. Uac (middle Masbate) and South side of Palanas of southeast coast.

Co; Distribution of anomalous values are almost same loacality of Ni. But other distribution is seen at west coast which underlies Miocene Sediments, the high and middle grade anomalous values accumulation are observed at north side of Balud in South-west Peninsula, south side of Baleno, west side of Madalidion in north part and south east side of Mt. Bagacay.

Mn; Anomalous values are seen almost same locality of Co. Accumulation of high and middle anomalous values are observed at west side of Madalidon and south side of Mt. Bagacay.

Mo; Strong accumulation of high and middle anomalous values is to be around diorite stock south side of Baleno (northern part), east side of Mt. Uac (middle part) and down stream of Daraga River in South Coast.

As; Accumulation of high and middle anomalous values are observed at gold mine area in west of Baleno and south side of Mt. Bagacay.

Hg; Accumulation of high anomalous values are seen around Aroroy Mine and east side of Mt. Uac.

2) Factor analysis (multivariate analysis) of stream sediment samples (Ref; attached plate 7-2)

Factor scores are classified with the limit of following basis. These classified anomalous values are plotted in 1:250,000 scale sample locality map with symbol , and , distribution features of anomalous value in each factor are as follows.

Factor Score

| | | | | | |
|---|---|---|---|---|---|
| $1\sigma$ value | ≦ | S | < | $1.5\sigma$ value | ● |
| $1.5\sigma$ value | ≦ | S | < | $2\sigma$ value | ▲ |
| $2\sigma$ value | ≦ | S | | | ■ |

First score; This factor has strongly concerned to Co, Mn, Zn elements. Anomalous values are accumulated at west side of diorite body at southern Baleno, Miocene sediment is distributed zone in Mataridion (northern part) and east side of Mt. Uac (middle part)

Second score; This factor has strong relationship to Hg, Ag, Cu elements. Accumulation of high and middle anomalous values are only seen at west side of diorite body in south Baleno (northern part) and west, south, east side of Mt. Uac. The former accumulation seems to be influenced by gold, mineralization concerned to Aroroy, Mantanglad etc., and the later seems to influence of polymetallic mineralization of Dogosangan, etc.

Third factor; This factor has strong relevancy to As, Ni, Mo elements. Strong accumulation of high and middle anomalous values are observed at northwestern part where distribute Miocene limestone and south side of Mt. Bagacay which expose Pliocene limestone and Pleistocene unconsolidated sand.

3) Univeriate Analysis for Heavy Mineral Samples (Ref; attached plate 7-3)

Anomalous values which are extracted by statistical procedure are classified by followed basis.

These classified anomalous values are plotted with symbol , and on 1;250,000 scale sample location map distributed. Features of anomalous value in each elements are as follows.

Analytical Value

Factor Score

| | | | | | |
|---|---|---|---|---|---|
| $1\sigma$ value | $\leq$ | Z | < | $1.5\sigma$ value | ● |
| $1.5\sigma$ value | $\leq$ | Z | < | $2\sigma$ value | ▲ |
| $2\sigma$ value | $\leq$ | Z | | | ■ |

Au; High and middle anomalous values are observed around Aroroy Mine, east side of Mandaon in west coast and south side of Mt. Uac in middle part.

Ag; High and middle anomalous values are seen at east side of Mandaon and east side of Mt. Uac.

Ga; High and middle anomalous values are observed at west side of Madalidon (northern part) where Miocene sediment and east side Mt. Uac (middle part) are exposed.

## 4-3 Geochemical Survey in Leyte Island

The survey of Leyte was carried out dividing area by the highway connecting Abuyog and Baybay. But Leyte Island belongs to one lithological and structual province. Therefore geochemical analysis took place on the island.

### 4-3-1 Basic statistical data

1) Statistical value in each lithological code

The analysis of geochemical survey results was performed in 9 populations considering on geochemical characteristics of country rocks.

| Lithological Code | Rock Facies | Number of Samples |
|---|---|---|
| 01 | Quarternary Volcanics | 485 |
| 02 | Miocene to Pliocene Limestone | 600 |
| 03 | Lower Miocene to Lower Pliocene Sedimentary Rocks | 1,691 |
| 04 | Lower Miocene to Lower Pliocene Volcanic Clastics and Andesite | 1,589 |
| 05 | Pre-Tertiary to Palaeogene Basaltic Volcanic Rocks | 87 |
| 06 | Pre-Tertiary Periodotite and Serpentine | 46 |
| 07 | Pre-Tertiary Metagabbro and Gabbro | 212 |
| 08 | Alluvium | 429 |
| 09 | Intrusive Rocks | 53 |
| | Subtotal | 5,192 |
| | Duplicate Samples | 85 |
| | Total | 5,277 |

The statistical values in each lithological code are as following table.
(These values are calcurated by logalithmic base then transferred to natural base)

Lithological code 01; Quarternary Volcanics

Sample Number: 485 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 43.8 | 1.02 | 1.1 | 123.9 | 0.1 | 17.7 | 29.4 | 926 | 1.5 | 26 | |
| 1$\sigma$ value | 63.4 | 1.2 | 1.8 | 195.2 | 0.102 | 31.0 | 53.2 | 1,463 | 3.5 | 78 | |
| 1.5$\sigma$ value | 76.2 | 1.3 | 2.2 | 245.1 | 0.103 | 41.1 | 71.5 | 1.839 | 5.3 | 135 | This value consider to be threshold |
| 2$\sigma$ value | 91.6 | 1.4 | 2.8 | 307.6 | 0.105 | 54.5 | 96.5 | 2,311 | 8.1 | 234 | |
| Maximum | 124 | 5.0 | 25.0 | 330.0 | 0.1 | 540.0 | 89.0 | 4,500 | 170.0 | 620 | |
| Minimum | 14 | 1.0 | 1.0 | 19.0 | 0.1 | 1.0 | 2.0 | 110 | 1.0 | 10 | |

## Lithological Code 02; Miocene to Pliocene Limestones

Sample Number: 600 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 36.3 | 1.13 | 2.0 | 88.2 | 0.10 | 45.5 | 23.2 | 855 | 3.5 | 38.5 | |
| 1σ value | 53.6 | 1.6 | 4.8 | 141.8 | 0.13 | 97.2 | 38.7 | 1,307 | 7.1 | 78 | |
| 1.5σ value | 65.0 | 1.9 | 7.3 | 179.9 | 0.14 | 142.2 | 50.1 | 1,606 | 9.9 | 135 | This value consider to be threshold |
| 2σ value | 78.8 | 2.2 | 11.3 | 228.2 | 0.16 | 207.9 | 64.8 | 1,998 | 14.1 | 234 | Over this value consider to be anomaly |
| Maximum | 109.0 | 9.0 | 66.0 | 395.0 | 4.50 | 1,480.0 | 95.0 | 3,300 | 50.0 | 530 | |
| Minimum | 7.0 | 0.15 | 1.0 | 13.0 | 0.10 | 3.0 | 1.0 | 90 | 1.0 | 10 | |

## Lithological Code 03; Lower Miocene to Lower Pliocene Sedimentary Rocks

Sample Number : 1691 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 43.4 | 1.19 | 1.45 | 104.0 | 0.10 | 37.3 | 26.1 | 1,055 | 2.87 | 22.7 | |
| 1σ value | 62.6 | 1.8 | 3.2 | 165.3 | 0.104 | 78.6 | 39.8 | 1,759 | 7.4 | 52.0 | |
| 1.5σ value | 75.0 | 2.2 | 4.8 | 208.4 | 0.106 | 114.1 | 49.2 | 2,272 | 12.0 | 80.0 | This value consider to be threshold |
| 2σ value | 90.0 | 2.8 | 7.1 | 262.7 | 0.113 | 165.6 | 60.8 | 2,935 | 19.4 | 121.0 | |
| Maximum | 300.0 | 9.0 | 37.0 | 560.0 | 0.30 | 1,050.0 | 89.0 | 6,900 | 59.0 | 390.0 | |
| Minimum | 2.0 | 1.0 | 1.0 | 0.2 | 0.10 | 3.0 | 1.0 | 67 | 1.0 | 10.0 | |

## Lithological Code 04; Lower Miocene to Lower Pliocene Volcanic Clastics and Audesite

Sample Number : 1,589 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 49.0 | 1.03 | 1.35 | 150.3 | 0.10 | 22.9 | 32.1 | 1,030 | 1.49 | 24.7 | |
| 1σ value | 68.8 | 1.2 | 2.8 | 243.6 | 0.13 | 43.0 | 50.0 | 1,476 | 3.2 | 60.0 | |
| 1.5σ value | 81.6 | 1.3 | 4.0 | 310.1 | 0.14 | 58.9 | 62.3 | 1,766 | 4.6 | 95.0 | This value consider to be threshold |
| 2σ value | 96.6 | 1.5 | 5.9 | 394.7 | 0.16 | 80.7 | 77.8 | 2,114 | 6.7 | 148.0 | |
| Maximum | 430.0 | 10.00 | 700.0 | 3,000.0 | 6.50 | 895.0 | 84.0 | 4,700 | 590.0 | 7,300.0 | |
| Minimum | 12.0 | 1.00 | 1.0 | 20.0 | 0.10 | 2.0 | 3.0 | 180 | 1.0 | 10.0 | |

## Lithological Code 05; Pre-Tertiary to Palaeogene Basaltic Volcanics

Sample Number : 87 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 51.3 | 1.02 | 1.47 | 91.2 | 0.10 | 71.0 | 27.9 | 884 | 2.1 | 30.5 | |
| 1σ value | 96.1 | 1.2 | 3.1 | 166.7 | 0.1011 | 172.6 | 41.9 | 1,322 | 4.4 | 49 | |
| 1.5 σ value | 131.4 | 1.3 | 4.5 | 226.5 | 0.1012 | 269.1 | 51.3 | 1,617 | 6.5 | 62 | This value consider to be threshold |
| 2σ value | 180.1 | 1.4 | 6.5 | 304.9 | 0.1013 | 419.5 | 62.8 | 1,977 | 9.4 | 79 | |
| Maximum | 6,600.0 | 4.0 | 17.0 | 990.0 | 0.10 | 795.0 | 90.0 | 2,850 | 48.0 | 110.0 | |
| Minimum | 22.0 | 1.0 | 1.0 | 91.2 | 0.10 | 11.0 | 9.0 | 320 | 1.0 | 10.0 | |

## Lithological Code 06; Pre-Tertiary Peridotite and Serpentinite

Sample Number : 46 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 45.6 | 1.02 | 1.49 | 63.2 | 0.13 | 435.1 | 45.5 | 816 | 1.8 | 39 | |
| 1σ value | 141.6 | 1.1 | 5.8 | 115.2 | 0.37 | 1,264.9 | 81.9 | 1,281 | 3.5 | 155 | |
| 1.5 σ value | 249.8 | 1.2 | 11.3 | 155.5 | 0.61 | 2,159.7 | 109.9 | 1,606 | 4.9 | 138 | This value consider to be threshold |
| 2σ value | 440.4 | 1.3 | 22.3 | 210.0 | 1.03 | 3,677.3 | 147.5 | 2,012 | 6.8 | 613 | |
| Maximum | 4,100.0 | 2.00 | 680.0 | 540.0 | 16.90 | 2,530.0 | 185.0 | 2,500 | 12.00 | 6,000 | |
| Minimum | 12.0 | 1.00 | 1.0 | 10.0 | 0.10 | 29.0 | 7.0 | 150 | 1.00 | 10 | |

## Lithological Code 07; Pre-Tertiary Metagabbro and Gabbro

Sample Number : 212 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarsk |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 43.8 | 1.01 | 1.01 | 35.5 | 0.10 | 65.7 | 25.4 | 529 | 1.04 | 10.3 | |
| 1σ value | 74.2 | 1.1 | 1.2 | 80.4 | 0.1011 | 103.8 | 36.7 | 948 | 1.4 | 13.0 | |
| 1.5 σ value | 96.4 | 1.2 | 1.3 | 121.0 | 0.1012 | 130.5 | 44.2 | 1,269 | 1.6 | 15.0 | This value consider to be threshold |
| 2σ value | 125.6 | 1.3 | 1.4 | 182.2 | 0.1013 | 164.0 | 53.1 | 1,700 | 1.8 | 16.0 | |
| Maximum | 970.0 | 4.00 | 5.00 | 1,280.0 | 0.10 | 480.0 | 84.0 | 2,080 | 12.00 | 160.0 | |
| Minimum | 14.0 | 1.00 | 1.00 | 3.0 | 0.10 | 0.20 | 8.0 | 120 | 1.00 | 10.0 | |

Lithological Code 08; Alluvium

Sample Number : 429 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 42.0 | 1.23 | 1.26 | 104.6 | 0.10 | 38.4 | 28.8 | 1,039 | 2.2 | 16.8 | |
| 1σ value | 59.4 | 1.9 | 2.4 | 185.0 | 0.102 | 81.2 | 44.2 | 1,780 | 5.7 | 38 | |
| 1.5σ value | 70.8 | 2.4 | 3.3 | 246.2 | 0.103 | 118.1 | 54.9 | 2,331 | 9.0 | 56 | This value consider to be threshold |
| 2σ value | 84.2 | 3.0 | 4.5 | 327.6 | 0.104 | 171.6 | 68.2 | 3,053 | 14.3 | 84 | |
| Maximum | 178.0 | 6.00 | 18.00 | 444.0 | 0.10 | 720.0 | 92.0 | 5,000 | 21.0 | 400.0 | |
| Minimum | 8.0 | 1.00 | 1.00 | 18.0 | 0.10 | 9.0 | 5.0 | 43 | 1.0 | 10.0 | |

Lithological Code 09; Intrusive Rocks

Sample Number : 53 (Unit; ppm excepted Hg)

| | Cu | Mo | Pb | Zn | Ag | Ni | Co | Mn | As | Hg(ppb) | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $\bar{x}$ | 68.5 | 1.05 | 1.87 | 84.8 | 0.10 | 40.4 | 25.0 | 678 | 2.4 | 26.0 | |
| 1σ value | 108.2 | 1.4 | 6.4 | 153.5 | 0.1011 | 56.7 | 33.1 | 1,055 | 5.2 | 40 | |
| 1.5σ value | 135.9 | 1.6 | 11.8 | 206.6 | 0.1012 | 67.2 | 38.1 | 1,315 | 7.6 | 50 | This value consider to be threshold |
| 2σ value | 170.8 | 1.8 | 21.7 | 278.0 | 0.1013 | 79.6 | 43.8 | 1,640 | 11.0 | 62 | |
| Maximum | 230.0 | 7.00 | 179.0 | 495.0 | 0.10 | 86.0 | 54.0 | 2,700 | 19.0 | 120 | |
| Minimum | 29.0 | 1.00 | 1.0 | 43.0 | 0.10 | 19.0 | 14.0 | 200 | 1.0 | 10 | |

2) Histogram

Hystograms for each element in each lithological code are made by logarithmic scale with 1/2 standard deviation class (shown in Appendix-5).

Each histogram features for each element are as follows.

Cu; Histogram of copper for each lithological code shows normal logarithmic dispersion except 05, 06 codes. In code 05, 06, copper content of 60% of samples are almostly just under mean value. This seems to mean that these rocks of code 05, 06 are extreme uniformity of copper content. The same tendency is observed on code 09. Code 05,06 are cosisted of pre-Tertiary basic rocks originated by ophiolite body.

The sample which has maximum content (6,600 ppm) is contained in code 05.

Mo; All histograms are out of normal logalithmic dispersion. Almost sampels show under detection limit and over 80% of samples are accumulated in the class of 1 ppm.

The sample which has maximum content (10 ppm) is included in code 03.

Pb; Almost samples show under detection limit. Therefore all histograms do not show normal logarismic dispersion.

Maximum value sample (700 ppm) include in code 04.

Zn; All histograms show normal logalithmic dispersion. But some exess accumulation are seen at low grade part in code 01, 02, 03.

Maximum value sample (3,000 ppm) include in code 04.

Ag; Over 90% of samples are under detection limit. Therefore all histograms do not show normal logalithmic dispersion. Maximum value sample include in code 06.

Ni; Except code 01, 02, 04, histograms show normal logalithmic dispersion. In code 01, 02, 04, some excess dispersions are seen in high grade part. Maximum value sample (2,530 ppm) is included in code 06.

Co; All histograms show normal logarithmic dispersion except code 01. In code 01, histogram show gentle slope in low grade side. Maximum value sample (185 ppm) is included in code 06.

Mn; All histograms show normal logalithmic dispersion except code 01.

In code 01, histogram shows gentle slope in low grade side. Maximum value sample (6,000 ppm) is included in code 03.

As; Except code 05, 06, 09, histograms show normal logalithmic dispersion. In these codes 05, 06, 09, samples are almostly observed under detection limit.

Maximum value sample (590 ppm) is included in code 04.

Cu; Transition point of the curve is observed between mean + 1 $\sigma$ value and mean + 2 $\sigma$ value on codes of R, N2S, N1S, KPA, KPS, INR.
The point is considered to be threshold value of mineralization anomaly.

Pb.Ag; Pb.Ag content of almost samples are under detetion limit. Therefore transition point is not clear.

Zn; On the code R, NQL, KPS, INR, transition point is observed at mean +2 $\sigma$ value while on the code N2A, N2L, N1S, KPA, this is located at mean + 1.5 $\sigma$ value. They are considered to be threshold value of mineralization anomaly.

Ni; On codes R. INR, transition point is not clear, but on other codes this is observed between mean + 1 $\sigma$ value and mean + 2 $\sigma$ value.
These values are considered to be threshold value of mineralization anomaly.

Co; On codes NQL, INR, transition point is not clear, but on other codes, this is observed between mean + 1 $\sigma$ value and mean + 2 $\sigma$ value. These values are considered to be threshold value of mineralization anomaly.

Mn; On codes R, N2A, transition point is not clear, but on other codes, this is observed between mean + 0.5 $\sigma$ value and mean + 2 $\sigma$ value. These values are considered to be threshold values of mineralization anomaly

Mo.Hg; The greater part of Mo, Hg content of samples is almostly under detective limits. Therefore transition point of these elements is not clear.

As; On codes R, NQL, N2L, N2S, KPL, transition point is not clear, but on other codes, this is observed between mean + 1.5 $\sigma$ value and mean + 2 $\sigma$ value. These values are considered to be threshold values of mineralization anomaly.

4) Correlation coefficient

Correlation coefficient between elements for all samples are shown in Table .
High correlation are observed between Cu and Zn, Ag and Hg, Zn and Co, Zn and Mn, Co and Mn.

The correlation coefficient tables between elements in each lithological code are shown in appendics-6.

ALL DATA

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Cu | 1.000 | | | | | | | | | |
| Pb | .358 | 1.000 | | | | | | | | |
| Ag | .355 | .355 | 1.000 | | | | | | | |
| Zn | .541 | .277 | .056 | 1.000 | | | | | | |
| Ni | .042 | .007 | -.013 | .148 | 1.000 | | | | | |
| Co | .426 | -.006 | -.016 | .648 | .377 | 1.000 | | | | |
| Mn | .433 | .022 | -.014 | .675 | .218 | .816 | 1.000 | | | |
| Mo | -.189 | .017 | -.025 | -.167 | .200 | -.237 | -.272 | 1.000 | | |
| As | .158 | .118 | .033 | -.128 | .306 | -.132 | -.105 | .293 | 1.000 | |
| Hg | .389 | .441 | .694 | .089 | -.047 | -.042 | -.025 | -.024 | .081 | 1.000 |

Table-6 Correlation Coefficient between Each Detective Elements in Masbate Area

Strong correlations are observed between Zn and Co, Zn and Mn, Co and Mn. In each lithological code, correlation coefficients between each detective elements are shown in Appendics.

5) Multivariate analysis (Factor analysis)

i) Determination of factor number

The relations between detective elements and factors by factor analysis of Leyte Area are as follows. (Ref. Table )

| Factor | Elements |
|---|---|
| 1st Factor; | Mn.Co.Zn |
| 2nd " | Hg.Pb.As |
| 3rd " | Mo.As |
| 4th " | Ni |
| 5th " | Ag.Cu |

Elements listed above are concerned in all detective elements. Therefore these 5 factors are adopted.

Factor contribution of 1st to 5th factor is 77.1%.

Table-13 Result of factor analysis in Leyte Area

| Factor Loading | 1st Factor | 2nd Factor | 3rd Factor | 4th Factor | 5th Factor |
|---|---|---|---|---|---|
| Cu | -0.3498 | 0.3356 | 0.0619 | 0.0599 | 0.4355 |
| Mo | -0.0309 | -0.0797 | 0.9162 | 0.0192 | 0.0614 |
| Pb | -0.0215 | 0.7487 | 0.1439 | 0.0987 | 0.1492 |
| Zn | -0.8446 | -0.0064 | -0.1421 | -0.3358 | 0.0916 |
| Ag | 0.0675 | 0.1149 | 0.0291 | -0.0085 | 0.9338 |
| Ni | -0.0331 | 0.0120 | 0.1080 | 0.9710 | 0.0200 |
| Co | -0.8611 | -0.1443 | -0.2450 | 0.2403 | 0.0606 |
| Mn | -0.8820 | 0.0429 | 0.1866 | 0.0754 | -0.0885 |
| As | 0.2050 | 0.4354 | 0.6784 | 0.2137 | -0.0033 |
| Hg | 0.0600 | 0.7985 | -0.0584 | -0.1015 | 0.0729 |