No. 54

The Mineral Exploration
Mineral Deposits and Tectonics of Two Contrasting Geologic Environments in The Republic of Philippines

Consolidated Report on Masbate, Panay and Romblon Area

MARCH 1988

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

17655

The Mineral Exploration
Mineral Deposits and Tectonics of Two Contrasting Geologic Environments in The Republic of Philippines

Consolidated Report on Masbate, Panay and Romblon Area

MARCH 1988

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

Preface

In response to the request of the Government of the Philippines, the Government of Japandecided to conduct a survey on the potential of mineral resources in the eastern Luzon, Visayas and Palawan and entrusted the survey to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

This Consolidated Report consists of the results of synthetic regional analysis about the Masbate Area, Panay Area and Romblon Area of already surveyed areas.

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

March, 1988

Kensuke Yanagiya
President
Japan International Cooperation Agency

Junichiro Sato
President
Metal Mining Agency of Japan

SUMMARY

This Consolidated Report outlines the results gathered during the implementation of the project "The Mineral Exploration, Mineral Deposits and Tectonics of Two Contrasting Geological Environments in the Republic of the Philippines."

Exploration and other related field surveys were conducted in the Masbate Area which was carried out during the second phase of the project in 1985 and the Panay and Romblon Areas which were carried out during the third phase of the project in 1986.

All the results as outlined and summarized in this report had taken into considerations the regional geologic and tectonic settings (i.e. geologic structures; igneous activities) of the areas.

Four types of statistical analyses as presented herein had been utilized in treating the geochemical data gathered. The survey areas had been divided into cells having dimensions of 2 km (east-west direction) by 2 km (north-south direction) which are the ones basically treated statistically.

The different statistical analyses utilized in selecting the most promising mineralized areas are as follows:

1) Univariate Analysis of each cell average, based on the arithmatic average value of each cell.

2) Univariate analysis of the moving average, based on the central cell value. This central value is the average of nine cell values.

3) Univeriate analysis of the high-pass filtering value. This high-pass value is the difference between each cell average and the moving average.

4) Multivariate analysis (factor analysis) of each cell average.

On the basis of these statistical analyses and other surve works, the following things have become clear:

1) The survey area is controlled by the post-Paleogene NNE-SSW trending fractures. Thrusting of the eastern block over the western block during Paleogene in the Masbate and Panay Areas had occurred along this NNE-SSW fracture zones. Diorite and ultramafic intrusions have also been noted along these fracture zones. Miocene diorites and andesites had been noted along these fracture zones too. Plio-Pleistocene hornblende andesite erupted

5) The overlapping condensed area of Ni and Co in the Antique Range, Panay Is. and central Sibuyan Is. (Romblon Is.).

6) The condensed area of Cu in the 20 km northeast of Tibiao in the west coast of Panay Is..

The Mineral Exploration and Tectonics of two Contrasting Geologic Environments in The Republic of Philippines

Consolidated Report on Masbate, Panay and Romblon Area

Contents

List of Illustrations

List of Tables

List of Attached Plates

Appendixes

1. Introduction

1-1 Background and Objective of the Report

1-1-1 Background and Particulars

Pursuant to the Implementing Arrangement (I/A) entered into between the Government of the Philippines through the Mines and Geo-Sciences Bureau (MGB) and the Government of Japan through the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ) signed on September 26, 1984, this report embodies, as a part of the consolidated report, the summary of the investigations for Masbate, Panay and Romblon Area.

1-1-2 Objective of the Report

This report embodies the summary of the survey results and existing data regarding the mineral resources in Masbate, Panay and Romblon Islands which are all part of the Visayan group of islands in the central part of the Republic of the Philippines.
The objective of this report includes the recognition of the mineral resources distribution in the different survey areas through synthetic analyses of acquired data and subsequently recommending areas for further exploration.

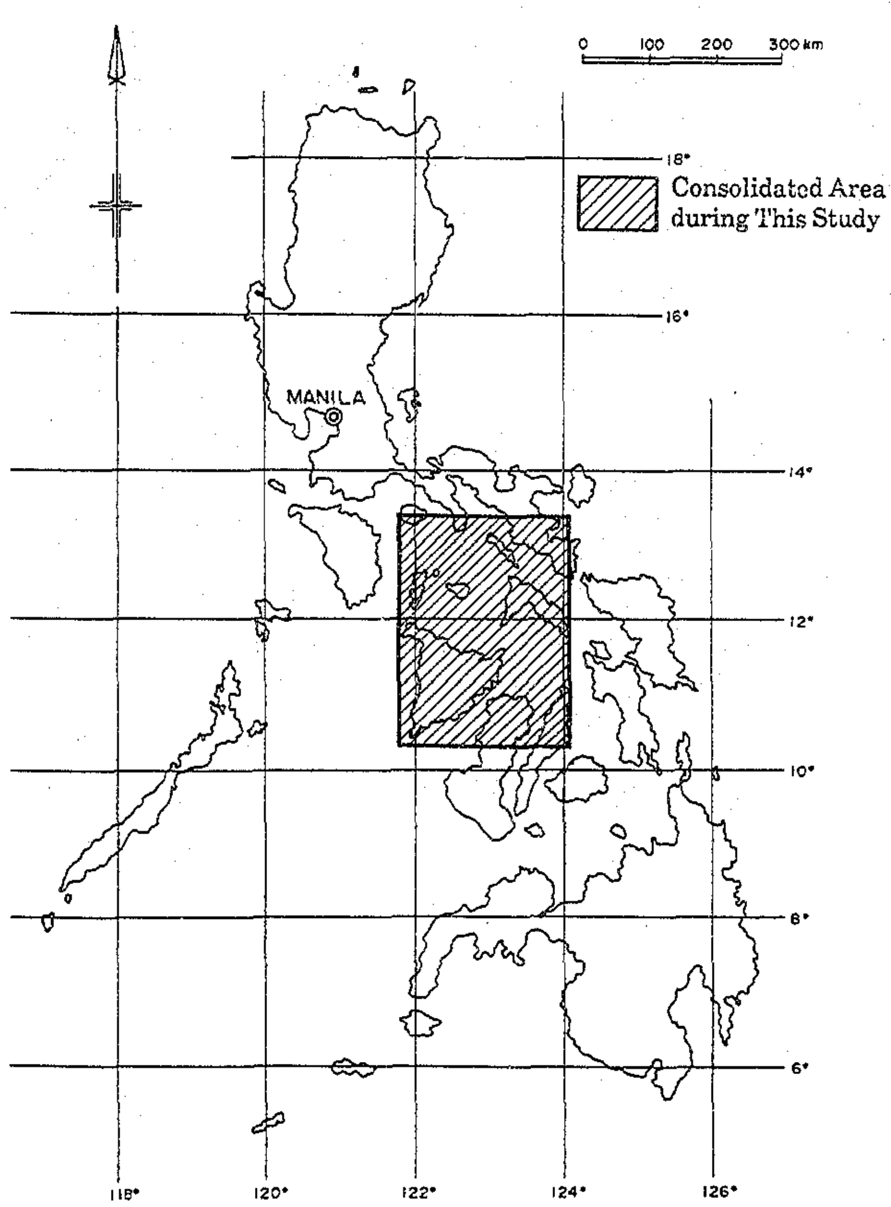


Fig. 1 Location Map of the Survey Area

1-2 Summary of the Utilized Processes and Methodologies

The data acquired from the Masbate, Panay and Romblon Area were summarized as follows:
Utilizing the existing and newly acquired geological data, the tectonic movements, sedimentary environments, igneous and other related activities have been synthetically examined that led to the formulation of a geological map with a unified established straitgraphy.
As for the geochemical data, the zones with anomalous values were identified utilizing the following processes:
The whole area was divided into 2 km × 2 km cells. Univariate and multivariate analyses of the average values from all the cells were carried out. The univariate analyses of the moving average values at all cells and of high-pass filtering values, which were calculated from the difference between the simple average values and the moving average values, were also conducted. There are 24,456 analyzed samples which were collected from the abovementioned area and other surrounding places that include Leyte, Cebu, Bohol, West Negros and Dinagat.
The analyzed elements were Cu, Pb, Zn, Ag, As, Mn, Ni, Co, Mo and Hg (10 elements).
With these existing data, a Lineament Distribution Map, an Aeromagnetic Survey Map, a Mineral Showing Locality Map, an Existing Data Index Map and a Consolidated Analyses Result Map were produced on a scale of 1/1,000,000 similar to that of the Geological Map and the Geochemical Anomaly Distribution Map. These maps are polychrome printed although some are in monochrome.

1-3 Composition of Members and Summary of the Itinerary

A. Planning of the summary and negotiations

Japanese panel:

Kyoichi Koyama	MMAJ
Hideo Hirano	id
Seiichi Ishida	id
Natsumi Kamiya	id
Yoshitaka Hosoi	id
Takashi Kamiki	JICA

Philippine panel:

Lirio T. Abuyan	DENR (Department of Environment and Natural Resources)
Benjamin Leong	id
Guillermo R. Balce	MGB
Romeo M. Luis	id
Edwin G. Domingo	id
Romeo L. Almeda	id

Noel V. Ferrer id

B. Preparation of the consolidated report

Yoshikazu Okubo	OMRD (Overseas Mineral Resources Development Co.)
Akira Yatsuji	id
Kiyomi Nishiki	id
Naoaki Tomizawa	id

C. Summary of the Itinerary

1987, Nov. 1st~Nov. 30th Planning, negotiations, settlement.

1987, Dec. 4th~Feb. 29th (1988) Analyses, report making.

1-4 General Situation of Consolidated Area

Masbate Is., Panay Is. and the Romblon Islands belong to Region V, Region IV-A and Region IV respectively. From Manila to Masbate (Mastate Is.), Iloilo (Panay Is.) and Kalibo (the northeastern part of Panay Is.), regular flight services are available (1 hr. ~ 1 hr. 20 min. flight).

In going to Romblon, there is a steamer service from Caticlan (the northwesten part of Panay).

The geographic situation are as follows:

	Masbate Is.	Panay Is.	Romblon Is.
Area:	3,300km^2	11,500 km^2	1,180 km^2
Elevation:	0~697 m	0~2,117 m	0~2,050 m
Highest peak:	Conical Peak (697 m)	Mt. Madiac (2,117 m)	Mt. Guitinguitin (2,050 m)
Average temperature:	26.5°C	28°C	27°C
Average annual precipitation:	1,857 mm	2,933 mm	2,039 mm

The climate belongs to the western Pacific monsoon climatic zone, so that the dry season (January~March) and the rainy season (November~December) are clearly observed.

Rice growing is practiced at swamps on the coast and plains along the main rivers. On the other hand, stock-farming and coconut growing are carried on the hilly areas. In the northern part and the southern part of Panay Is., prawn culture is practiced at swamps by the seashore.

This area is in the Visayas Area which is in the central part of the Republic of the Philippines, and is geologically situated in a Palaeogene diorite-granodiorite intrusive belt. In Masbate Is. and Panay Is., there are north-northeast~south-southwest directional mountains at the western parts. Their eastern sides are characterized by gentle hills. Tablas Is. in the Romblon Islands, has the same directional mountains; however, Romblon Is. and Sibuyan Is. consist of platform or coneshaped basement rocks and ultramafic rocks.

1-5 Conclusion and Recommendation

1-5-1 Conclusion

The mineralization areas noted in this area are almost concerned to igneous activities post-Tertiary period and geochemical anomalous cells also locate around these igneous rocks.

The following six recommending areas for further exploration are extracted by the results of mineral showing investigation and results of various kinds geochemical analysis.

(1) Poly-metallic (Cu, Pb, Ag, Hg) condensed zone east side of Mt. Uac in middle part of Masbate Is.

(2) Poly-metallic (Cu, Pb, Mn) condensed zone south side of Pilar in northeastern part of Panay Is.

(3) Poly-metallic (Cu, Pb, As) condensed zone south side of Aroroy in northernmost part of Masbate Is.

(4) Poly-metallic (Cu, Pb, Ag, Ni, Co) condensed zone 15 km northeastern side in southwestern Panay Is.

(5) Poly-metallic (Ni, Co) condensed zone north and south parts of western Panay Is. and middle part of Sibuyan Is.

(6) Uni-metallic (Cu) condensed zone 20 km northeastern Tibiao middle part of west coast of Panay Is.

1-5-2 Recommendation

Six additional promising mineralized areas had been selected after analyzing all the available informations. An exploration program is hereby recommended which may be implemented in the near future as a follow-up survey in the recognized mineralized areas.

1) Detailed geological and geochemical surveys in the selected promising areas.
   Geochemical Survey: Systematic soil sampling in a 200 m order grid.
   Geological Survey: Detailed investigation of the alteration and mineralization zones.

2) Drilling of selected targets which may be based on the findings of the abovementioned detailed surveys.

2. Geology and Mineralization

2-1 General Geology

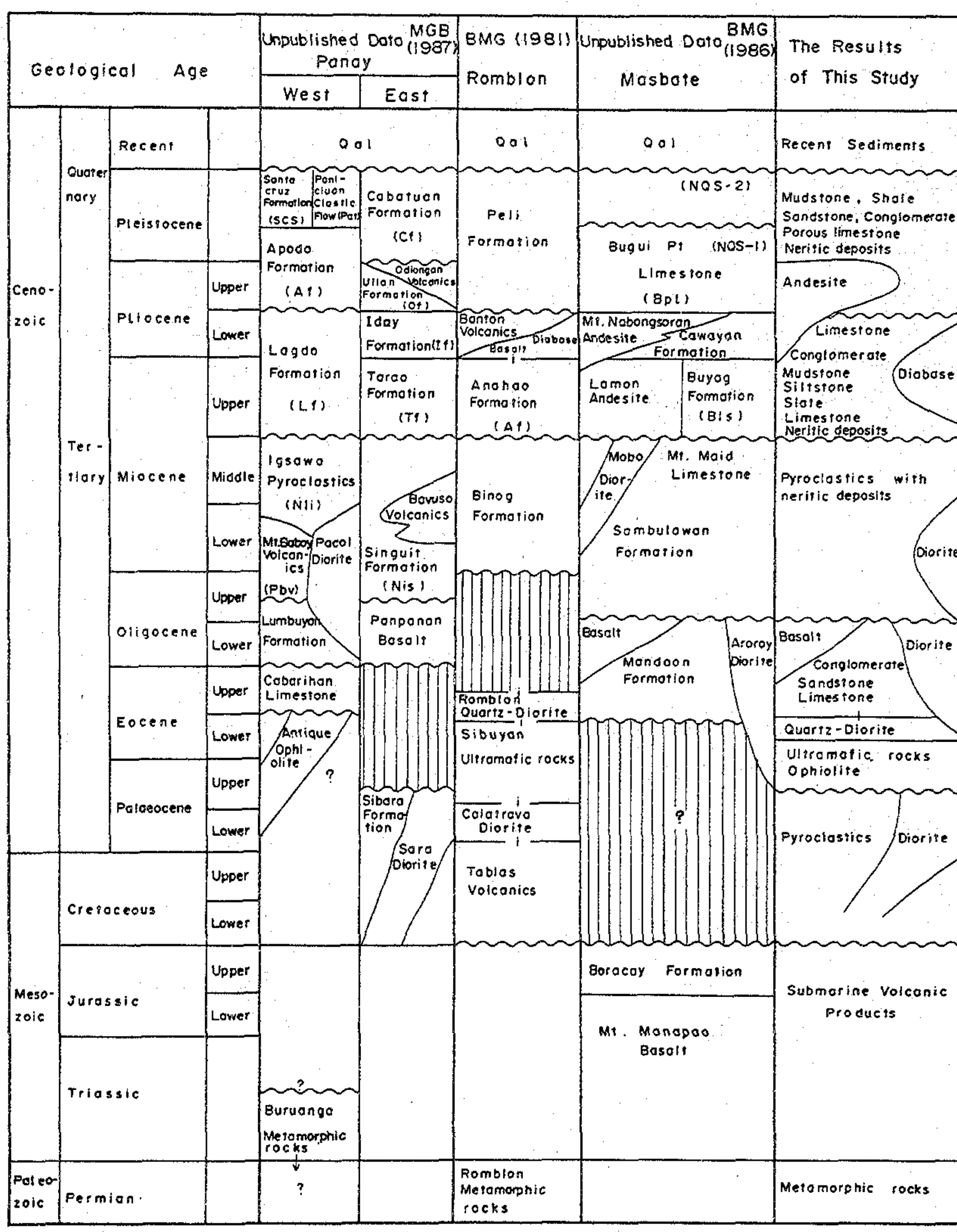
In this area, the basement rocks are composed of crystalline schist, crystalline limestone, slate, chert, phyllite, which are all considered pre-Tertiary, with ultramafic rocks intruding them. Palaeogene andesitic tuff, altered andesite and basalt cover the basement rocks unconformably.

These lower rocks are exposed in the northwestern part of Masbate Is., the western part of Panay Is. and the central part of Tablas Is. in the Romblon Islands, characterized by mountainous terrains.

The Palaeogene system generally shows gently undulating north-south trending folds; however, in the western part of Panay Is., the north-east directional steep folds accompanied by thrust faulting are observed. It is considered that the eastern block of Panay Is. thrusted over the western block during the Eocene.

The Neogene system is composed of various sedimentary rocks, andesite-basalt lava and pyroclastic rocks, and it is distributed with gentle flexure in the central part and the southeastern part of Masbate Is., the outskirts and the central lowlands of Panay.

Intrusive rocks in this area are pre-Tertiary ultramafic rocks (Sibuyan Is.), diorite (Masbate Is. and Panay Is.), Palaeogene ophiolite (the southwestern part of Panay Is.), andesite, basalt, diorite and Pleistocene hornblende andesite (noted in the northeastern part of Masbate Is. and the eastern coastal area of Panay Is.).



| : Boundary among intrusive rocks

Fig. 2 Schematic Columnar Sections

2-2 Straitgraphy

At the consolidated study starting, MGB requested to use the stratigraphic succession which made by BMG (1981). This is summarized results of existed surveys and useful for such purpose, therefore the straitgraphy succession of this report based on that.

In Masbate and Panay Area, MGB member of this project are already preparing the stratigraphic succession of each area, which based on abovementioned, so we use these succession, as the result of that stratigraphic succession of this report change partially to that of 2nd and 3rd phase report.

1) The Buruanga Formation (Bm, Bml) and the Sibuyan Ultramafic Rocks make up the basement complex of the area. The Buruanga Formation is composed of crystalline schist, crystalline limestone, slate, chert, and phyllite. These two formations are exposed at the core of the Antique Range in Panay Is., in Romblon and in the island of Masbate. In masbate Is., the basement is characterized by pillow basalt (Mt. Manapo Basalt), red shale, basaltic pyroclastics, conglomerates, wackes, semi-schists and tuff.

This formation is unconformably covered by the lower Palaeocene andesitic tuff and lava (Sibara Formation) and is intruded by upper Palaeocene diorite and monzonite bodies. In Romblon Is., the basement rocks are unconformably overlain by Cretaceous andesitic-basaltic volcanic rocks. As for the Masbate Is., the basement seems to be covered by the Paleogene meta-andesite and meta-basalt. Unfortunately, the relationship between these two rock units is unclear and the only contact observed between the two is a fault.

Sufficient data are not available at present to give a precise age for the basement rock formation except for the crystalline limestone sampled in Romblon Is. which gave an age of upper Permian (BMG, 1981).

(Results of microscopic observation)

The sample of the basement formation taken from the southern coast of the Buruanga Peninsula is identified as a zoisite bearing quartz semi-schist.

The sample of the basement rock in the northern coast of Tablas Is. is determined as an amphibole bearing quartz schist, and a very small amount of epidote is observed as alteration mineral.

2) Palaeocene Formation

The only Palaeocene formation in this area is the Sibara Formation which is exposed in the central to the eastern portion of island of Panay. This formation is composed of pyroclastic rocks and lavas composed mainly of andesitic sometimes basaltic tuff and tuff breccias. A propylitic alteration zone is very noticeable around the periphery of the diorite intrusion which resulted into the pyroclastic rocks near it acquiring a vivid green color. Massive graywackes and mudstones were noted to be intercalated with the pyroclastic rocks. Thin layers of alternating chert, siltstone and conglomerates have also been observed. This formation is thought to be of Palaeocene age (BMG, 1981).

3) Eocene Formation

The Cabariohan Limestone is the only Eocene formation exposed in the area and it is in contact with the exposed ophiolite in southwestern Panay. The Eocene period saw the intrusion of the ophiolite and the thrusting of the eastern Panay block over the western Panay block. The eastern portion of the Panay Is., Masbate Is., and the eastern part of Romblon Isls., were uplifted as terranes (Mitchell et al, 1986).

4) Oilgocene Formation

The Oligocene formations in this area consist of the Sambulawan (Sm) and Mandaon (Mf) Formations distributed mainly in the western and midnorthern part of Masbate Is., Lumbuyan (P1) Formation and Mt. Baloy Volcanics (Pbv) in southwestern Panay and Singuit Formation (Nis) exposed at the east side of the Antique Range in Panay Is.

These formations are made up of basic to intermediate volcanic lavas, clastics, wackes, mudstone, siltstone, turbidite, conglomerate and calcarenite.

The Singuit Formation is thought to be the lowermost sedimentary rock unit in the Iloilo Basin (BMG, 1981).

(Results Microfossil Analysis)

Nannoplankton determinations gave Eocene to Oligocene age for a sedimentary rock sample collected from the northeastern part of the Milagros area which is in the mid-southern portion of Masbate Is.

5) Lower Miocene Formation

The lower Miocene formations in the area are composed of the middle Sambulawan Formation in the west and mid-south portion of Masbate Is, and the upper Singuit Formation in the western part of Panay Is. these formations are covered by the Igsawa Pyroclastics and the Bavuso Volcanics as exposed in the northern part and western side of the Iloilo Basin in mid-west Panay Is.

The Middle Sambulawan Formation consists of calc-alkali volcanic rocks and shallow marine clastics with a small amount of limestone.

The upper Singuit Formation consists of shallow marine sediments and pyroclastics.

The Igsawa Pyroclastics and Bavuso Volcanics consist of basaltic clastics, mudstone, sandstone and basal conglomerates.

(Results of microscopic observation)

The sample collected from Gargo Is. in the western coast of Masbate Is. is a porphyritic two pyroxene andesite that has undergone sericitization. Quartz and zeolite veinlets have been noted.

Geology and Mineral Resources of the Philippines, Vol. 1, 1982,BMG.

(Results of K-Ar Dating)

K-Ar Dating on the abovementioned sample gave 22.6±1 1Ma. This age corresponds to lower Miocene.

(Results of Microfossil Analysis)

Nannoplankton determination in a sample collected from the Mandaon area, in the western coast of Masbate Is. gave a lower Miocene age.

6) Middle Miocene Formation

The middle Miocene formations in this area correspond to the limestone of the upper Sambulawan Formation (Mountain Maid Limestone) and the upper Singuit Formation in Panay Is. and the lower Binoog Formation (Ffl) exposed from the mid-eastern to the northern part of the Tablas Is. The Binoog Formation consists of calcarenite and coral limestone.

(Results of Microfossil Analysis)

Nannoplankton determinations of samples collected from the upper Sambulawan Formation in southern Masbate Is. yielded fossils of middle Miocene age.

7) Upper Miocene Formation

The upper Miocene formations of this area are the Buyag Formation (Bls), distributed in the northwestern and mid-southern part of Masbate Is., the Tarao and Ladgo Formations exposed around the Iloilo Basin in Panay Is. and the Anahao Formation (Af, Afl) in the northern part of Tablas Is.
The Buyag Formation consists of conglomerate, sandstone, siltstone and interbedded limestone lens which are only noted at the lower horizons.
The Tarao Formation consists of mudstone, siltstone and slate.
The Lagdo Formation consists of siltstone, mudstone, tuff and wacke with accompanying small amount of basal conglomerates.
The Anahao Formation is made up of calcarenite and limestone. (BMG 1981)

(Results of Microfossil Analysis)

Nannoplankton determinations of samples collected from southern Masbate yielded fossils of upper Miocene age (CN9 Zone).

8) Lower Pliocene Formation

The lower Pliocene formation of this area are the Iday Formation, made up basically of porous limestone and exposed at the southeastern coast of Masbate Is. and a conglomerate formation distributed from south to north in the middle portion of Panay Island (BMG, 1981).

9) Upper Pliocene Formation

The upper Pliocene formations of this area consist of the Bugui Pt. Formation, composed of porous limestone and which can be found at the southeastern coast of Masbate Is., the Apodo Formation which consist of marl, mudstone and wacke and is exposed at the middle part of the Iloilo Basin and the western part of Guimaras Is., Panay area and the lower Peli Formation which consist of conglomerate, limestone, and calcareous shale and were deposited at the middle portion of Tablas Is., Romblon Area (BMG, 1981).

10) Pleistocene Formation

The Pleistocene formations of this area are the NQS-1 Formation, which are made up of porous sponge-like limestone and are distributed at the northwestern and southern parts of Masbate Is. and the Santa Cruz, Guimaras Formation made up of porous limestone and are exposed at the northwestern part of Guimaras Is., Panay area and the Cabatuan Formation which consist of loose sandstone, siltstone and mudstone and were encountered at the northern part of Iloilo City in Panay Island (BMG, 1981).

11) Recent Sediments

The Recent sediments, characterized by clay, gravel, sand and coral reefs are distributed along the seashores and flood plains of the main river systems.

2-3 Intrusive Rocks

A summary of the history of igneous activities that have occurred in this area is presented in this area. Most of the materials utilized aside from the data gathered during the field surveys were drawn from unpublished reports of the BMG.

The oldest igneous rock in this area estimated to be of lower Cretaceous age is the Boracay Formation. This rock unit is made up of basaltic rocks exposed as windows around Mt. Manapao which is located at the eastern part of Balud in southwestern Masbate Island.

Next came the extrusions of the upper Cretaceous Romblon volcanic rocks which were encountered at the middle and northern portions of Tablas Is., Romblon Area. Simultaneously being intruded during the extrusions of the Romblon volcanic rocks are the Patria Quartzdiorite at the southern part of the Buruanga Peninsula. Panay Is. and the Sara Diorite in eastern Panay Is.

The Palaeocene period saw the intrusion of the Calatrava Diorite which followed the intrusion of the Sibuyan ultramafic rocks in the Romblon Area. The Antique Ophiolite consisting of pillow basalts, diabase, gabbro and lherzolite was intruded during the upper Palaeocene to Eocene period in southwestern Panay Is. Quartzdiorite intrusion in the Romblon Area during upper Eocene came next which was followed by the intrusion of the Aroroy Diorite during lower Oligocene time.

The Oligocene to Miocene period is characterized by large-scale andesitic and basaltic volcanic activities covering the western Masbate and western Panay Areas. Pyroclastics of these rocks as a consequence are widely distributed in these areas.

During the middle Miocene, the Mobo Diorite was intruded in the mid-northern part of Masbate Is. while the Pacol Diorite was

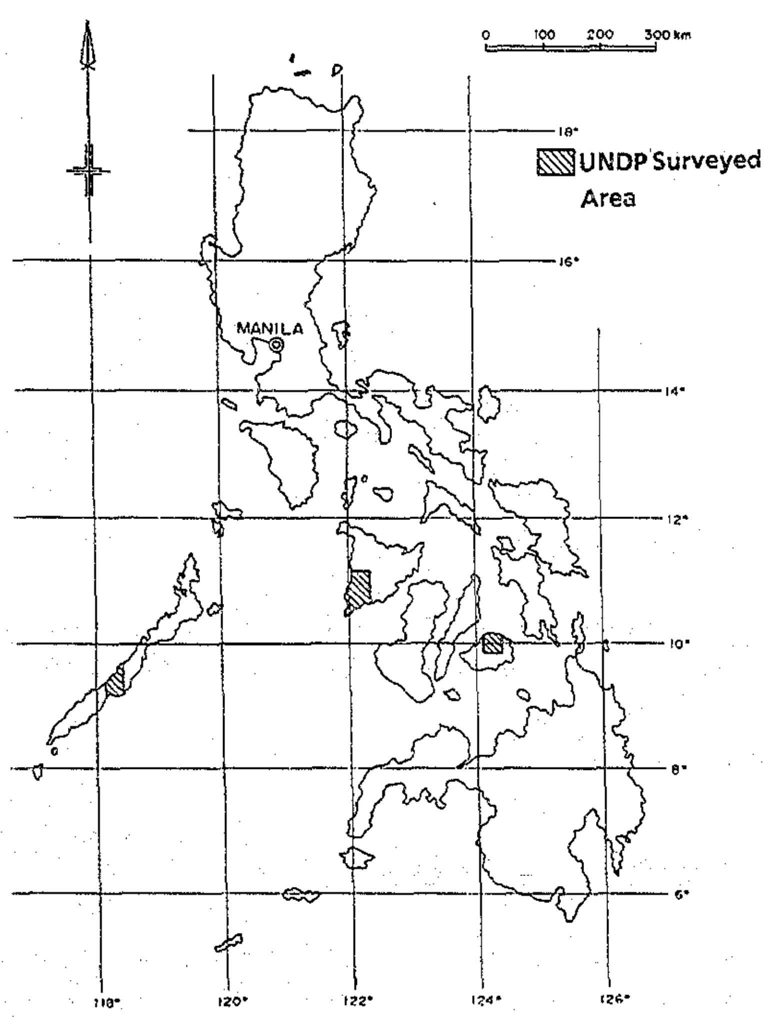


Fig. 3 Locality Map of UNDP Surveyed Area

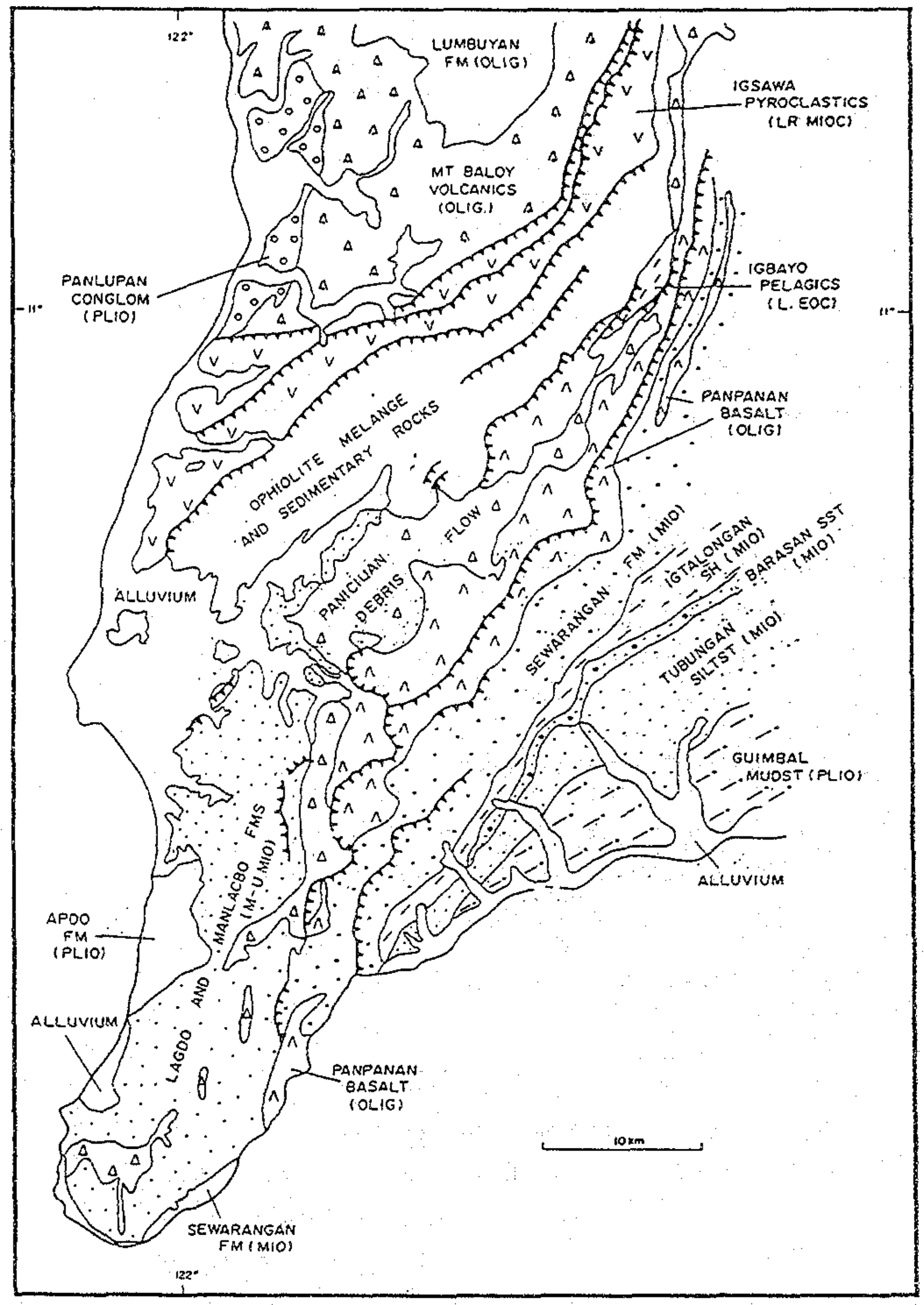


Fig. 4 Outline Map of the Ophiolite Zone in Southwest Panay (after UNDP, 1986)

intruded in the northwestern part of Panay Is. Andesitic eruptions around Mt. Uac located at the middle part of Masbate Is. occurred during upper Miocene.

The lower Pliocene saw the extrusion of the Mt. Nabungsoran andesite porphyry as several stocks at the northwestern part of Masbate Is. Several divided hornblende andesite stocks called the Odiongan Volcanics have also been extruded at the eastern coast of Panay Is. during the upper Pliocene time.

The Paniciuan Debris Flow, containing different exotic rock fragments with age ranging from pre-Tertiary to Miocene, was erupted at the southern portion of the Antique Range during the Pleistocene time. This subsequently flowed down in a southwest direction towards the Dao Peninsula.

The descriptions of each igneous rock body are as follows:

1) Sara Granodiorite

This igneous body intruded the Sibara Formation over an area 600 km^2 wide. This batholith sometimes act as roof pendant for the Sibara Formation in some localities. Metamorphism had been noted along the boundary in which the Sibara Formation had undergone phyllitic alteration whereas the Sara Granodiorite had undergone propyritization.

(Results of microscopic observation)

A sample from this igneous body collected 10 km north of San Francisco, southern Panay Is., is a medium-grained biotite hornblende granodiorite exhibiting holocrystalline equigranular texture. Very rare amount of chlorite and sericite had been noted as alteration minerals.

2) Sibuyan Ultramafic Rocks

This rock unit which is distributed in the middle portion of Sibuyan Is. and northern Tablas Is., Romblon Area is composed of lherzolite, pyroxenite, amphibolite and gabbro. Its relationship with the Tablas Volcanics is unclear and the only contact observed was a fault boundary. Mt. Guitinguitin, which is the highest peak in the Romblon Area, is underlain by this rock unit.

(Results of microscopic observation)

A sample from the northern shore of Sibuyan Is. is a lherzolite, which is made up mainly of olivine and clinopyroxene. Small amount of iron minerals and picotite are present which could account for its magnetic property.

3) Antique Ophiolite Group

The area of distribution of this rock group is outside the scope of the present survey and the detailed description presented herein is based on the UNDP Technical Report No. 8 (1986).
The ophiolite group is composed of basalt, gabbro, serpentinite, debris flow and tectonic breccia which was intruded from Palaeocene to Eocene time and subsequently thrusted over the northern Palawan oceanic crust as a MELANGE body during the upper Oligocene. A generalized geologic map of the ophiolite region is shown in Fig. 4.

4) Romblon Quartzdiorite Group

This igneous body distributed at the middle portion of Tablas Is. and in the northwestern part of Sibuyan Is. had intruded the Tablas Metamorphic Rocks. Tablas Volcanic Rocks and the Sibuyan Ultramafic Rocks during late Eocene (BMG, 1981).

(Results of microscopic observation)

A sample collected 10 km southeast of Saupiton in southwestern Sibuyan Is. is a hornblende-biotite tonalite which consists of potash feldspar, quartz, biotite, hornblende and plagioclase. This rock exhibits holocrystalline equigranular texture. It is slightly magnetic due probably to its magnetite content. Rare amount of sphene had also been noted.

5) Aroroy Quartzdiorite Group

This rock group is made up of several rock facies which include granodiorite, quartz diorite, tonalite and hornblende diorite. It is basically exposed as stocks in the northeastern and mid-northern part of Masbate Island.

(Results of microscopic observation)

A sample collected south of Baleno in the mid-northern portion of Maasbate Is. is a quartz diorite made up of hornblende, biotite, quartz, plagioclase and sphene. It exhibits holocrystalline equigranular texture. Chlorite and epidote are the alteration minerals. Ularite had also been noted along cracks of these rocks (MGB unpublished data, 1987).

(Result of K-Ar dating)

Radiometric dating of the above sample yielded an age of 7.1 ± 0.5 Ma. (upper Miocene) which appears to be the alteration age.

6) Panpanan Basaltic Rocks

Again, the detailed description of this rock group had been taken from the UNDP Technical Report No. 8 (1986) since the area of distribution of this rock group is not included in the present survey.
This rock group consists of basaltic lavas and clastics with interbedded sedimentary rocks distributed along the east and west sides of the Antique Range, western Panay Island. The pyroxene basalt facies predominates wherein pyroxene phenocrysts are set on black colored groundmass. Concentric circle shaped zeolites, chlorites and quartz amygdales have also been noted.
An olivine basalt facies is also thought to exist on the basis of the olivine crystals noted in stream sediments. The distribution of this rock group follows the controlling northeast trending structure and dips 20 to 40 degrees southeast: estimated thickness is approximately 2000 m.

7) Mobo Diorite Group

This rock group distributed at the south side of Mobo in the midnorthern part of Masbate Is. intruded the Sambulawan Formation as circle-shaped stocks. Various facies of this group include hornblende diorite and biotite diorite.

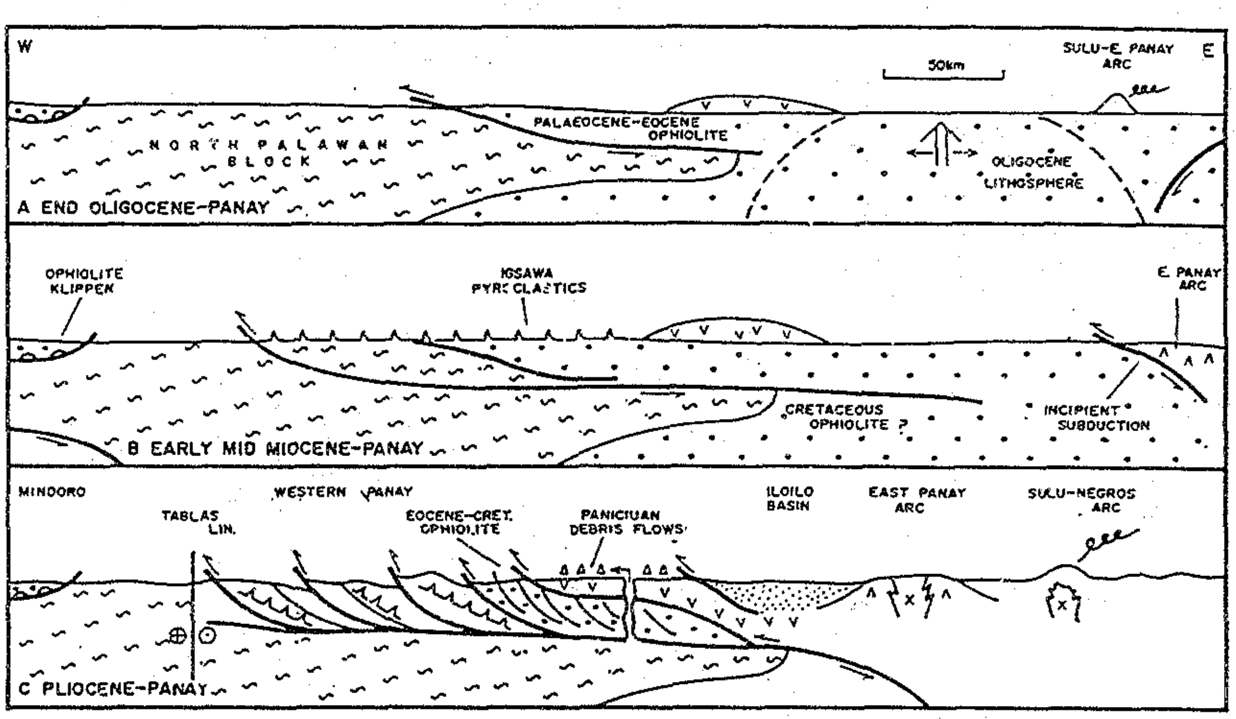


Fig. 5 Schematic Cross Sections of Tectonic Movement in West Panay Is. (after UNDP, 1986)

(Results of microscopic observation)

A sample collected near Masbate City is a tonalite which is composed of clay minerals, chlorite, epidote, quartz and plagioclase with hornblende completely altered to chlorite.

8) Pacol Diorite Group

This group intruded into the lower Miocene formation is exposed at the west side of Madalag and southeast side of Dibacao in northwestern Panay. Observed facies include biotite-hornblende diorite, biotite-hornblende quartzdiorite and biotite-hornblende granodiorite.

(Results of microscopic observation)

A sample collected from the southern part of Buruanga Peninsula, northwestern Panay Is. is a weakly altered biotite-hornblende granodiorite which exhibits holocrystalline equigranular texture.

9) Lamon Andesite Group

This rock group is distributed at the southern part of Mobo in the mid-northern portion of Masbate Is. and is characterized by eroded shallow or terrigeneous stratified volcanoes. Rock facies include plagioclase andesite to hornblende andesite porphyry. This rock group unconformably overlie the lower to middle Miocene formations and had intruded into the Mobo Diorite Group.

(Results of microscopic observation)

A sample collected from an area near Dogosongan, middle Masbate Is. is a chloritized augite andesite porphyry. Medium grain sized twinned plagioclase and small augite phenocrysts are dispersed on a groundmass made up of glass and microcrystalline feldspar.

(Result of K-Ar dating)

A hornblende andesite dyke sample collected from Lamon riverside gave an estimated age of 12.2+/-0.6 Ma. (Upper Miocene) (UNDP, 1981).

10) Mt. Nabongsoran Andesite Group

This rock group intruded into the lower Pliocene Lanang Formation and lower-middle Sambulawan Formation is exposed as monument-shaped stocks at Aroroy, Baleno and Mandaon, at

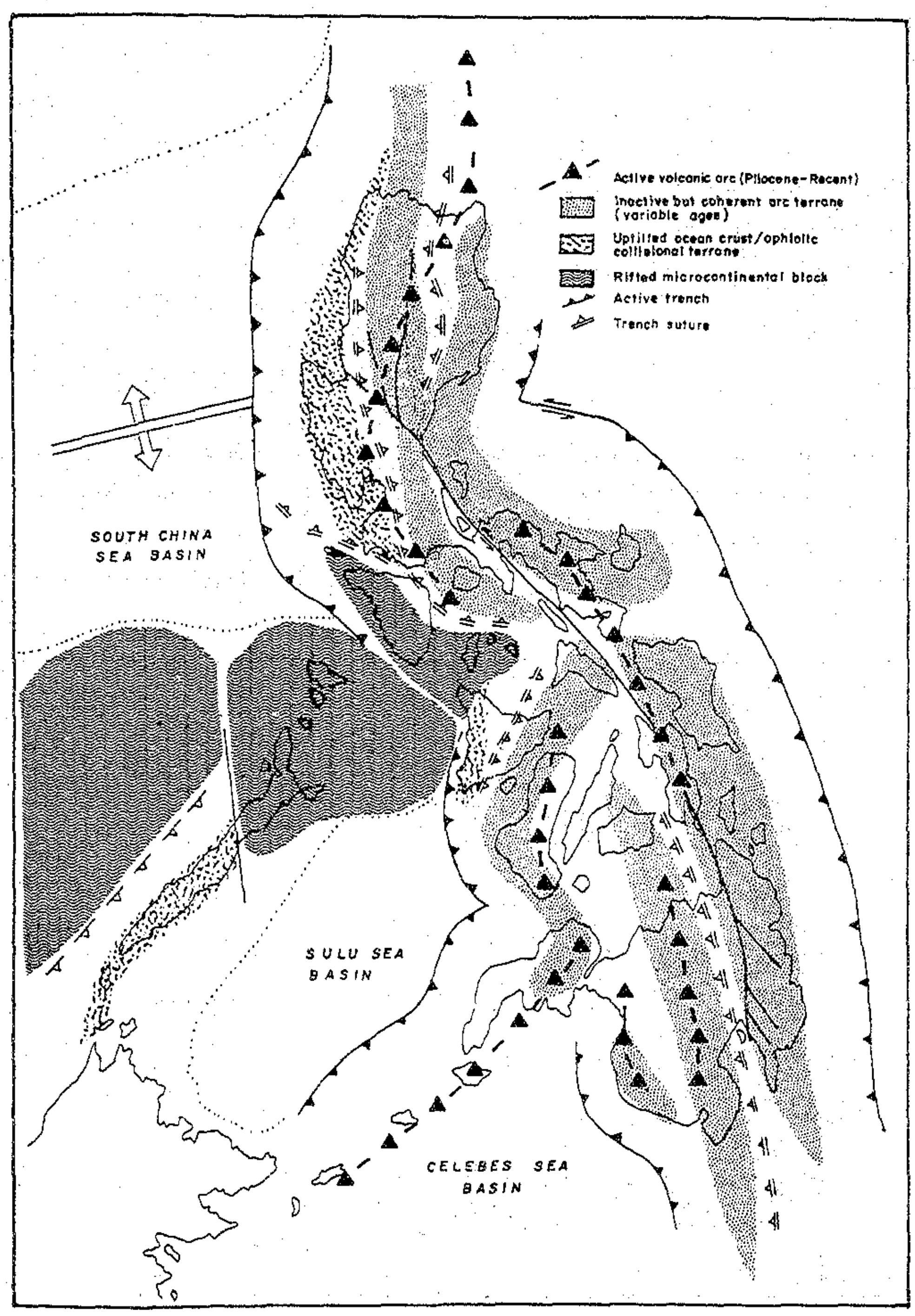


Fig. 6 Regional Tectonic Map of the Philippine Archipelago (after A.S. Zanoria et al., 1984)

the western part of Masbate Is.

Fresh samples were identified as andesite porphyry in which dark to pale gray hornblende and fine-to medium-grained plagioclase phenocrysts are dispersed in a microcrystalline to glassy groundmass.

11) Odiongan Hornblende Andesite

This rock group is distributed as a line of stocks trending NNE-SSW along the eastern coastline of Panay Island. Pale-grayish, brown hornblende andesite and porphyritic plagioclase andesite had been recognized. Silicification, pyritization and argillization had been noted. Kaolin deposits are being mined in argillized zones sometimes.

(Results of microscopic observation)

A sample collected SSE of Concepcion in the eastern coast of Panay Island is a hornblende andesite with plagioclase and hornblende phenocrysts.

12) Paniciuan Debris Flows

Description of this rock group had been taken from the UNDP report since the areal distribute of this rock group is outside the limit of the surveyed field area.

The distribution of this debris flow from the watershed line of the Antique Range to its western slope covers an area/volume 40 km long, 7 km wide and 100 m thick.

Best exposures show this debris flow to cover the Panpanan Basalt at the Dao Peninsula, southwestern Panay, with the flow reaching the western seashore.

This debris flow, which is basically thought to be clastic rocks, include exotic rock fragments from pre-Tertiary blue-schist to Miocene limestone. It has a bluish-gray muddy matrix. Sizes of fragments range from several cm to 100 m. Estimated age for the flow movement is Pliocene to Pleistocene (UNDP, 1986).

Tectonic breccias related to the thrust movements seem to be included into this member and distinguishing them is hard.

2-4 Geological Structures

The Paleozoic to Mesozoic crystalline schists exposed at the middle to western Masbate Is., northwestern part of Panay Is. and Romblon Islands are considered to the lithologies making up the basement complex in these regions. This rock unit had been divided into blocks/terranes which had been juxtaposed as a result of major collisions due to large scale tectonic movements and igneous activities after the Cretaceous period.

The pre-Cretaceous Boracay Formation which is distributed along the watershed line of southwestern Masbate Is. was thrusted over the western lower Oligocene Mandanao Formation during the upper Oligocene period. Exposures of the basement formation from Aroroy to Mobo along the northeastern coastline of Masbate Island are chaotic due to the several pulses of intrusions of igneous rocks from lower Oligocene to middle Miocene. The exposure of the basement formation in this area suggests that this is an uplifted block resulting into the formation of a horst.

The exposures of the basement formation in western Panay Is. had been encountered along the eastern side of the Antique Range. This basement formation which is thought to underlie the eastern Panay block had been thrusted over the western Panay block.

Along the N-S trending thrust fault, exposures of an Eocene ophiolite, upper Oligocene basalt and diorite and Miocene andesite-basalt rock suites had been encountered. Thrusting activities are believed to have span a period from Oligocene to to Pliocene (Mitchell et al, 1986).

On the other hand, the basement formations of the Buruanga Peninsula, northwestern Panay Island and of the Tablas Is., Romblon Area are of continental origins which are believed to have been translated southward to their present positions along the N-S trending Plio-Pleistocene Tablas lineament (Mitchell et al, 1986).

A comparison of the Paleogene formations of eastern Masbate Island and eastern Panay Island as against those of the western Panay area shows distinct differences. The eastern Masbate Is. and eastern Panay Is. are characterized by weak warping with a general N-S trend whereas on the contrary, the western Panay Area is characterized by thrust-related composite foldings. These things suggest that the west block, which probably is of oceanic origin, had been subjected to strong structural movements (Fig. 5) (Mitchell et al, 1986).

The early Paleogene time also saw the intrusion of the Sara Diorite as a 600 km^2 broad batholith in eastern Panay resulting into the prophylitization of the Sibara Formation.

The Antique ophiolite had been emplaced during late Paleogene time in southwestern Panay which was followed by the extrusions of basaltic lava and depositions of clastics along the Antique Range.

During the Eocene period, Masbate Is., eastern portion of Antique Range area, Panay Is., Sibuyan and Romblon Is. of the Romblon Area are thought to have been uplifted on the basis of the non-deposition/erosion of Eocene sedimentary rocks on these areas (Mitchell et al, 1986).

As for the intrusive rocks, the Aroroy Diotite intruded during the lower Oligocene occupy the northernmost position along the diorite intrusive belt from west Negros Is. to west Masbate Is. The middle Miocene Mobo Diorite intruded at southern Mobo, mid-northern part of Masbate Is. is the northernmost intrusive body along the west Bohol via Cebu Is., to middle Masbate Is. diorite intrusive belt. The NW-SE trending Philippine Fault, which passes at the northern portion of Masbate Is., was active during this period resulting into the strong upliftment and erosion around the Mobo area. Mineralization around Mobo is believed to have started during this period. (Fig. 6)

The Neogene formations in Panay Is. are deposited around the periphery of the Antique Range and at the western portion of the Iloilo Basin. These formations generally strike N-S and dip east, and are characterized by thick sedimentation. The Miocene formation in the Romblon Is. are had a change of folding trends from a N-S one to a NW-SE direction.

Pleistocene limestones are deposited along the northwestern to the southeastern portion of Masbate Is., at the northwestern (Buruanga Peninsula) and southern part (Guimaras Is) of Panay Is. and at the west coast of Tablas Is (around Looc) in Romblon Area. Weakly compacted sandstone, siltstone and mudstone have also been deposited simultaneously with these limestones in southeastern Masbate Is. and around the Iloilo Basin, Panay Island.

The Plio-Pleistocene volcanic activities are characterized by the eruption of an andesite porphyry in western Masbate Is. and of hornblende andesite in the east coast of Panay Is. Most of these extrusive bodies form stocks. Circulation of hydrothermal solutions and ore depositions related to the Philippine Fault activities during this period resulted into mineralizations, specifically around the Aroroy area. The Plio-Pleistocene period also saw the extrusions of the Panicuian debris flow which covered the Antique Range extending up to the southwestern coast of southwestern Panay over a length of 100 km. This debris flow is characterized by a bluish-gray matrix that is host to various exotic rock fragments ranging from pre-Cretaceous blue-schist to middle Miocene wackes. This debris flow can be explained by the introduction of fluids, probably in the form of hydrous magmas or hydrothermal solutions, along the crust zones of the thrust faults and in the process, these fluids engulfed different rock fragments from the country wall rocks. When extruded, these hydrous materials were transformed to mudflows that covered the western slope of the Antique Range in a southwest direction.

2-5 Mineralization

The different types of known mineralization in this area are as follows:

1) Porphyry Copper deposits associated with diorite intrusions (Cu)

2) Epithermal vein type deposits around dioritic rocks (Au, Cu)

3) Contact metasomatic deposits (Cu, Pb, Zn)

4) Sedimentary origin Mn deposits (Mn)

5) Massive sulfide deposit associated with ophiolite

6) Weathering nickel-laterite deposit in ultramafic rocks

The descriptions of each mineralization, discussed in chronological order from oldest to youngest, are as follows:

Evaluation standard applied:

A: Necessity of follow-up survey is highest
B: Necessity of follow-up survey is high.
C: Necessity of follow-up survey is fair.
D: Necessity of follow-up survey is low
E: Follow-up survey is needless

1 Pre-Tertiary Deposits

Sedimentary origin Manganese deposits

Many syngenetic manganese deposits of sedimentary origin had been encountered among the sedimentary rocks which make up the basement formation of this area. This type of deposit had been noted from western Masbate up to Buruanga Peninsula which is the northwestern tip of Panay Is. The different manganese deposits surveyed from 1985 to 1986 are as follows:

Western Masbate Island:
Nabangic (E); Ayat (E); Taisan (E); Calumpang (E); Balud (E).

Northwestern Panay Island
Panaktakan (C); Tagororoc (D); Ibanlac (D).

Contact Metamorphic Deposit.
Small-scale skarn zone had been observed at the contact between the crystalline limestone basement and pre-Tertiary diorite intrusive, 8 km east of Libertad, in the southern part of Buruanga Peninsula, northwestern Panay Is.

2. Palaeocene Deposits

Gold bearing quartz veins or silicified zones in Sara diorite exposed at the middle-southern Panay Is.

1) Quinabonglan: Drill exploration carried out by ATLAS Corp. showed malachite disseminations in a silicified zone (20 cm wide) (C).

2) Santo Tomas: Exploration carried out by ATLAS Corp. 5 years ago showed copper mineralization in silicified zones.

3. Eocene Deposits

Cupriferous massive sufide deposits are observed at 15 km NE of San Jose in SW Part of Panay Is., which accompany with ophiolite.

4. Miocene Deposits

Many epithermal quartz veins are known to have accompanied the intrusions/extrusions of the Mobo diorite in Masbate Is., the Bavuso volcanics and the Pacol diorite in Panay Is.

1) Masbate Is.

Dogosangan: Mineral showing is located 9 km NE of Borongan in the quartz veinlets in silicified andesite.

Disseminated zone: 3 m wide, Au: 0.21 g/t; Ag: 14.5 g/t
Cu: 2.15%; Zn: 8.86%. Evaluation: (B)

Mt. Uac:
Hydrothermal vein type showing at 10 km north of Borongan in middle southern part of Masbate Is., showing scale is small, mineralization and alternation in adjacent part are not recognized. Country rock is basalt, expected ore is Au, Cu, Pb. Evaluation: (D).

Mandalc, Marintoc:

Mineral showings are located 3–9 km south of Mobo in the middle northern Masbate Is., as gold bearing mineralized zones in altered basalt and andesite. Alteration: silicification, argilzation.

Assay grade: Au<0.07 g/t, Ag: 2.5–0.5 g/t. Evaluation: (C)

Baang:

Hydrothermal vein type disseminated showing locate 7 km south of Mobo in middle north part of Masbate Is. Mineralization and alteration are weak.

Country rock: hornblende diorite. Expected metal: gold.

Evaluation: (E)

2) **Panay Is.**

Osman:

Chalcopyrite and pyrite ore accompanied hydrothermal clay vein in dolerite, locate at 20 km southwest of Kalibo in northwestern part of Panay. Evaluation: (C)

Pari:

Hydrothermal vein deposit locate at 3 km south of Pilar in northeastern Panay Is. About 40 years ago, Ishihara Industrial Co. carried out with 4 level total 500 m adit. Country rock: andesite. Ore mineral: marachite, azurite.

Evaluation: (B)

Loay:

Hydrothermal vein deposit locate at 4 km southeast of Pilar in northeastern part of Panay Is. Azur Mining Co. carried out exploration mining up to 1983.

Country rock: andesite. Ore mineral: Chalcopyrite, chalcocite. Evaluation: (B)

Salvacion:

Hydrothermal vein type deposit in diorite at southernmost of Guimaras Is. in southern part of Panay. Gossan and pyrite are visible in quartz vein but other ore minerals are unvisible. Evaluation: (C)

San Antonio:

Hydrothermal vein type type deposit in basaltic andesite locate at southernmost of Guimaras Is. in southern Panay Is. About 10 years ago, Hixbar mining Co. carried out exploration with 500 m adit, several tons of copper quartz vein ore were mined out. Evaluation: (D)

Anilao:

Lenticular shape high grade Manganese deposit locate at 6 km north of Anilao in southeren coast of Panay Is. Several hundreds tons manganese oxide produced. Evaluation: (C)

3) **Romblon Area**

Nailog:

Hydrothermal vein type deposit in Tertiary diorite. At western part of Sibuyan Is., accompanies Cu, Pb, Zn ore minerals and show relatively high grade, vein width is 1.5 m.

Evaluation: (D)

Caloring, Cogon:

Porphyry copper type alteration zone in diorite locate at 7 km and 12 km north of Alcantala in southern east coast of Tablas Is. Alteration zone is wide but ore minerals is poor.

Evaluation: (D)

5. **Ore deposit in Pliocene – Pleistocene**

1) **Masbate Area**

Mineral showings accompanied Plio-Pleistocene andesite are as follows:

Aroroy Mine:

This mine is only one actual operating mine in this area, locate at 5 km south of Aroroy in northernmost Masbate Is. Gold bearing quartz vein in silicified zone is operated with open pit mining, silicified zone has 150 m width. Mining right belongs to Atlas Consolidated Co. Ore Reserve: 7 million tons, average grade show Au: 2.13 g/t, heap leaching for low grade ore is carried out with syanic potash method.

Concepcion:

Gold bearing quartz vein deposit in meta-andesite locate at 19 km SSE of Aroroy in northenmost of Maasbate Is. Silicified zone has 4 km length.

Assay grade: Au: 0.14 g/t, Ag: 1.7 g/t Evaluation: (C)

Cpsay:

Epithermal gold bearing quartz vein in quartz porphyry locate at 9 km SSE of Aroroy. Agrilization is main, other alternation and mineralization is weak. Expected metal: gold. Evaluation: (D)

Luya:

Epithermal vein type showing in hornblende andesite locate at 12 km south of Aroroy. Showing has not continuity, development is unexpected. Evaluation: (D)

Matanglad:

Hydrothermal vein type deposit in andesite porphyry locate at 10 km north of Bacolod in middle south of Masate Is., high grade part of copper is visible.

Assay grade: Au<0.07 g/t, Ag: 142.9 g/t, Cu: 61.63%, Pb<0.01%, Zn:<0.01%. Evaluation: (D)

XYZ:

Epithermal vein type deposit in sedimentary rock locate at 16 km north of Bacolod. Old adit exist but mineralization and alternation are not so stable, development is unexptected. Evaluation: (D)

2) **Panay Area**

Mineral showings accompanied Plio-Pleistocene andesite are as follows:

Calagnaan Is:

White argilitized zone in silicified andesite locate at south side of Calagnaan Is. in eastern side of Panay Is. White clay near volcanic vent mined as raw material of kaolin, in 1987

Table - 1 List of Mineral Deposits Classified in Geological Age and Tectonic Province

	Ocean Crust	Fore Arc Basin	Volcano-Plutonic Arc	Back Arc	Continental Block
Pleistocene			Epitherm		
Pliocene			Epithermal Quartz Vein ∘ Aroroy (Masbate) Au (Under Operation) ∘ Concepcion (Masbate) Au (C) ∘ Calagnaan Is (Panay) clay (C)		
Miocene			Epithermal Quartz Vein ∘ Pari-Loay (Panay) Cu (B) ∘ Salvacion (Panay) Cu (C) ∘ Osman (Panay) Cu (C) ∘ Anilao (Panay) Mn (C) ∘ Dogosongan (Masbate) Au (B) ∘ Handalc (Masbate) Au (C) ∘ Maritoc (Masbate) Au (C)		Porphyry Copper ∘ Caloring (Tables Is.) Cu (D) ∘ Cogon (Tables Is.) Cu (D)
Oligocene					
Eocene					
Palaeocene			Epithermal Qu Vein ∘ Quinabonglan (Panay) Cu (C) ∘ Santo Tomas (Panay) CU (C)		
Cretaceous					Syngenetic Mn Deposit ∘ Panaktakan (Panay) Mn (C) Contact Metasomatic Deposit ∘ Libertad (Panay) skarn, (E)
Jurassic					
Triassic					
Permian					

placer gold condenced part is discovered at near site of these andesite stocks, the relation between gold mineralization and these andesite is attracted attention.

These mineral showings are shown in Table-1 - according to their originated age and tectonic location.

3. Consolidated Analysis of Geochemical Results

3-1 Method of Consolidated Evaluation

As described in Introduction 1-2, all surveyed areas since the fiscal year 1984 are divided into cells extending 2 km both in NS and EW directions. With the analyzed values of stream sediment samples in the cells, statistical analyses were executed by the following four methods.

1) Univariate analysis of arithmetic means of analyzed values at every cell
(hereinafter referred to as cell average value)

2) Multivariate analysis of cell average values (factor analysis to the 3rd factor)

3) Univariate analysis of moving average values which are obtained as follows:
The average value of the 9 cells (3 cells in NS, 3 cells in EW) is assumed to be the value of the central cell. This is a univariate analysis of moving average values (hereinafter referred to as the moving average value) of the cell, with a moving range of 2 km.

4) Univariate analysis of the differences between the cell average values and moving average values
(hereinafter referred to as the high-pass filtering value)

The number of analyzed values is 24,456 samples, which were taken from the following areas: Masbate Is., Panay Is. and the Romblon Islands, and the surrounding areas; Leyte, Cebu, Bohol, west Negros and Dinagat. Analyzed elements are Cu, Pb, Zn, Ag, As, Mn, Ni, Co, Mo and Hg (10 elements).
Each element analytical value of these 24,456 samples (cell numbers are 8,716) is population of cell average analysis, high pass filtering value analysis and moving average analysis.
Each element analytical value of Masbate, Panay and Romblon Areas 10,465 samples (cell number 3,840) is population of maltivariate analysis.
the contents of 24,456 samples are 20,561 samples on this project and 3,895 samples on UNDP project.
2,945 UNDP samples in southwestern Panay Is. are lack of Hg analysis and 950 UNDP samples in northern Bohol Is. are lack of Ag analysis.
As for this project samples, 1,764 samples in eastern Bohol and Siquijor area are lack of Mo analysis, 1,500 samples in western Bohol Is. are lack of Ni, Co analysis and 809 samples in Dinagat area are lack of Mo analysis.
Two chemical laboratory were adopted, PETROLAB analyzed 14,907 samples and CHEMEX CANADA analyzed 9,549 samples in similar treatment of atomic absorption method.
The detection limit value of PETROLAB is applied as the detection limit of each element (Table -2).

Table-2 Detection Limit of AAS Analysis

Element	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg
Detection limit (ppm)	2	10	2	1	0.5	50	3	3	2	40 (ppb)

Samples having less than the detection limit value are processed statistically as having the half value of the detection limit.
Using computer for statistical analysis is IBM3084Q and soft ware is "Statistical analysis package BMD08M" which developed at UCLA.

3-2 Examination of Accuracy of Analysis

In order to check the precision of each value before the analysis the variance of the analyzed value at 95% confidence level is calculated by the method of Thompson and Howarth (1973)* with the result of the batch test by PETROLAB, the analyst of MGB, and CHEMEX company, an analyst of CANADA.
The checked result by PETROLAB is given as follows:

1) Process of the batch test

A sample is chosen from each analyzed batch (about 20 samples) and is analyzed with another batch, after which, the variance is calculated by the statistical procedure with the former and the latter values.

2) Result of the batch test

Element	Variance	Detection limit
Cu	± 15%	2 ppm
Zn	± 20%	2 ppm
Pb	± 20%	10 ppm
As	± 25%	0.5 ppm
Hg	± 25%	40 ppb
Sb	± 25%	40 ppb
Ni	± 20%	3 ppm
Co	± 20%	3 ppm
Mn	± 10%	50 ppm
Cr	± 30%	100 ppm

The variance of Mo, Ag, Sn and W can not be determined because many samples have values lower than the detection limit. The result of the batch test by CHEMEX in CANADA and the result

* Thompson, M. and Richard, J. Howarth (1973): A new approach to the estimation of analytical precision. Journal of Geochemical Exploration, Vol. 9, p. 23-30.

of the crosscheck between PETROLAB and CHEMEX indicates similar variance, making it possible to analyze all the data together without any hindrance.

3-3 Univariate Analysis of Cell Average Values

The surveyed areas where 24,456 samples have been taken are divided into 8,716 cells (2 km × 2 km both in NS and EW directions) and the arithmetic mean of the analyzed value of each cell is calculated. The average number of samples is 2.8 per each cell. For a blank cell which has no sampling point, a gap filling is done as follows:

(1) When there are effective values in not less then 4 cells among the 8 cells around the blank cell, the average of these effective values is taken as the value of the blank cell.

When there are effective values only in less than 4 cells, gap filling is not done.

(2) This gap filling procedure is made twice.

1) Basic statistical value

The basic statistical value of cell average values for each element is shown in Table

These values are calculated on logarithmic principles.

Table-3 Basic Statistical Value of Cell Average Value (Each Element)

unit = ppm (ppb on Hg)

	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg
Average value	37.840	5.374	64.025	0.502	2.256	727.978	29.723	20.549	1.138	24.987
Standard deviation	1.851	1.323	1.838	1.062	2.452	1.856	3.349	2.183	1.413	1.524
Minimum vlaue	1.000	5.000	2.646	0.500	0.250	25.000	1.500	1.500	1.000	20.000
Maximum value	5051.70	470.1	920.00	10.561	83.641	10000.0	7250.0	610.00	55.00	4899.0

2) Histogram

Histograms are shown in Appendix-1 and indicate grade frequency distribution of cell average values for each element. Characteristics of histograms are given as follows:

(1) Cu:
The most frequent part is observed at the higher grade side of the average value. The frequency falls steeply from this point to the higher grade side, whereas it falls gently to the lower grade side.

(2) Pb:
82% of cell average values concentrate at the value of 5 ppm indicating the lower value than the detection limit. The frequency at higher grades than the detection limit falls gently to the higher grade side.

(3) Zn:
The most frequent part is at the average grade. The frequency falls with similar lines to both higher and lower grade sides, and its distribution is close to a logarithmic normal distribution.

(4) Ag:
99.86% of cell average values indicate lower values than the detection limit, so that the details of the frequency distribution can not be determined.

(5) As:
The frequency distribution is symmetrical around the average value except the values of samples being lower than the detection limit. Approximately 10% of cell average values concentrate around the value of 80 ppm.

(6) Mn:
The frequency distribution is nearly symmetrical around the average value, but a little excess of the values of samples is observed at the higher grade side of the average value.

(7) Ni:
The frequency distribution is nearly symmetrical around the average value, but a little shortage of the values of samples is observed at the higher grade side of the average value.

(8) Co:
A little shortage of the frequency is observed at the lower grade side of the average value.

(9) Mo:
80% of cell average value indicate lower values than the detection limit. The frequency at higher grades than the detection limit falls gently to the higher grade side.

(10) Hg:
65% of cell average values indicate lower values than the detection limit. The frequency at higher grades than the detection limit falls gently to the higher grade side.

3) Cumulative frequency curve

Cumulative frequency curves of cell average values for each element were drawn and are shown in Appendix-1.

Characteristics of cumulative frequency curves are given as follows:

(1) Cu:

The distribution is close to a logarithmic normal distribution. A significant turning point is observed near the value of 100 ppm, and the frequency distribution at this point is approximately 99%.

(2) Pb:

82% of cell average values indicate lower values than the detection limit, and the distribution is not applicable to a logarithmic normal distribution. A turning point is observed near the value of 8 ppm, but this point is not considered to be the true turning point because the value of 8 ppm is lower than the detection limit.

(3) Zn:

The distribution is close to a logarithmic normal distribution. An insignificant turning point is observed near the value of 110 ppm, and a significant turning point is near the value of 140 ppm. The frequency distributions at these points are 93% and 99.8% respectively.

(4) Ag:

99.86% of cell average values indicate lower values than the detection limit, so that the details of the cumulative frequency can not be determined.

(5) As:

10% of cell average values indicate lower values than the detection limit, and the average values higher than the detection limit do not indicate a logarithmic normal distribution. A turning point is observed near the value of 80 ppm, and the cumulative frequency at this point is 88%.

(6) Mn:

The cumulative frequency is close to a logarithmic normal distribution. A turning point is observed near the value of 2000 ppm, and a significant turning point is near the value of 5000 ppm. Cumulative frequencies at these points are 93% and 99.8% respectively.

(7) Ni:

The cumulative frequency is close to a logarithmic normal distribution. Turning points are observed near the values of 100 ppm and 500 ppm, and a significant turning point is near the value of 3000 ppm. Cumulative frequencies at these points are 85%, 94% and 98% respectively.

(8) Co:

The cumulative frequency is close to a logarithmic normal distribution. A turning point is observed near the value of 50 ppm, and a significant turning point is near the value of 200 ppm. Cumulative frequencies at these points are 95% and 98% respectively.

(9) Mo:

80% of cell average values indicate lower values than the detection limit, and the distribution is not applicable to a logarithmic normal distribution. A turning point is observed near the value of 2 ppm, and the cumulative frequency at this point is 95%.

(10) Hg:

66% of cell average values indicate lower values than the detection limit, and the distribution is not applicable to a logarithmic normal distribution. A turning point is observed near the value of 80 ppb, and the cumulative frequency at this point is 98%.

Table-4 Correlation Coefficient between Elements of Cell Average Value

	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg
Cu (ppm) Number	1.0000 8716									
Pb (ppm) Number	0.1524 8716	1.0000 8716								
Zn (ppm) Number	0.5721 8716	0.1123 8716	1.0000 8716							
Ag (ppm) Number	0.1596 8506	0.3245 8506	0.0424 8506	1.0000 8506						
As (ppm) Number	0.0004 8716	0.2467 8716	−0.0802 8716	0.0484 8506	1.0000 8716					
Mn (ppm) Number	0.5795 8716	0.0789 8716	0.7231 8716	−0.0048 8506	−0.0702 8716	1.0000 8716				
Ni (ppm) Number	0.2717 8341	0.0137 8341	0.3455 8341	0.0091 8133	−0.0360 8341	0.4707 8341	1.0000 8341			
Co (ppm) Number	0.5239 8341	−0.0052 8341	0.6698 8341	0.0059 8133	−0.1888 8341	0.7955 8341	0.7369 8341	1.0000 8341		
Mo (ppm) Number	−0.1616 7998	0.0908 7998	−0.1953 7998	−0.0034 7791	0.2959 7998	−0.2445 7998	−0.1517 7627	−0.3775 7627	1.0000 7998	
Hg (ppb) Number	0.0830 8716	0.2759 8716	0.2056 8716	0.2809 8506	0.2516 8716	0.1658 8716	0.1977 8341	0.1886 8341	0.0742 7998	1.0000 8716

4) Correlation coefficient

Table-4 shows the correlation coefficients of cell average values among all elements respectively.
Remarkable correlations are observed between Cu-Zn-Mn As, Zn-Mn-Co and Ni-Co.

5) Local Distribution of Cell Average Value

(Univariate Analysis)

Arithmetic average values of each element and cell are classified into 11 ranks. Each rank is painted in different colors and plotted on a 1/1,000,000 scale topographic map.

(Ref. attached plate -21)

Classified Range	Rank	Color
99%<Z	A	Red
95%<Z<99%	B	Pink
90%<Z<95%	C	Orange
75%<Z<90%	D	Yellow
60%<Z<75%	E	Yellowish green
50%<Z<60%	F	Green
40%<Z<50%	G	Dark green
30%<Z<40%	H	Blue
20%<Z<30%	I	Purple
D.L.<Z<20%	J	Violet
D.L.>Z	K	Dark violet

D.L.: Detection Limit
Z: Cell average value

Accumulated zones of "A" "B" "C" rank grids on each element are as follows:

1. Masbate Area

(1) East side zone of Mt. Uac in middle part. (Cu, Pb, Ag, Hg)

(2) South side zone of Aroroy in the northernmost part. (Cu, As)

(3) South side of Baleno and adjacent of Conical Peak zone in northwestern part. (Cu, Zn, Mn, Hg)

(4) Adjacent zone of Bunducan in the southernmost part. (Pb, Zn)

(5) Adjacent zone of Mandalion in northwestern part. (Mn, Co)

(6) Adjacent zone of Balud in southwestern part. (Mn, Co)

(7) Northern part zone of west-coast. (Zn)

(8) Adjacent zone of San Ishidoro in northwestern part. (Pb, As, Mo)

(9) Southeastern zone of Palanas in southeastern part. (Mo, As)

In these zones, three of them are able to explain by geology, igneous activity and mineralization.

(1) East side zones of Mt. Uac in middle part: This zone locate in the northernmost part of diorite intrusion belt which elongate from Bohol to Middle of Masbate Is. In NNE direction, and overlap to distributed zone of Miocene Mobo diorite and Lamon andesite, the hydrothermal alternation as chloritization and sericitization, which derived from Philippine Fault activity passing just north side of this zone, affected to these rocks (Q. Baybayan and Alvin M. Matos, 1985). Umabay, Handalc, Baang, Marintoc, Dogosongan are known as mineral showings of gold bearing copper quartz vein.

(2) Southern zone of Aroroy northernmost part: Lower Pliocene Mt. Nabongsoran andesite intruse in this zone and many gold bearing quartz veins occur in silicified zone connected this andesite intrusion. Aroroy Mine, only one operating metal mine in this area and many other gold bearing quartz vein showings (Baleno, Capsay, Luya, Concepcion, etc.) are observed in this zone.

(3) Southern part of Baleno and around part of Conical Peak in northwestern part: This zone locate at northernmost part of western diorite intrusion belt from west Negros Is.via. east Panay Is. to west Masbate. Aroroy diorite intruse in this zone between Eocene and Oligocene, western part of this zone is covered by Pliocene Lamong conglomerate and eastern part is covered by Miocene Sambulawan Formation. Mineralization details are unknown, but it seems to be older (may be Miocene) than that of southern Aroroy as suprior copper mineralization observed in this zone, known showings are Matanglad, X. Y. Z. etc.
As for another accumulated zone, (5) Adjacent zone of Mandalion in northwestern part and (6) Adjacent zone of Balud in southwestern part are codenced Mn zone which locate in Oligocene Mandaon Formation, and affected by the influence of syngenetic manganese beds which interbed in Boracay Formation. (4) Adjacent zone of Bunducan in the southernmost part and (7) Northern part zone of west coast locate in Plio-Pleistocene Bugui Pt. limestone area, but Zn, Pb condenced reason is unknown. (8) Adjacent zone of San Ishidoro in northwestern part and (9) South-east zone of Palanas in southeastern part locate also in Bugui Pt. limestone area, but Mo, As condenced reason are unknown.

2. Panay area

Accumulate zones of "A" "B" "C" rank cells on each elements in Panay Area are as follows:

(1) South zone of Pilar in norhteastern part. (Cu, Pb)

(2) North-east zone of San Jose in southwestern part. (Cu, Pb, Ag, Ni, Co)

(3) North-east zone of Tibiao middle part of west coast. (Cu)

(4) Adjacent zone of Tangaran in northwest coast. (Ni, Co)

(5) East coast zone. (As, Mn, Mo)

(6) Buruanga Peninsula zone in northwestern part. (As, Mn, Hg)

(7) South of Iloilo basin zone in mid-south part. (Mn, Co)

(8) North-west zone of Guimaras Is. in southern part. (An, As)

(9) Adjacent zone of Roxas in northern part. (Pb, Mn)

In these accumulate zones, four of them are able to explain by geology, igneous activity and mineralization as follows:

(1) South zone of Pilar in northeastern part: This zone locate at the site, in which upper Cretaceous Yabeng diorite (partially monzonite) and Miocene Bavuso volcanic rocks intruded in Cretaceous Sibara Formation. This Bavuso volcanics show strong alternation as like of Lamon andesite in Masbate Is., mineralization is epithermal type copper bearing quartz vein and had been exploited mines as Pari, Loay etc. are known.

(2) North-east zone of San Jose in southwestern part: This zone locate at the root of Dao Peninsula in southwestern part, overlap to ophiolite distribution which erupted in Paleocene to Eocene, overthrust to eastern block in Oligocene. Mineral showings are massive sulfide and lateritic nickel-chromite ore, Carawisan (massive sulfide), Panicicuan (*massive sulfide), Karamar (chromite) etc. are known.

(3) Northeastern zone of Tibiao middle part of west coast: This zone locate in lower Miocene Mt. Baloy volcanics area, and Miocene Pacol diorite intrude at north side of this zone this diorite seems to elongate to Tablas diorite group in north direction, this diorite intrusion belt occupy west wing of diorite intrusion in this area. Mineral showings in this zone are unknown but at northern part of Pacol diorite body some mineral showings as Osman etc. are known.

(4) Adjacent zone of Tangalan in northwestern coast: This zone locate northern of Antique Range at near seashore, and in the distributed area of upper Miocene to lower Pliocene Lagdo Formation, several serpentine small bodies intrude in Lagdo Formation, Ni, Co, condenced zone will be derived from this serpentine materials.
As for (5) East coast As, Mn, Mo condenced zone, the location of this zone is very near to upper Pliocene Odiongan andesite eruption belt, therefore this zone will be derived from hydrothermal alternation accompanied this andesite eruption.

3. Romblon Area

Condenced zone of "A" "B" "C" rank cells on each element in this area are as follows:

(1) Middle part zone of Sibuyan Is. (Ni, Co)

(2) Northwestern pat zone of Sibuyan Is. (Cu, Pb, As, Hg)

(3) Middle east part zone of Tablas Is. (Cu, Hg)

All above zones are able to explain by geology, igneous activity and mineralization.

(1) Middle part zone of Sibuyan Is.: This zone overlap to Palaeocene to Eocene Sibuyan ultramafic rocks, weathering zone of this rocks is enriched Ni and Cr laterite, in such place several mineral showings as Bato, Binayan, and Olango etc. are known, but laterite thickness is generally thin (±1 m).

(2) Northwestern part zone in Sibuyan Is.: This zone locate boundary part of Eocene diorite and Palaeocene to Oligocene Sibuyan ultramafic rocks, hydrothermal vein type showings as Dulangan, Nailog etc. are locate in diorite, metal contents are relatively high.

(3) Middle east part zone of Tablas Is.: This zone locate in boundary part between lower Miocene diorite and Oligocene pyroclastic rocks, some porphyry copper type alteration as Caloring, Cogon are observed, but ore minerals are rare.

3-4 Multivariate Analysis (Factor Analysis) of Cell Average Values

1. Determination of Factor Number

Factor analysis is carried out on each cell average value in the objective area. The relationship between each extracted factor and each element with reference to the factor score is as follows:

Factor 1 has intimate relation to Cu, Zn, Mn, Ni, Co.
Factor 2 has intimate relation to Pb, As, Hg.
Factor 3 has intimate relation to As, Mo.

These combination of elements contain all the analyzed elements except Ag. Almost 98.6% of all the samples have Ag value below the detection limit, which led to the deletion of the Ag data. The analytical data of Ag are obviously not suitable for statistical treatment.
The above three factors are then utilized on the multivariate factor analysis.
Variance extent of each element cell average value which is covered by 1 to 3 factor is 67.5%. (Cumulative proportion of total variance.)

Table-5 List of Factor Loading

Element	Factor 1	Factor 2	Factor 3
Cu	0.78534	0.07837	0.05191
Pb	0.12086	0.73682	−0.24598
Zn	0.86992	0.02330	0.01540
As	−0.08057	0.62792	0.42246
Mn	0.86869	−0.09557	0.05814
Ni	0.67129	0.09089	0.12377
Co	0.92245	−0.11693	0.07310
Mo	−0.19685	0.25723	0.79120
Hg	0.08023	0.68576	−0.42161

2. Factor score of each cell is obtained by totaling each element cell average value then multiplied by the factor weight (factor score coefficient).

The factor scores of each cell are analyzed with the univariate analysis method and classified into 3 ranks as below:

$M+2.0\sigma$ value<Z	1st Class (Highly) Anomaly
$M+1.5\sigma$ value<Z<$M+2.0\sigma$ value	2nd Class (Probably) Anomaly
$M+1.0\sigma$ value<Z<$M+1.5\sigma$ value	3rd Class (Possibly) Anomaly

These results were plotted utilizing three colors namely, red for the first class, yellow for the second class and blue for the third class, on a 1/1,000,000 scale topographical map separated on the basis of each factor analyses.

The number of these anomalous cells in each factor are as below.

3. Local distribution of anomalous values

	Factor 1	Factor 2	Factor 3	Total
1st Class Anomaly	9	2	135	146
2nd Class Anomaly	37	16	35	88
3rd Class Anomaly	328	37	61	426
Total	374	55	231	660

Table-6 List of Factor Score Coefficients

Element	Factor 1	Factor 2	Factor 3
Cu	0.22860	−0.04049	0.03944
Pb	−0.00263	−0.53953	0.02798
Zn	0.24797	−0.02643	−0.01061
As	0.03001	−0.17741	0.54473
Mn	0.25430	0.06153	−0.01331
Ni	0.20603	−0.01356	0.10586
Co	0.27170	0.07929	−0.00980
Mo	0.05005	0.20297	0.73178
Hg	−0.03968	−0.58603	−0.12934

The local distribution for each factor are shown in PL.-2-4.

The local distributions of highly and probably anomalous cells for each factor are as follows:

1) Masbate Area

The highly anomalous cells of the 1st factor that has the high correlation with Cu, Zn, Mn, Ni, Co are located in the east side of Bacolod. Both mineralization and alteration are not known around its place. Its geology consist of Mn rich Mandaon Formation and its clastics. The anomalous origin seems to derive from Mn of the clastics. Otherwise it is possible to be brought by Botong River metal concentrated clastics in the east side of Mt. Uac at 10 km east of its place. The several probably anomalous cells are located around Conical Peak of northwest part and in north part of west coast. The former's origin of the high condensed cells of Cu, Zn sourced from mineralization and the latter's origin sourced from the high condensed cells of Mn, Co around Mandelidon. The highly anomalous cells of the 2nd factor that has the high correlation with Pb, As, Hg are located only around San Ishidoro in north part of west coast. Its anomalous cells are located in the limestone zone around San Ishidoro where has the high condensed cells of Pb, As. The probably anomalous cell are located around San Ishidoro and in the southeast part. The former is located in the distribution area of high condensed cells of Pb, As. The latter is located in the distribution area of high condensed cells of As. Its origin is unknown.

The highly and probably anomalous cells of the 3rd factor are located in northwest part and southeast part. These anomalous cells are located in the Bugui Point limestone of the Pliocene to Pleistocene of north part and southeast part of west coast. They are situated in the distribution area of high condensed cells of Mo. these origin is unknown.

2) Panay Area

The 1st factor has the high correlation with Cu, Zn, Mn, Ni and Co. Its highly and probably anomalous cells are located in the northeast part of San Jose and the south part of Pilar of northeast coast. The former is located in Palaeocene to Eocene ophiolite area and the latter is located in Cretaceous pyroclastics area (Sibara Formation area). Both anomalous cells are situated in the distribution area of high condensed cells of Cu, Ni and Co.

The 2nd factor has the high correlation with Pb, As and Hg. One probably anomalous cell is located in the northwestern part of Guimaras Island. Its origin is unknown.

The 3rd factor has the high correlation with As and Mo. Its high anomalous cells are located in the central part of east coast in the Calagnaan Island of north part and in the northeast part of San Jose.

The anomalous cells of the central part of east coast and Calagnaan Island are located in the distribution area of upper Pliocene Odiongan hornblende andesite. These origin seems to the andesite. Elements of As and Mo has the correlation with the 3rd factor and both has the relationship with the mineralization. It seems to indicate the mineralization in the andesite. The origin of the anomalous cell in northeast part of San Jose seems to the influence of the ophiolite and its massive sulfide deposits.

3) Romblon Area

The 1st factor has the high correlation with Cu, Zn, Mn, Ni and Co. Its highly and probably anomalous cells are located from the northeast part to middle-north part of Sibuyan Island. The area is located in the northeast part of the distribution area of Sibuyan ultramafic rocks. It coincide with the northeast part of condensed area of Ni and Co. Its

anomalous origin seems the concentration of Ni and Co.
The 2nd factor has the high correlation with Pb, As and Hg. One possibly anomalous cell is located in the southernmost part of Tablas Island. Its cell coincide with the condensed cell of Hg.
The 3rd factor has the high correlation with As and Mo. Its one high anomalous cell is located in the southernmost part of Tablas Island and one probably anomalous cell is located in the west part of Sibuyan Island. The former seem to has the relationship with the condensed cell of Mo in crystalline limestone. The latter seem to has the relationship with the condensed cell of As with diorite intruded in crystalline limestone.

3-5 Univarite Analysis of Moving Average Values

In the abovementioned 8,716 cells, the average value of the 9 cells (3 cells respectively both in NS and EW directions) is supposed to be the value of the central cell. This average value is the moving average value of the cell.
Moving average values are calculated at all 8,716 cells. For the cells on the edge, gap filling is done as follows.
When there are effective moving average values in 3 cells among 6 cells which are cells in the second and third row from the edge, the average value of these 3 values is taken as the moving average value of the central cell of the 3 cells on the edge.
This gap filling procedure is made twice.

1) Basic statistical value

The basic statistical value of the moving average values is shown in Table -7.

These value were calculated on logarithmic principles.

2) Histogram

Histograms are shown in Appendix-2 and indicate frequency distributions of moving average values for each element.

Table-7 Basic Statistical Values of Moving Average Value (Each Element)

unit: ppm (Hg: ppb)

	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg
Mean value	37.884	5.366	64.066	0.502	2.250	728.809	29.770	20.490	1.138	24.931
S. D.	1.673	1.214	1.703	1.027	2.149	1.703	3.125	2.034	1.331	1.384
Minimum	4.270	5.000	8.274	0.500	0.257	86.272	1.950	1.500	1.000	20.000
Maximum	722.751	38.556	343.004	1.045	47.054	5169.867	5278.844	398.905	8.402	431.22

S. D.; standard deviation

Generally these histograms have the same tendency as that of the cell average values. Characteristics of frequency distribution on each element are given as follows:

(1) Cu:
The most frequent part is observed at the higher grade side of the average value. The frequency falls steeply from this part to the higher grade side, whereas it falls gently to the lower grade side.

(2) Pb:
Approximately 63% of all the average values indicate lower grades than the detection limit, so that the distribution does not show a logarithmic normal distribution.

(3) Zn:
The most frequent part is at the average value. The frequency at the higher grade side is slightly excessive, however, it generally shows a logarithmic normal distribution.

(4) Ag:
Approximately 96% of all the average values indicate lower grades than the detection limit, so that the distribution does not show a logarithmic normal distribution.

(5) As:
A shortage of the frequency is observed at the lower grade side of the average value, but the distribution is close to a logarithmic normal distribution.

(6) Mn:
A shortage of the frequency is observed at the lower grade side of the average value, but the distribution is close to a logarithmic normal distribution.

(7) Ni:
The frequency distribution is nearly symmetrical around the average value, but a little shortage of the frequency is observed at the higher grade side.

(8) Co:
A shortage of the frequency is observed at the lower grade side of the average value, and the frequency at the higher grade side is slightly excessive.

(9) Mo:
Approximately 72% of all the average values indicate lower grades than the detection limit, so that the distribution does not show a logarithmic normal distribution.
The frequency at higher grades than the detection limit

falls gently to the higher grade side.

(10) Hg:

Approximately 60% of all the average values indicate lower grades than the detection limit, so that the distribution does not show a logarithmic normal distribution.

The frequency at higher grades than the detection limit falls gently to the higher grade side.

3) Cumulative frequency curve

Cumulative frequency curves of cell average values for each element were drawn and are shown in Appendix-2.

Characteristics of cumulative frequency curves are given as follows:

(1) Cu:

The cumulative frequency is close to a logarithmic normal distribution.

A significant turning point is observed near the value of 100 ppm, and the frequency distribution at this point is 93%.

(2) Pb:

63% of all the average values indicate lower values than the detection limit, and the distribution is not applicable to a logarithmic normal distribution. A turning point is observed near the value of 7 ppm, however, it is not considered an anomaly because it indicates the average value including lower values than the detection limit: 10 ppm.

(3) Zn:

The cumulative frequency is close to a logarithmic normal distribution.

A turning point is observed near the value of 90 ppm, and the cumulative frequency at this point is 83%.

(4) Ag:

91% of all the average values indicate lower values than the detection limit, so that the cumulative frequency does not show a logarithmic normal distribution.

(5) As:

The cumulative frequency is close to a logarithmic normal distribution.

A turning point is observed near the value of 11 ppm, and the cumulative frequency at this point is 99%.

(6) Mn:

The cumulative frequency is close to a logarithmic normal distribution.

A significant turning point is observed near the value of 2500 ppm, and the frequency distribution at this point is 99.8%.

(7) Ni:

The cumulative frequency is not applicable to a logarithmic normal distribution at the higher grade part of the average value. Turning points are observed near the values of 75 ppm and 200 ppm, and a significant turning point is near the value of 1200 ppm. Cumulative frequencies at these points are 87%, 95% and 97.5% respectively.

(8) Co:

The cumulative frequency is not applicable to a logarithmic normal distribution at the higher grade part of the moving average value. Significant turning points are observed near the values of 50 ppm and 100 ppm. Cumulative frequencies at these points are 95% and 97.5% respectively.

(9) Mo:

80% of all the average values indicate lower values than the detection limit, so that the cumulative frequency does not show a logarithmic normal distribution. A turning

Table-8 Correlation Coefficient between Elements of Moving Average Value

	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg
Cu Number	1.0000 8667									
Pb Number	0.0848 8667	1.0000 8667								
Zn Number	0.5951 8667	0.0341 8667	1.0000 8667							
Ag Number	0.1615 8454	0.3508 8454	0.0404 8454	1.0000 8454						
As Number	−0.0896 8667	0.2953 8667	−0.1346 8667	0.0509 8454	1.0000 8667					
Mn Number	0.6144 8667	0.0438 8667	0.7444 8667	0.0031 8454	−0.1319 8667	1.0000 8667				
Ni Number	0.2654 8229	0.0022 8299	0.3510 8299	−0.0024 8089	−0.0612 8299	0.4822 8299	1.0000 8299			
Co Number	0.5388 8299	−0.0476 8299	0.6766 8299	0.0038 8089	−0.2444 8299	0.8108 8299	0.7511 8299	1.0000 8299		
Mo Number	−0.2750 7970	0.1320 7970	−0.2616 7970	0.0195 7760	0.3874 7970	−0.2839 7970	−0.1929 7606	−0.4678 7606	1.0000 7970	
Hg Number	0.0348 8667	0.3012 8667	0.2757 8667	0.2804 8454	0.2613 8667	0.2021 8667	0.2498 8299	0.2465 8229	0.1220 7970	1.0000 8667

point is observed near the value of 2.5 ppm, and the cumulative frequency at this point is 96%.

(10) Hg:

59% of all the average values indicate lower values than the detection limit, so that the cumulative frequency does not show a logarithmic normal distribution. A turning point is observed near the value of 70 ppm, and the cumulative frequency at this point is 99%.

4) Correlation coefficient

Table-8shows the correlation coefficients of moving average values among all elements respectively.
Remarkable correlation are observed between Cu-Zn·Mn·Co, Zn-Mn·Co, Mn-Co and Ni-Co.

5) Local distribution of moving average value

Moving average value in each cell is classified into 11 ranks. Each rank is painted in different colors and plotted on a 1/1,000,000 scale topographic map (Attached Plate - 2-3)

Range	Rank	Color
99%<Z	A	Red
95%<Z<99%	B	Pink
90%<Z<95%	C	Orange
75%<Z<90%	D	Yellow
60%<Z<75%	E	Yellowish green
50%<Z<60%	F	Green
40%<Z<50%	G	Dark green
30%<Z<40%	H	Blue
20%<Z<30%	I	Purple
D.L.<Z<20%	J	Violet
D.L.>Z		Dark violet

Z: Moving Average Value
DL: Detection Limit

5. Local distribution of anomalous values of moving average values

The moving average values in each cell are classified in the following range limit. These classified anomalous values were plotted in 1:1,000,000 scale topographical map (PL.- 2-3)
The local distribution of moving average values in each element are as follows:
The condensed zones of "A", "B" and "C" ranks in each element are as follows:

1. Masbate Area

(1) East side of mt. Uac in central part (Cu, Pb, Ag, Hg)

(2) South part of west coast (Mn, Co)

(3) North part of west coast (Zn, Mo)

(4) Southeast part (As, Mo)

(5) Near Aroroy of the northernmost part (Cu, As)

(6) Conical Peak and its adjacent part of northwest part (Cu)

In the abovementioned parts, four of them are able to explain by geology, igneous activity and mineralization, as follows:

(1) East side of Mt. Uac: This condensed zone are located in the northernmost part of east side diorite intrusion belt from Bohol Is. to central part of Masbate.
They coincides with the distribution areas of Miocene Mobo diorite and Miocene Lamon andesite. Both rocks suffer hydrothermal alterations of chloritization and sericitization influenced the activity of the Philippine Fault passing through just north side (Geology of Masbate Island Central Philippines; Q. Baybayan and Alvin Matos, 1985).
Gold bearing copper quartz vein showings, Umabay, Handalc, Baang, Marintoc and Dogosongan are known as mineral showings.

(2) South part of west coast: This condensed cells of Mn seem to be influenced the syngenetic manganese deposits of Oligocene Mandaon Formation. The many sedimented manganese showings as Ayat and Taison etc. are known in this area. The condensed cell of Co is seen around Balud.

(5) Near Aroroy of the northernmost part: This condensed zone have the relationship with Mt. Nabongsoran andesitic porphyry intruded in lower Pliocene. Many gold bearing quartz veins are observed in the strongly silicified zone. Aroroy Mine is only one operating mine in this area. The many mineral showings of gold bearing quartz veins as Baleno, Capsay, Luya and Concepcion are known.

(6) Conical Peak and its adjacent zone of northwest part: This condensed zone are located in the northernmost part of west side diorite intrusion belt from west Negros to west Masbate through east Panay. The area suffer the intrusion of Aroroy diorite in Eocene to Oligocene. The west part is covered by Pliocene Lamong Formation and the east part is covered by Miocene Sambulawan Formation. The details about the mineralization are unknown but the mineralization of this area (probably in Miocene) is seem to be different from the mineralization near Aroroy. As mineral showings, Matanglad, X.Y.Z. are known.

(7) The other condensed zone: (3) and (4) locate in Pliocene-Pleistocene limestone. The mineral showing in this area is not known and the relationship with mineralization is unknown.

2. Panay Island

(1) Northeast part of San Jose in southwest part (Cu, Pb, Mn, Ni, Co)

(2) Pilar in northeast part (Cu, Pb, Mn)

(3) Buruanga Peninsula in northwest part (As, Mn)

(4) Adjacent part of Roxas in north part (Mn, Co)

(5) South part of Tangalan in northwest coast (Ni, Co)

(6) North part of Anilao in middle-south part (Co)

(7) South part of east coast (Mo)

In the abovementioned zones, four of them are able to explain by geology, igneous activity and mineralization as follows:

(1) Northeast part of San Jose: This condensed zone locate in the Antique ophiolite zone of southwest part. The area develop composite folds of N-E trend. Massive sulfide deposits are seen in this area. The high condensed zone are influenced by the ophiolite and massive sulfide. As the mineral showings, Carawisan (Cu), Panicicuan (Cu), and Karmar (Cr) etc. are known.

(2) Pilar in northeast part: This zone suffer the intrusion of Yabeng diorite (partly Monzonite) in Pyroclastics of Cretaceous Sibara Formation, and Miocene Bavuso volcanics also erupt in this zone. The Bavuso volcanics rocks suffers the strong alteration by the contemporaneous andestic intrusion as Lamon andesite of Masbate Area. Epithermal copper bearing quartz veins in andesite are observed. In this zone, the mineral showings of Pari and Loay were prospected positively.

(5) South part of Tangalan in northwest coast: This area is located near north coast of Antique Range and is situated at the distribution area of Lagdo Formation in upper Miocene to lower Pliocene. The Lagdo Formation near the condensed zone suffer the intrusion of several small serpentinite bodies. The high condensed zone of Ni and Co are seem to be originated by the serpentinite.

(7) South part of east coast: This area is located in the stocklike upper Pliocene Odiongan hornblende andesite.
The condensed zone of Mo is seems to be influenced by the andesite intrusion.

(8) The other condensed zone: (4) is located in pre-Cretaceous sedimentary rocks of continental blocks. The condensed zone of Mn is seems to be originated from the syngenetic sedimentary banded manganese beds in the sedimentary rocks.

3. Romblon Area

(1) West part of Sibuyan Island (Pb, Zn, As, Hg)

(2) Middle part of Sibuyan Island (Mn, Ni, Co)

(3) South part of Sibuyan Island (Hg)

(4) Northeast part of Tablas Island (Zn)

In abovementioned condensed zone, three of them are able to explane by the relationship of geology, igneous activity and mineralization as follows:

(1) West part of Sibuyan Is.: This condensed zone locate in Eocene diorite intrusive body, which altered around Sibuyan ultramafic rocks. Hydrothermal vein type mineral showings, Nailog etc. are known.

(2) Middle part of Sibuyan Is.: This condensed zone overlap intrusing area of Palaeocene to Eocene Sibuyan ultramafic rocks, accumulation of Ni, Co is originated from this ultramafic rock.

As for (3) condensed zone of Hg south part of Sibuyan is. and condensed zone of Zn, northeast part of Tablas Is., mineralization of originated these condensed zone are unknown.

3-6 Univariate Analysis of High-Pass Filtering Values

A high-pass filtering value is the difference between the cell average value and the moving average value as mentioned above in 3-3 and 3-5 (only positive numbers, excluding negative numbers).
A univariate analysis of high-pass filtering values is executed. The high-pass filtering value shows the excess of the cell average value over the smoothed moving average value, so the guide to the location, intensity and priority order of a geochemically anomalous zone without the influence of a hinterland is obtained by investigating the high-pass filtering value.

1) Basic statistical value

The basic statistical values of high-pass filtering values are shown in Table-9.
These values are calculated on logarithmic principles.

2) Histogram

Histograms indicating frequency distributions of high-pass filtering values for each element are shown in Appendix-3.
Characteristics of histograms are given as follows.

(1) Cu:
The most frequent part is observed at the higher grade side of the average value ($M+0.5\sigma$ value). The frequency falls steeply from this part to the higher grade side, whereas it falls gently to the lower grade side.

(2) Pb:
A little excess of the frequency distribution is observed at the higher grade side of the average value; however, the frequency distribution is close to a logarithmic normal distribution.

(3) Zn:
An excess of the frequency distribution is observed at the higher grade side of the average value, but the frequency distribution is close to a logarithmic normal distribution.

(4) Ag:
An excess of the frequency distribution is observed at the higher grade side of the average value ($M+1.0\sigma$ value), but the frequency distribution is close to a logarithmic normal distribution.

Table-9 Basic Statistical Values of High-pass Filtering Value (Each Element)

unit: ppm (Hg: ppb)

	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg
Mean value	3.250	0.595	5.596	0.040	0.347	63.690	3.495	1.804	0.113	3.629
S. D.	6.075	8.756	5.865	10.068	8.972	6.014	9.907	6.439	15.183	8.070
M + 1.0σ value	19.731	5.210	32.824	0.400	3.116	383.020	34.623	11.613	1.717	29.283
M + 1.5σ value	48.623	15.478	79.494	1.270	9.334	939.282	108.976	29.469	6.691	83.186
M + 2.0σ value	119.823	45.524	192.52	4.030	27.959	2303.403	342.997	74.777	26.071	236.313
Maximum	4768.469	148.879	764.538	9.562	69.675	8055.430	2602.312	332.411	48.783	4743.496
Minimum	0	0	0	0	0	0.004	0	0	0	0
Total No.	4217	1031	4134	71	3970	4234	3988	4075	1099	1910

S. D.: Standard Deviation

(5) As:

An excess of the frequency distribution is observed at the higher grade side of the average value.

Generally the frequency distribution is close to a logarithmic normal distribution.

(6) Mn:

The most frequent part is observed at the higher grade side of the average value (near M+0.5σ value). The frequency falls steeply from this part to the higher grade side, whereas it falls gently to the lower grade side.

(7) Ni:

The frequency distribution is nearly symmetrical around the average value and generally shows a logarithmic normal distribution.

(8) Co:

The most frequent part is at the higher grade side of the average value (near M+0.5σ value). The frequency distribution is close to a logarithmic normal distribution.

(9) Mo:

The most frequent part is at the higher grade side of the average value (near M+0.5σ value). The frequency distribution is close to a logarithmic normal distribution.

(10) Hg:

The most frequent part is observed at the higher grade side of the average value (near M+2.0 value). The frequency falls steeply from this part to the higher grade side, whereas it falls gently to the lower grade side.

3) Cumulative frequency curve

Cumulative frequency curves of high pass filtering values for each element were drawn and are shown in Appendix-3.

Characteristics of cumulative frequency curves are given as follows:

(1) Cu:

The cumulative frequency generally indicates a logarithmic normal distribution except at the value of M+0.5σ. An insignificant turning point is observed at the value of M+1.0σ, and a significant turning point is at the value of M+1.5σ.

(2) Pb:

The cumulative frequency is close to a logarithmic normal distribution.

An insignificant turning point is observed at the value of M+1.0σ.

(3) Zn:

The cumulative frequency is close to a logarithmic normal distribution except at higher values than M+1.0σ.

A significant turning point is observed at the value of M+2.0σ.

(4) Ag:

The cumulative frequency generally shows a logarithmic normal distribution except at the value of M+3.0σ. A significant turning point is observed at the value of M+1.5σ.

(5) As:

The cumulative frequency is close to a logarithmic normal distribution except at the value of M+1.0σ. There is no turning point.

(6) Mn:

The cumulative frequency generally indicates a logarithmic normal distribution except at higher values than M+1.0σ. There is no turning point.

(7) Ni:

The cumulative frequency is close to a logarithmic normal distribution.

A turning point is observed at the value of M+1.0σ, and a significant turning point is at the value of M+2.0σ.

(8) Co:

The cumulative frequency is close to a logarithmic normal distribution.

A turning point is observed at the value of $M+1.0\sigma$.

(9) Mo:

The cumulative frequency is close to a logarithmic normal distribution.

A turning point is observed at the value of $M+1.0\sigma$.

(10) Hg:

The cumulative frequency is close to a logarithmic normal distribution.

A turning point is observed at the value of $M+1.5\sigma$, and a significant turning point is at the value of $M+2.0\sigma$.

4) Correlation coefficient

Table-10 shows the correlation coefficients of high pass filtering values among all elements respectively.

Remarkable correlations are observed between Cu-Pb-Hg, Pb-Zn-Ag-As-Mn-Mo, Zn-Ag-Mn-Co, Ag-Ni-Co-Mo-Hg, As-Mo-Hg, Mn-Co-Mo, Ni-Co-Mo and Mo-Hg.

5) Local distribution of high pass filtering value

Anomalous values ($>M+1.5\sigma$ value) of high pass filtering values are classified by the formula as follows:

Classification Formula	Color	Rank
$M+1.0\sigma$ value $<Z<M+1.5\sigma$ value	Blue	3rd Anomaly (Possibly)
$M+1.5\sigma$ value $<Z<M+2.0\sigma$ value	Yellow	2nd Anomaly (Possibly)
$M+2.0\sigma$ value $<Z$	Red	1st Anomaly (Highly)

These classified colored anomalous cells are plotted on 1/1,000,000 topographic maps. (Attached Plate - 2-2)

The distribution area of anomalous values which has the intimate relationship with the highly and probably anomalous cells in each element are as follows:

1. Masbate Area

(1) East side of Mt. Uac in central part (Cu, Pb, Ag, Hg)

(2) West coast (Cu, Zn, Mn)

(3) Southeast part (Pb, Mo, Zn)

(4) Near Conical Peak of northwest part (Cu)

(5) Northwest part of Bacolod (Cu)

High-pass filtering values are indicated by the difference between cell average values and moving average values.

the anomalous values are not shown directly, the mineralized alteration zone. The anomalous values coincided the high cell average values are indicated the mineralized alteration zone.

In the abovementioned four anomalous distribution areas, (1), (2), (3), (4) have the relationship with high condensed cells.

2. Panay Area

(1) South part of Pilar (Cu, Pb)

(2) Northeast part of San Jose (Cu, Mn, Ni, Co)

(3) Near Roxas of north part (Pb, Mn, Co)

(4) East coast (As, Mo)

(5) West part of Kalibo (Ni, Co.)

(6) Buruanga Peninsula (As, Mn, Hg)

Table-10 Correlation Coefficient between Elements of High-pass Filtering Value

	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg
Cu Number	1.0000 4217									
Pb Number	0.5504 647	1.0000 1031								
Zn Number	0.4446 2723	0.957 644	1.0000 4134							
Ag Number	0.6610 42	0.7864 42	0.6595 49	1.0000 71						
As Number	0.3973 2298	0.5785 667	0.4526 2022	0.4855 44	1.0000 3970					
Mn Number	0.4617 2807	0.5248 657	0.5551 3060	0.4849 36	0.4553 2145	1.0000 4234				
Ni Number	0.2989 2501	0.3876 517	0.2954 2478	0.7075 29	0.3807 2028	0.3691 2591	1.0000 3988			
Co Number	0.4560 2691	0.5036 533	0.5690 2938	0.6304 29	0.3551 1896	0.6034 3098	0.5859 2900	1.0000 4075		
Mo Number	0.4858 512	0.5304 224	0.5041 472	0.8297 19	0.6681 601	0.5271 447	0.5371 435	0.4984 387	1.0000 1099	
Hg Number	0.4642 1074	0.6163 407	0.4133 1021	0.6985 32	0.5680 1104	0.4599 1096	0.3121 989	0.3777 958	0.6247 355	1.0000 1910

(7) North part of Anilao (Co)

(8) Middlewest part of Gimaras Island (As)

In the abovementioned areas, (1), (2), (4), (5) have the relationship with high condensed cells.

3. Romblon Area

(1) West part of Sibuyan Island (Pb, Zn, As, Hg)

(2) Middle-north part~middle-south part of Sibuyan Island (Mn, Ni, Co)

(3) North part of Tablas Island (Hg)

In the abovementioned areas, (1), (2) have the relationship with high condensed cells.

4. Interpretation on the Data of Regional Survey

The compilation of the aeromagnetic map and the extraction of the lineaments from the landsat image analysis were carried out during the first fiscal year (1984) of the project. These materials had been prepared as a joint effort among ESCAP-CCOP, US Naval Oceanographic Office, JICA-ITIT of Japan and the MGB.

These data, as presented in this report, were plotted on 1/1,000,000 scale topographic maps (Attached map PL-4) and were analyzed in terms of its significance and relationship with the results of both the field and geochemical surveys.

4-1 Data on the Aeromagnetic Survey

The available aeromagnetic survey data covered only the Panay Area. The survey was conducted utilizing an airborne proton magnetometer. Flight operations involved coverage of N-S traverse lines spaced at 2.5 km and E-W tie lines spaced at 10 km at an altitude of 6000 barometric feet. The results have been compiled as IGRF Map (the International Geomagnetic Reference Field Map).

An examiantion of this map shows that the area of the Antique Range, west Panay area has fewer aeromagnetic anomalies than east Panay. This may mean that the magnetic susceptibility of the basement rock of the east Panay area which is the Sibara Foramtion consisting of basic pyroclastics is higher than the magnetic susceptibility of the basement complex of the Antique Range which is thought to be of oceanic crust materials.

An anomalous magnetic pair had also been recognized which consists of a low anomaly (-350 γ) at 13 km NNE of Iloilo City and a high anomaly (+200 γ) at 10 km E of the abovementioned place.

Such pairing arrangement is considered to indicate blind high magnetic materials below the surface.

Although the geological and geochemical data on this area are few since the anomalous area is blanketed over the Iloilo Basin, the mineral showings in Anilao and Santo Tomas situated at the northeastern part of the area correspond to the high-density area of Mn and Co.

Based on this relationship between the aeromagnetic anomalies and the geological/geochemical survey findings, mineralization is expected to exist in this area. In addition to this, the high anomalous area located 13 km SSW of Pilar and which more or less correspond to the Miocene Bavuso volcanics is near the high density cell of Mn and Mo. This, again is considered as indications of mineralizations.

4-2 Data on the Lineament from the Landsat Image Analysis (PL-5)

The areas of the high lineament densities are in northwest Masbate, west Panay, the Romblon Islands and south Tablas. In Masbate Is., the NE-SW system is prominent while in Panay Is., the system NNE-SSW from a NE-SW system is prominent. Both trends had been noted in Tablas Is.

The relationships between the geological structures of each island and these linesaments are as follows:

1) The NE-SW lineament system at northwest Masbate shows the thrust fault direction which pass through between the upper Oligocene Mandaon Formation and the Jurassic Boracay Formation. Movements associated with this fault system mainly control the block movement of west Masbate. The NW-SE lineament system near Uson Bay in the northern coast area parallels the Philippine Fault which passes at the northeastern portion of Masbate. The age of the lineament is thought to be Miocene.

2) The NE-SW lineament system in west Panay defines the trend of the ophiolite body which was thrusted over the western block of Panay Is. during Palaeocene – Eocene time. The axes of the thrust fault-related composite folds noted at the western block of Panay Is, also follow the same direction. The trend of the thrust fault responsible for the juxtapositioning and emplacement of the eastern block over the western block in the Panay region parallels the NNE-SSW lineament system. This fault zone parallels the Tablas Lineament which is believed to have migrated from the Buruanga Peninsula, northwest Panay and Tablas island to its present site. The tectonic movements responsible for these events are believed to span the period from Oligocene to Pleistocene.

3) The ENE-WSW lineament system at south Tablas defines the boundary line between the Miocene diorite and Tablas volcanics. It is considered to be the directions of fractures in the block. The NNE-SSW lineament system is parallel to the Tablas Lineament which migrated from the Tablas Is. up to its present site. The age of the formations of these lineaments is thought to be Plio-Pleistocene.

5. Relationship between Mineral Showings and Results of Geochemical Analysis

The relationships between the mineral showings investigated at the second year (1985), the third year (1986) and the results of geochemical survey are shown in Table-11.

The high density cells of Cu of cells average value are accompanied most closely with the minral showings. Secondary, the high desnity cells of Mn and Pb have the relationship with the mienral showings.

The high density cells of As, Mn, Ni and Co are accompanied with the mineral showings of Ni and Mn.

Table-11 Relationships between Mineral Showings and Geochemical Analyses

◎ > C rank or = Highly anomalous value
○ = D rank or = Probably anomalous value
– > 0

Area	Index No.	Evaluation			Grid Average Value- Univariate Analysis										High-pass Filtering Value-Univariate Analysis										Grid Value Multivariate Analysis		
			Mineral Showing	Kind of Ore	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg	Cu	Pb	Zn	Ag	As	Mn	Ni	Co	Mo	Hg	1st Factor	2nd Factor	3rd Factor
Masbate	2	A	Aroroy Mine	Au	◎	–	○	–	◎	–	–	–	◎	–	–	○	–	–	○	–	–	–	–	–			◎
	3	D	Capsay	Au	○	–	–	–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–			◎
	34	D	Luya	Au	○	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	8	C	Concepcion	Au	◎	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	35	D	Matangiad	Cu	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	10	D	X.Y.Z (Maslate)	Au	◎	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	36	C	Handaic	Au	◎	◎	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	37	E	Baang	Au	◎	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	38	C	Marintoc	Au	○	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	39	D	Mt. Uac	Au, Cu, Pb	◎	◎	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	29	B	Dogosangan	Au, Cu, Pb	◎	◎	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	40	E	Nobangic	Mn	–	–	–	–	–	–	○	–	◎	–	–	–	–	–	–	–	–	–	–	–			◎
	41	E	Ayat	Mn	–	–	–	–	–	–	–	○	–	–	–	–	–	–	–	–	–	–	–	–			
	42	E	Taisan	Mn	–	–	–	–	–	◎	–	○	–	–	–	–	–	–	–	○	–	–	–	–			
	43	E	Calumpang	Mn	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	44	E	Balud	Mn	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
Panay	107	C	Quinabonglan	An	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	64	B	Pari	Cu, Au	◎	◎	–	–	–	○	–	–	–	–	◎	–	–	–	–	–	–	–	–	–	◎		
	66	B	Loay	Cu	◎	–	–	–	–	–	–	–	–	–	◎	◎	–	–	–	–	–	–	–	–	◎		
	108	D	Del Pilar	Cu, Mo	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	91	C	Santo Tomes	Au	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	106	C	Salvacion	Cu, Pb, Zn	○	–	–	–	◎	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	93	C	Anilao	Mn	–	–	–	–	–	◎	○	◎	–	–	–	–	–	–	–	–	–	–	–	–			
	109	D	San Antonio	Cu	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	110	C	Osman	Cu	–	–	–	–	–	–	◎	○	–	–	–	–	○	–	–	–	–	–	–	–			
	5	C	Panaktakan	Mn	–	–	–	–	◎	–	○	–	–	–	–	–	–	–	–	–	–	–	–	–			
	6	D	Tagororoc	Mn	–	–	–	–	◎	–	○	–	–	○	–	–	–	–	○	–	–	–	–	–			○
	111	D	Ibaniac	Mn	–	–	–	–	◎	◎	○	–	–	–	–	–	–	–	–	○	–	–	–	–			
Romblon	15	D	Caloring	Cu	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	16	D	Cogon	Cu	◎	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–			
	17	D	Nailog	Cu, Pb, Zn	–	◎	◎	–	◎	–	◎	–	–	◎	–	◎	–	–	–	–	–	–	–	–			○
	18	E	'Bato	Ni	–	–	–	–	–	○	◎	◎	–	–	–	–	–	–	–	–	◎	–	–	–			
	19	D	Binaya-an	Ni	–	–	–	–	–	–	◎	◎	–	–	–	–	–	–	–	–	◎	–	–	–			

6. CONCLUSION AND RECOMMENDATION

6-1 Summary of the Consolidated Work

6-1-1 Geology and Structure

The subject areas of this consolidated evaluation are the Masbate, Panay and Romblon Area. These areas are located in the central portion of the Visayan region. The left-lateral NW trending Philippine Fault passes in the northeastern part of this region.

On the basis of regional tectonic settings, the Masbate, east Panay, Sibuyan Island and Romblon Island regions belong to a volcano-plutonic arc. Diorite intrusives and andesite extrusives are known in the west Negros-east Panay Is.-west Masbate Is. The western part of the Antique Range and Tablas Is., Romblon Area are thought to be made up of oceanic and continental crusts. Crystalline schists, limestones and cherts form the basement formation of this tectonic block.

The north-south trending Iloilo Basin in Panay Is. is located between the two tectonic regions. Thick sediments occurred in this basin after the Miocene period.

NNE-SSW trending geologic structures are dominant in this area. Thrusting of the eastern block over the western block and the different intrusive bodies in the area manifest the same direction. The lithologies in west Masbate and west Panay areas are basically Paleogene in age.

The diorite and andesite bodies were intruded/extruded respectively along this fracture zone in the form of two rows during Miocene. The hornblende andesite erupted in west Masbate and east Panay areas in Plio-Pleistocene time seems to be the youngest igneous rock unit in the area.

The Pliocene lateral fault is also thought to have migrated to its present position in Buruanga Peninsula and Tablas Is. (Romblon Area) and follows the general direction of the NNE-SSW fracture zone of the area.

6-1-2 Mineralization

Except for the pre-Tertiary sedimentary manganese deposits, the mineralizations in the area are related to the post-Tertiary intrusive rocks. The following mineralizations had been encountered:

* Gold-bearing quartz veins in the southern part of Aroroy, Masbate Is.;
* Cupriferous massive sulfides in the northeastern part of San Jose, southwest Panay Is.:
* Nickeliferous laterite type deposits in Antique Range and Sibuyan Is. (Romblon Area).

The gold-mineralization in the Aroroy area is considered to be related to the extrusion of the Plio-Pleistocene hornblende andesite body. Placer gold consentration had in fact been recognized near hornblende andesite stocks in the eastern part of Panay Is. On the basis of the results of analyses from the present survey, a new deposit may be discovered within the vicenity of the abovementioned area.

6-1-3 Consolidated analysis of the geochemical survey

A consolidated analysis of the geochemical results gathered during the Phase II (1985) and Phase III (1986) surveys was carried out. The whole survey area was divided into cell units with each cell having the dimensions 2 km (east-west) by 2 km (north-south).

Four types of statistical analyses were performed which formed the basis in selecting the most promising mineralized areas. These statistical analyses are:

1) Univariate analysis of "cell average" from the arithmetic average of the analytical results in each cell sample;

2) Univariate analysis of the "moving average". This average value is the central cell value which is the average value of the nine cells;

3) Univariate analysis of the high-pass filtering value. This high-pass filtering value is the difference between each cell average and the moving average;

4) Multivariate analysis (factor analysis) of each cell average value.

In order to observe the wide-area element distribution, samples from the Masbate, Panay, Romblon, Leyte, Cebu, Bohol, Dinagat and west Negros areas had been statistically treated utilizing the first three abovementioned methods. A total of 24,456 samples equivalent to 8,716 cells form the population of the analyses.

A total of 10,465 samples from the Masbate, Panay and Romblon Areas equivalent to 3,840 cells had been treated using the fourth statistical method mentioned above.

6-1-4 Analysis of Regional Geophysical Data

1 **Aeromagnetic Survey Data**

There are aeromagnetic survey data in the Panay Area only. The data were studied by IGRF (The International Geomagnetic Reference Field Map).
The following things became clear after the study of the geophysical data:
The magnetic susceptibility of the Antique Range, Panay Is. is lower than the susceptibility of the east Panay Is. The basement formation of the former is thought to be of oceanic crust material while that of the latter is of basic pyroclastics.

The following magnetic anomalies had attracted interest:

1) The distribution of a high and low anomally pair located in a place 13 km northeast of Iloilo City;

2) A high anomaly showing located in a place 13 km south-southwest of Pilar.

It is expected that these anomalies are related to mineralizations.

2) Lineament Data (Landsat Image Analysis)

Numerous lineaments had been noted distributed in the Masbate, west Panay and Tablas Is. areas. These lineaments usually assume NNE-SSW and NE-SW directions. These trends define the fracture zone and related sub-fault/folding axes directions. Both structures are considered to be diagonal joints.

6-1-5 Conclusion

After a thorough consideration of all the available informations as mentioned above, several promising mineralized areas had been recognized and selected and is hereby presented according to the order of priority:

1) Overlapping condensed area of Cu, Pb, Ag and Hg in the east side of Mt. Uac, central Masbate area. This area coincide with the area of distribution of the upper Miocene Lamon andesite. Strong hydrothermal alteration (e.g. chloritization) had been noted in this andesite body. Mineral showings have been recognized in the surrounding areas which include the Baang. Malintog, Mt. Uac and Dagosangan areas. Au and Ag deposits are expected to be present.

2) Overlapping condensed area of Cu, Pb and Mn in the southern portion of Pilar, northeast Panay Is. In this area, the Miocene Bavuso volcanics intruded into the Palaeocene Sibara Formation. Old mines such as Pari and Loay are known to exist in this area. The presence of Cu deposits are highly expected.

3) Overlapping condensed area of Cu, Pb and As in the southern part of Aroroy, north Masbate Is. The basement formation in this area is the Paleogene Mandaon Formation. This area is also covered by the upper Miocene Lanaang Conglomerate. Small stocks of Pliocene Mt. Nabongsoran andesite porphyry intruded the abovementioned formations.

The abovementioned andesite serve as host country rocks to mineralizations. Dominant type of mineralization is the gold – bearing quartz vein deposits usually observed accompanying storongly silicified zones. Mineral showings had been encountered in Aroroy Mine, Capsay, Luna and Concepcion. Au and Ag deposits are expected to be present.

4) Overlapping condensed area of Cu, Pb, Ag and Co in the northeastern part of San Jose, southwest Panay Is. The upper Miocene-lower Pliocene Lagdo Formation unconformably covers the Eocene ophiolite in this area. UNDP surveys had shown that cupriferous massive sulfide deposits associated with the ophiolite had been encountered here.

5) Overlapping condensed areas of Ni and Co in the southern and northern parts of Antique Range, Panay Is. and the central part of Sibuyan Is., Romblon Area. Ultramafic and mafic rocks are distributed chaotically in these areas. Nickel deposits which are laterite-related are expected to be present.

6) Condensed area of Cu in the northeast Tibiao, west coast Panay Is. Miocene Pacol diorite intrude into lower Miocene Mt. Baloy volcanics northernside of the condensed area. Several mineral showings are known northern portion of Pacol diorite body, but in this condensed area mineral showing is unknown. Copper vein type deposits are expected.

6-2 Recommendations

Six additional promising mineralized areas had been selected after analyzing all the available informations. An exploration program is hereby recommended which may be implemented in the near future as a follow-up survey in the recognized mineralized areas.

1) Detailed geological, geophysical and geochemical surveys in the selected promising areas. Geochemical survey: Systematic soil sampling in a 200 m order grid.

2) Drilling of selected targets which may be based on the findings of the abovementioned detailed surveys.

References

Bureau of Mines and Geo-Sciences (1982): Geology and Mineral Resources of the Philippines, Vol. One, Two

A.H.G. Mitchell et al (1986): Cenozoic evolution of the Philippine Archipelago, Journal of Southeast Asian Earth Sciences, Vol. No.1, pp. 3-22

Hashimoto Wataru, Sato Tadashi (1968-1969): A Contribution to the Study of Geologic Sturcture of the Philippines, Journ Geogr., Tokyo Geogr. Soc., LXXVII (763), 68-116 LXXVIII (771), 235-270

Hashimoto Wataru (1969): Paleontology of Philippines, Geology and Paleontology of Southeast Asia, Vol. 6, p. 293-329

W.G. Digor, A.M. Matos: Tectonic Implication of the RP-Japan Project Area Part 1 (Unpublished)

N.Q. Baybayan, A.M. Matos: Geology of masbate Island, Central Philipines (Unpublished)

Edwin Caliboso: Geology of Romblon Island Group (Unpublished)

S.D. David Jr.: Geology of Panay Island (Unpublished)

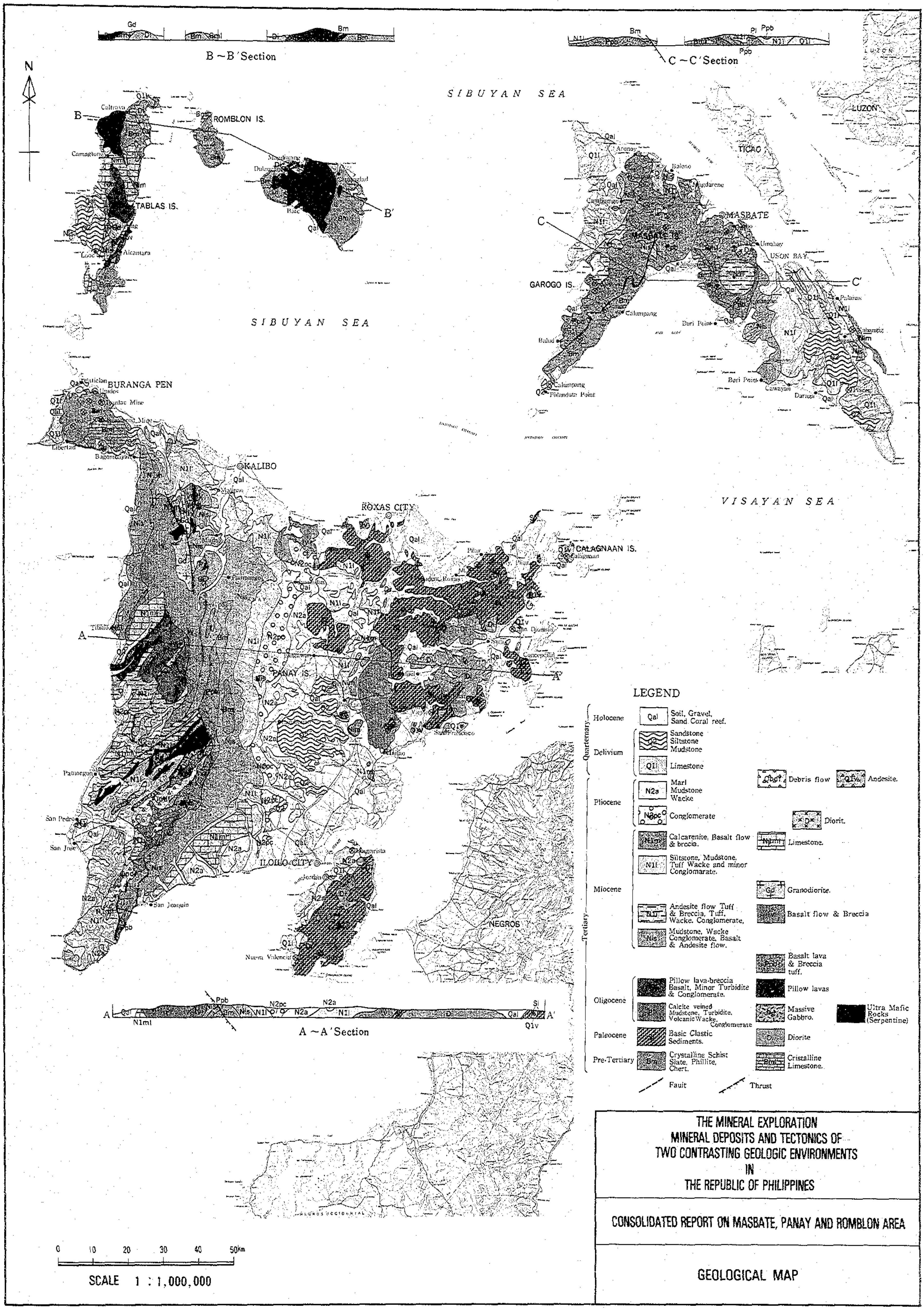
United Nations Development Program (1986); Technical Report No. 8, Geology of Southwest Panay.

JICA /MMAJ (1985): Report on the Mineral Exploration, Mineral Deposits and Tectonics of Two Contrasting Geologic Environments in the Republic of the Philippines, PHASE II

JICA /MMAJ (1985): Report on the Mineral Exploration, Mineral Deposits and Tectonics of Two Contrasting Geologic Environments in the Republic of the Philippines, PHASE III

ATTACHED PLATE

PL-1 Consolidated Geological Map and Section (1/1,000,000)


B ~ B′ Section
C ~ C′ Section
SIBUYAN SEA
ROMBLON IS.
TABLAS IS.
LUZON
TICAO
MASBATE
USON BAY
GAROGO IS.
SIBUYAN SEA
BURANGA PEN
KALIBO
ROXAS CITY
VISAYAN SEA
CALAGNAAN IS.
PANAY IS.
ILOILO CITY
NEGROS
A ~ A′ Section
LEGEND
Holocene
Qal Soil, Gravel, Sand Coral reef.
Quaternary
Delivium
Sandstone Siltstone Mudstone
Q1l Limestone
Debris flow
Andesite.
Pliocene
N2a Marl Mudstone Wacke
N2pc Conglomerate
Diorit.
Calcarenite, Basalt flow & breccia.
Limestone.
N1l Siltstone, Mudstone, Tuff Wacke and minor Conglomarate.
Miocene
Granodiorite.
Tertiary
Andesite flow Tuff & Breccia, Tuff, Wacke, Conglomerate,
Basalt flow & Breccia
Mudstone, Wacke Conglomerate, Basalt & Andesite flow.
Basalt lava & Breccia tuff.
Oligocene
Pillow lava-breccia Basalt, Minor Turbidite & Conglomerate.
Pillow lavas
Calcite veined Mudstone, Turbidite, Volcanic Wacke, Conglomerate
Massive Gabbro.
Ultra Mafic Rocks (Serpentine)
Paleocene
Basic Clastic Sediments.
Diorite
Pre-Tertiary
Bm Crystalline Schist Slate, Phillite, Chert.
Cristalline Limestone.
Fault
Thrust
THE MINERAL EXPLORATION
MINERAL DEPOSITS AND TECTONICS OF
TWO CONTRASTING GEOLOGIC ENVIRONMENTS
IN
THE REPUBLIC OF PHILIPPINES
CONSOLIDATED REPORT ON MASBATE, PANAY AND ROMBLON AREA
GEOLOGICAL MAP
0 10 20 30 40 50km
SCALE 1 : 1,000,000