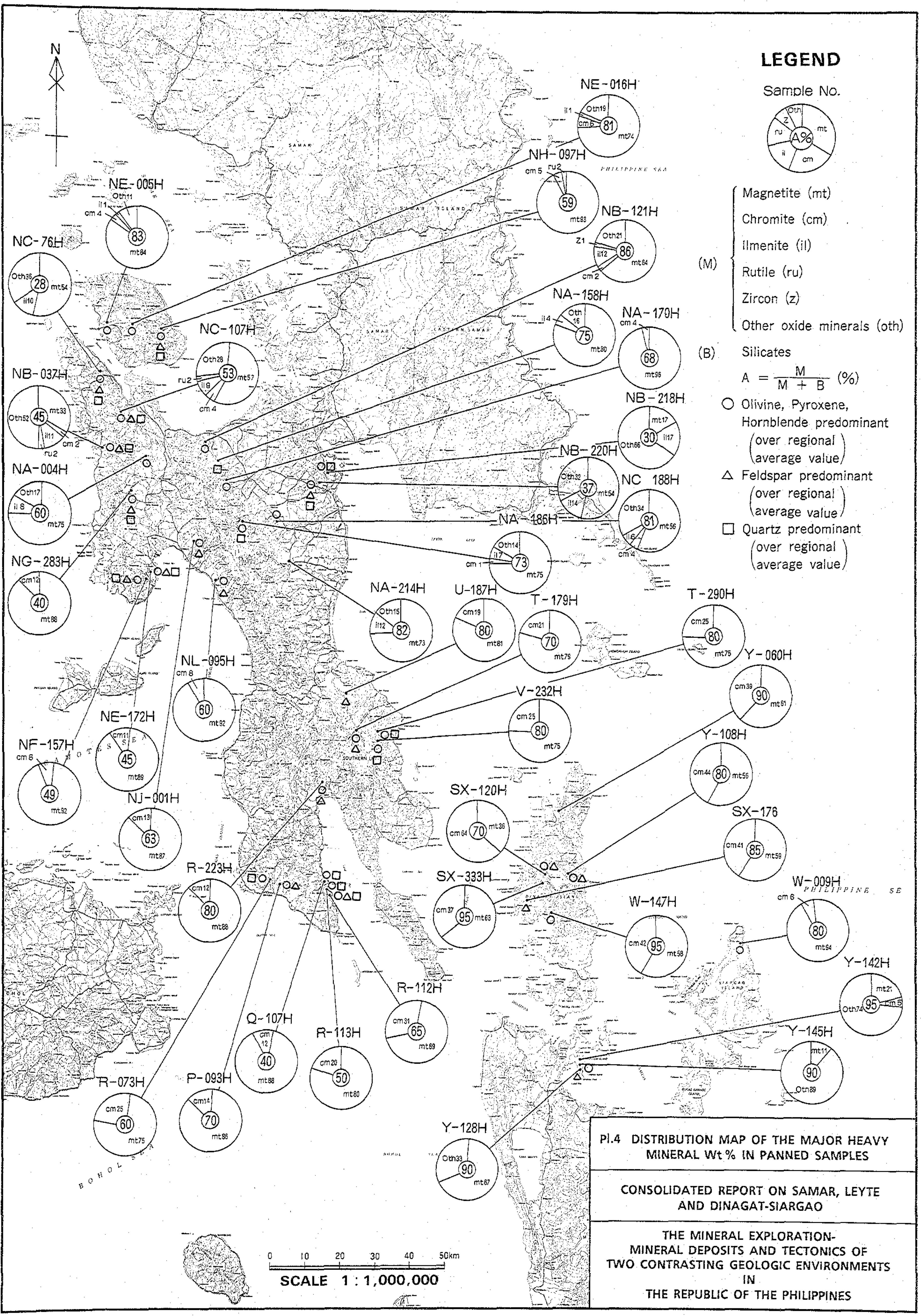

Pl.4 DISTRIBUTION MAP OF THE MAJOR HEAVY MINERAL Wt % IN PANNED SAMPLES

CONSOLIDATED REPORT ON SAMAR, LEYTE AND DINAGAT-SIARGAO

THE MINERAL EXPLORATION-
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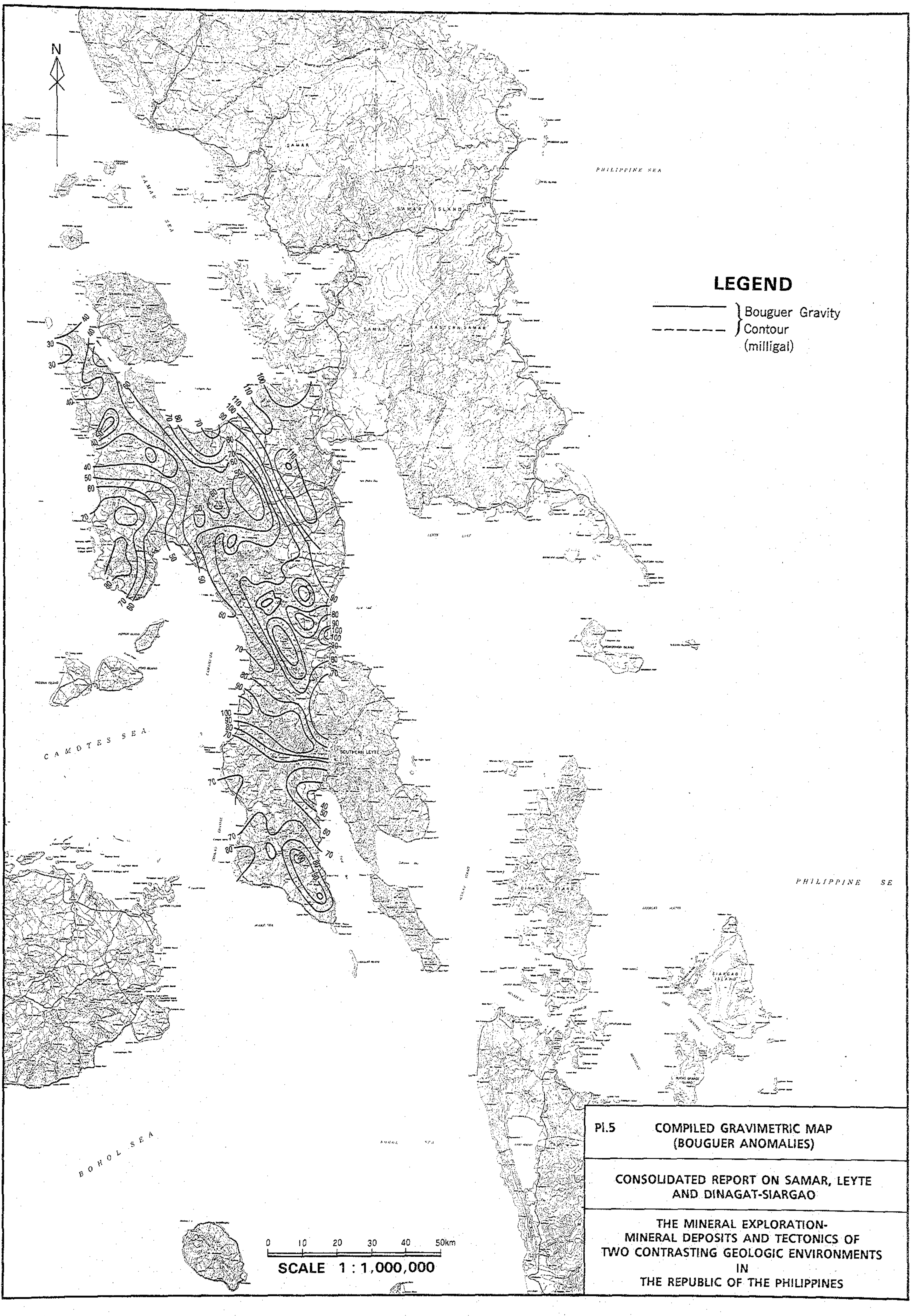

Pl.5 COMPILED GRAVIMETRIC MAP (BOUGUER ANOMALIES)

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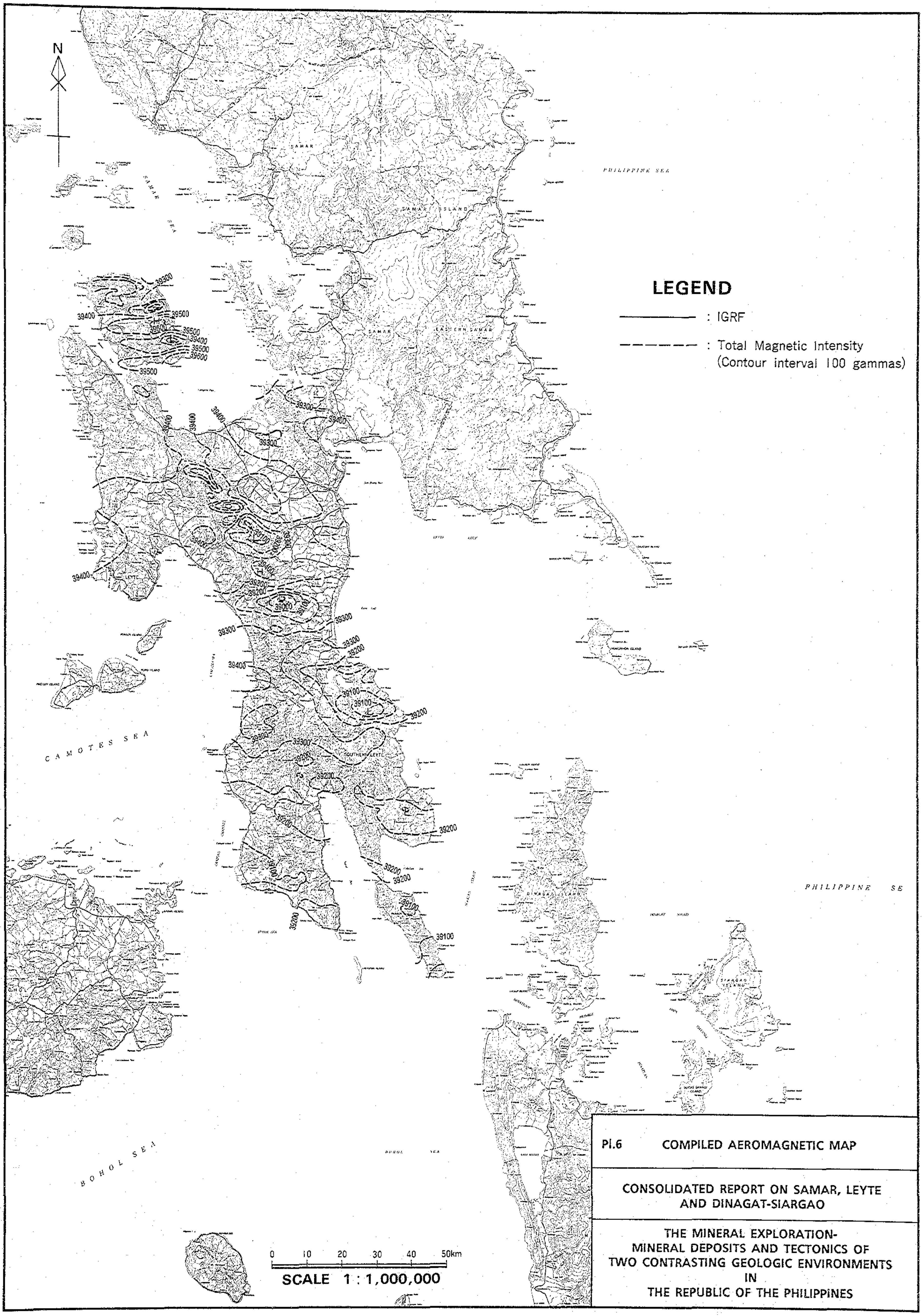

Pl.6 COMPILED AEROMAGNETIC MAP

CONSOLIDATED REPORT ON SAMAR, LEYTE
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MINERAL DEPOSITS AND TECTONICS OF
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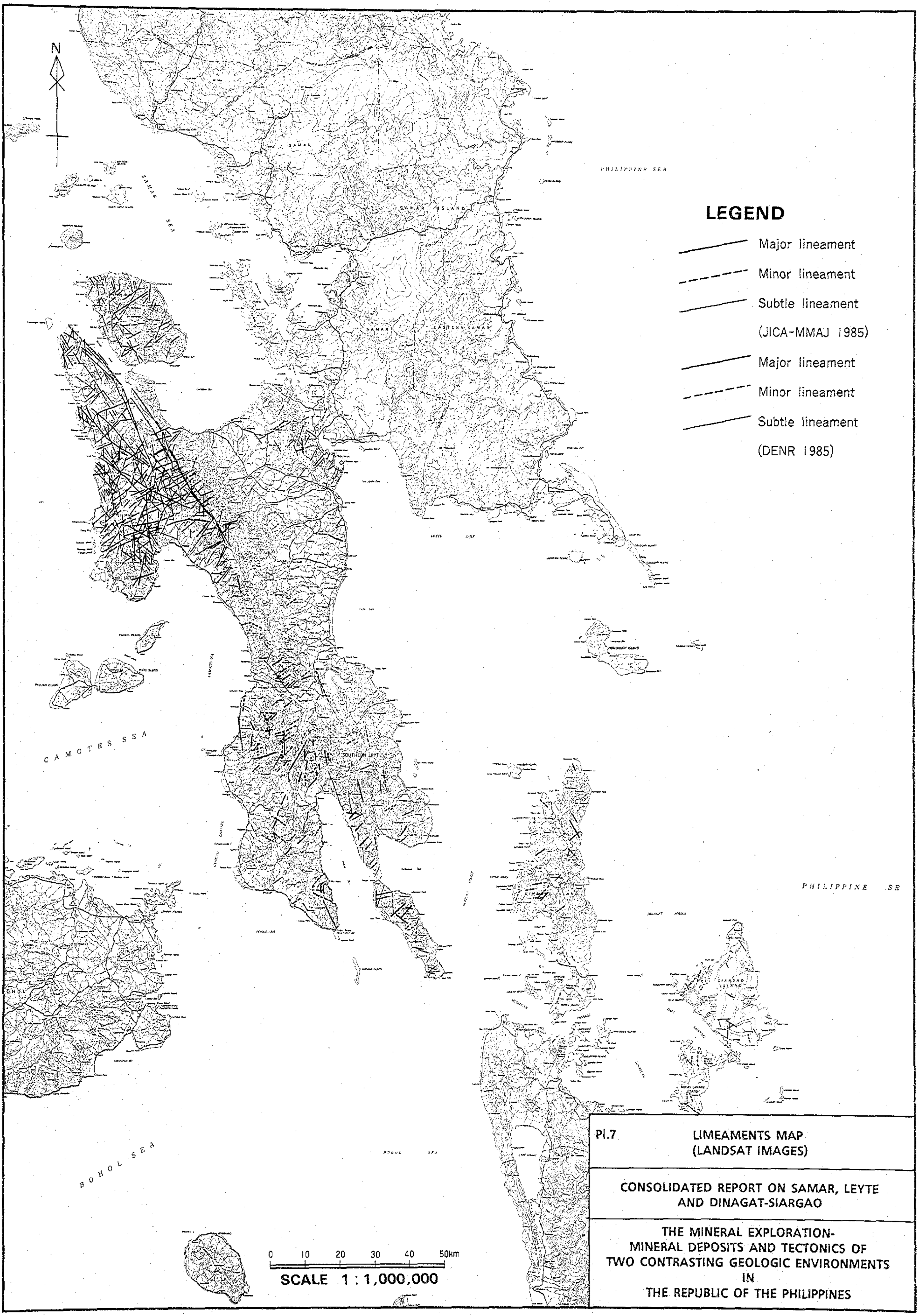
THE REPUBLIC OF THE PHILIPPINES



Pl.7 LIMEAMENTS MAP
(LANDSAT IMAGES)

CONSOLIDATED REPORT ON SAMAR, LEYTE
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Index Table of Mineral Showings

Leyte Island

Metallics

6.	Pas-ay	Au
8.	Bitun	Au, Cu
10.	Hiunangan	Fe
11.	Tolosa	Fe
12.	Hiunangan	Fe
14.	MacArther	Fe
15.	Abuyog	Fe
16.	Lambonao (Mt. Bagacay)	Au
17.	St. Rafael	Ni
18.	Tigbawan	Ni
19.	Hinambangan	Ni
21.	Balagawan	Au
22.	Sumuhi (Ingan)	Au, Cu, Mn
23.	Sogod	Au, Cu
24.	Pulta, Hilongos	Cu
25.	Bagacay, Tacloban	Cu
29.	Silago	Fe
30.	Pun Punan	Mn
40.	Pulta, Hilongos	Cu
41.	Cura-jo, Caiba-an, Tacloban	Cu
43.	Bay Bantawan, St. Bernard	Au
46.	Antipolo, Jaro	Ni
47.	San Jose, Tanauan	Fe
48.	Caibaan	Cu
50.	Suhi	Cu
51.	Pinut-an	Au
52.	Anilao	Cu

Nonmetallics

9.	Mapula	S
26.	Liberty, Ormoc City	Peat
31.	Balite, Villaba	Asp
32.	Balite, Villaba	Asp
33.	Biliran	S
49.	Ormoc	Bnt

Dinagat and Siargao Islands

Metallics

1.	Bel (Talisay)	Cr
2.	Mt. Redondo (Masdang)	Cr
3.	Cliff-Kalanungan	Fe, Ni
4.	Tubajon	Fe, Ni
5.	Libjo (Velore)	Cr
6.	Northern Maliano-Mabini	Fe, Ni
7.	Gaas-Southern Maliano	Fe, Ni
8.	Boa-Valencia	Fe, Ni
9.	Tagabaga-Paniog	Fe, Ni
10.	Lutawon Basin	Al
11.	Nonoc	Ni, Co
12.	Siargao Is.	Mn
13.	Redondo	Cr
14.	Tagbaboy	Cr
15.	Cangmod	Au
16.	Avelina	Cr

LEGEND

Deposit

metallic	nonmetallic	
◎	◬	: Operating mine
○	△	: Explored, Developed, Prospect or Indication

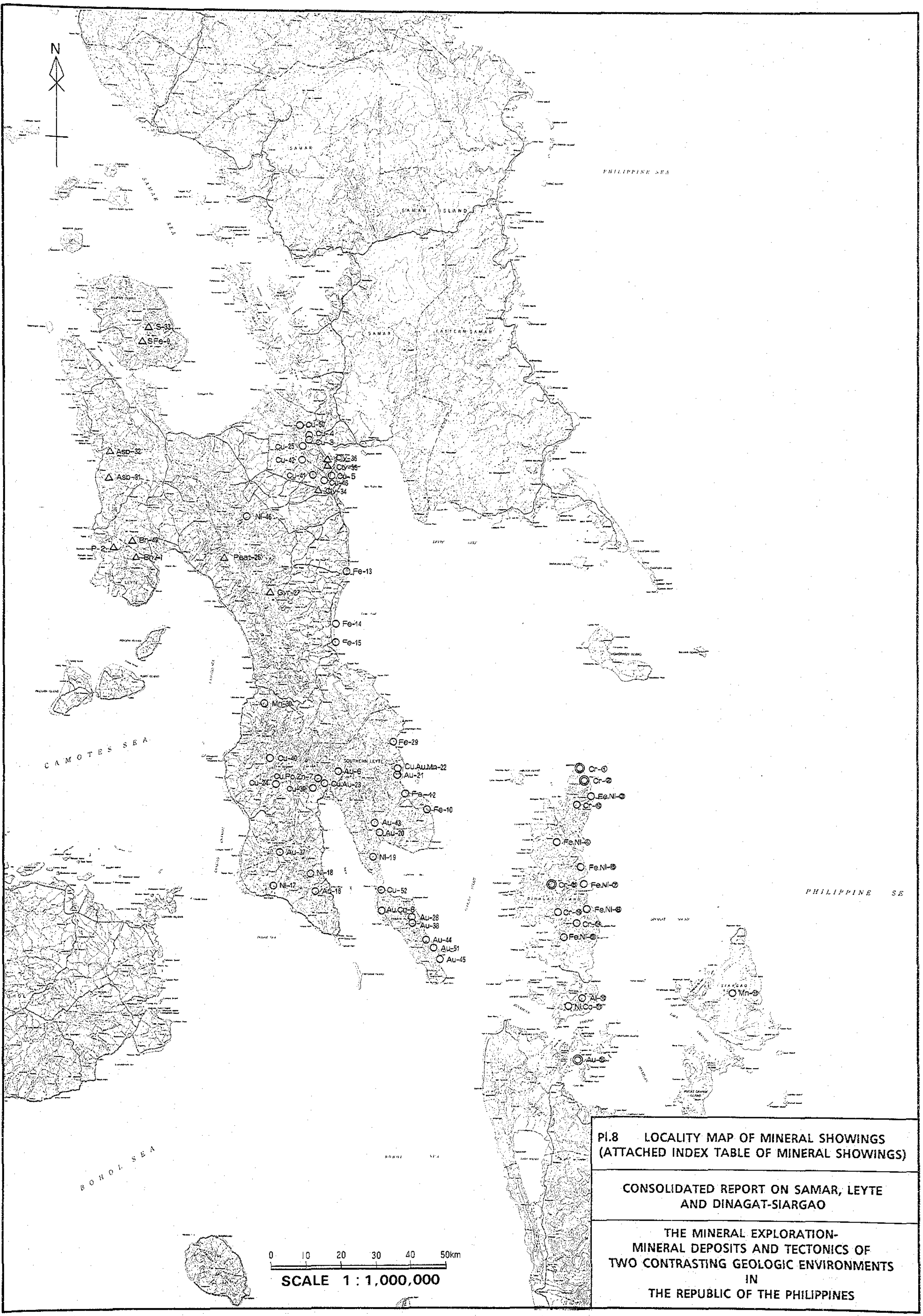
Symbols

metallic

Au : Gold
Ag : Silver
Al : Aluminum
As : Arsenic
Bax : Bauxite
Cu : Copper
Co : Cobalt
Cr : Chromite
Fe : Iron
Hg : Mercury
Mn : Manganese
Mo : Molybdenum
Ni : Nickel
Pb : Lead
Sb : Antimony
Sn : Tin
U : Uranium
W : Tungsten
Zn : Zinc

nonmetallics

Asb : Asbestos
Asp : Asphalt
Bar : Barite
Bnt : Bentonite
Cly : Clay
Coal : Coal
Dia : Diatomaceous Earth
Dol : Dolomite
Fd : Feldspar
Fl : Flourite
Gn : Guano
Gnp : Guano-Phosphate
Gr : Granite
Gyp : Gypsum
Ls : Limestone
Mbl : Marble
P : Phosphate
Peb : Pebble
Peat : Peat
Per : Perlite
Py : Pyrite
S : Sulfur
Sh : Shale
Si : Silica
SiS : Silica Sand
SS : Sandstone
Tlc : Talc



Pl.8 LOCALITY MAP OF MINERAL SHOWINGS
(ATTACHED INDEX TABLE OF MINERAL SHOWINGS)

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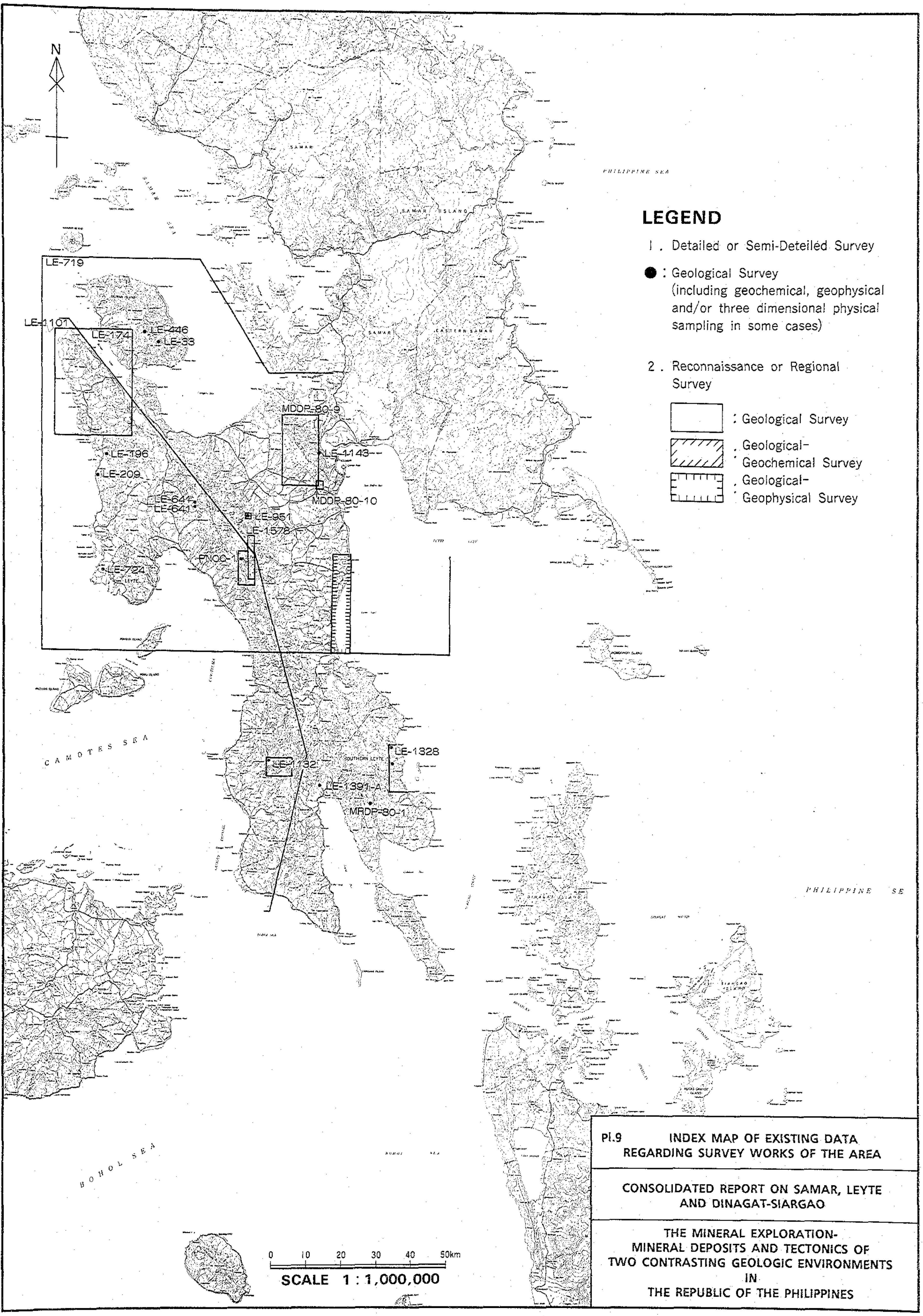

Pl.9 INDEX MAP OF EXISTING DATA REGARDING SURVEY WORKS OF THE AREA

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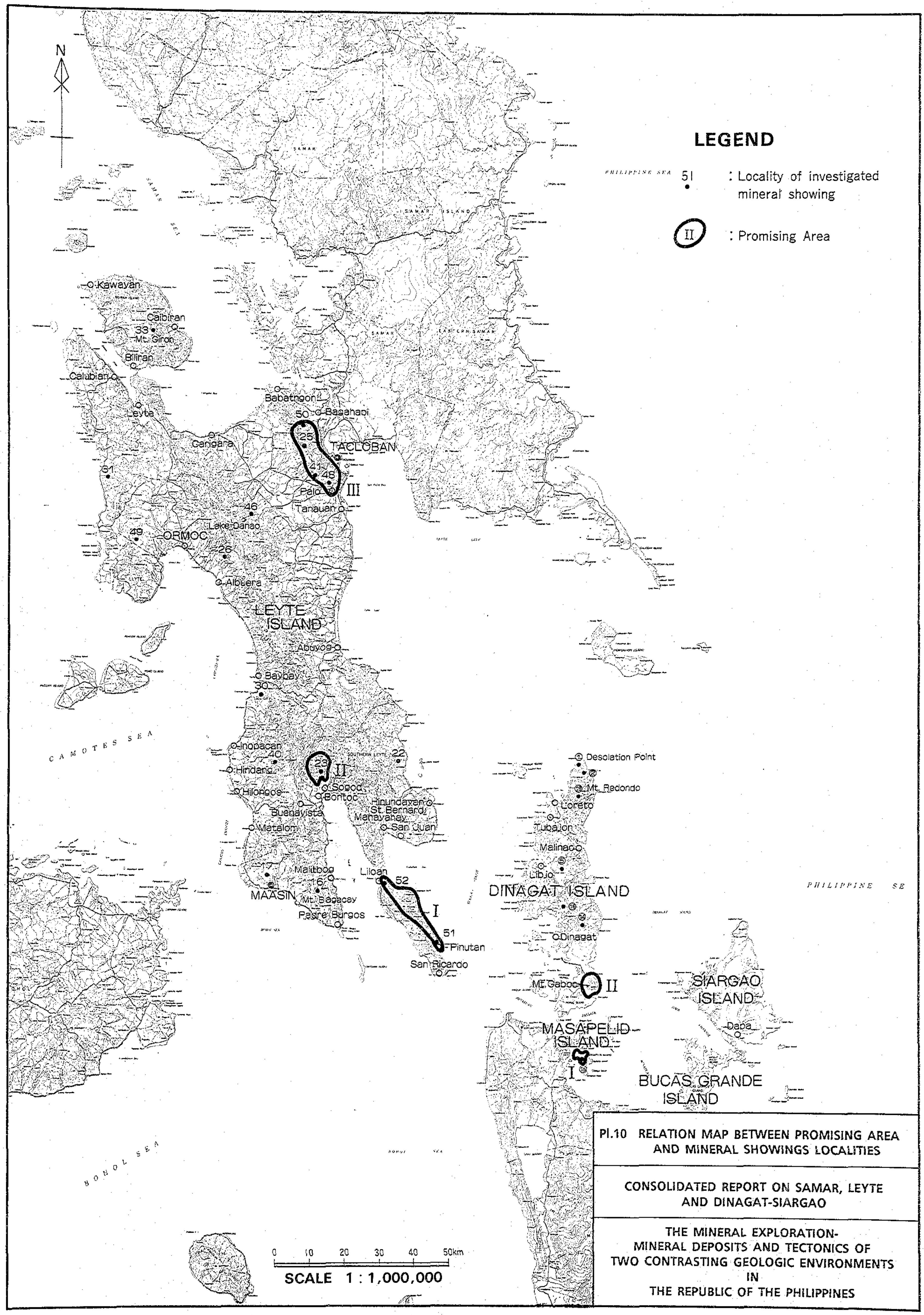

Pl.10 RELATION MAP BETWEEN PROMISING AREA AND MINERAL SHOWINGS LOCALITIES

CONSOLIDATED REPORT ON SAMAR, LEYTE AND DINAGAT-SIARGAO

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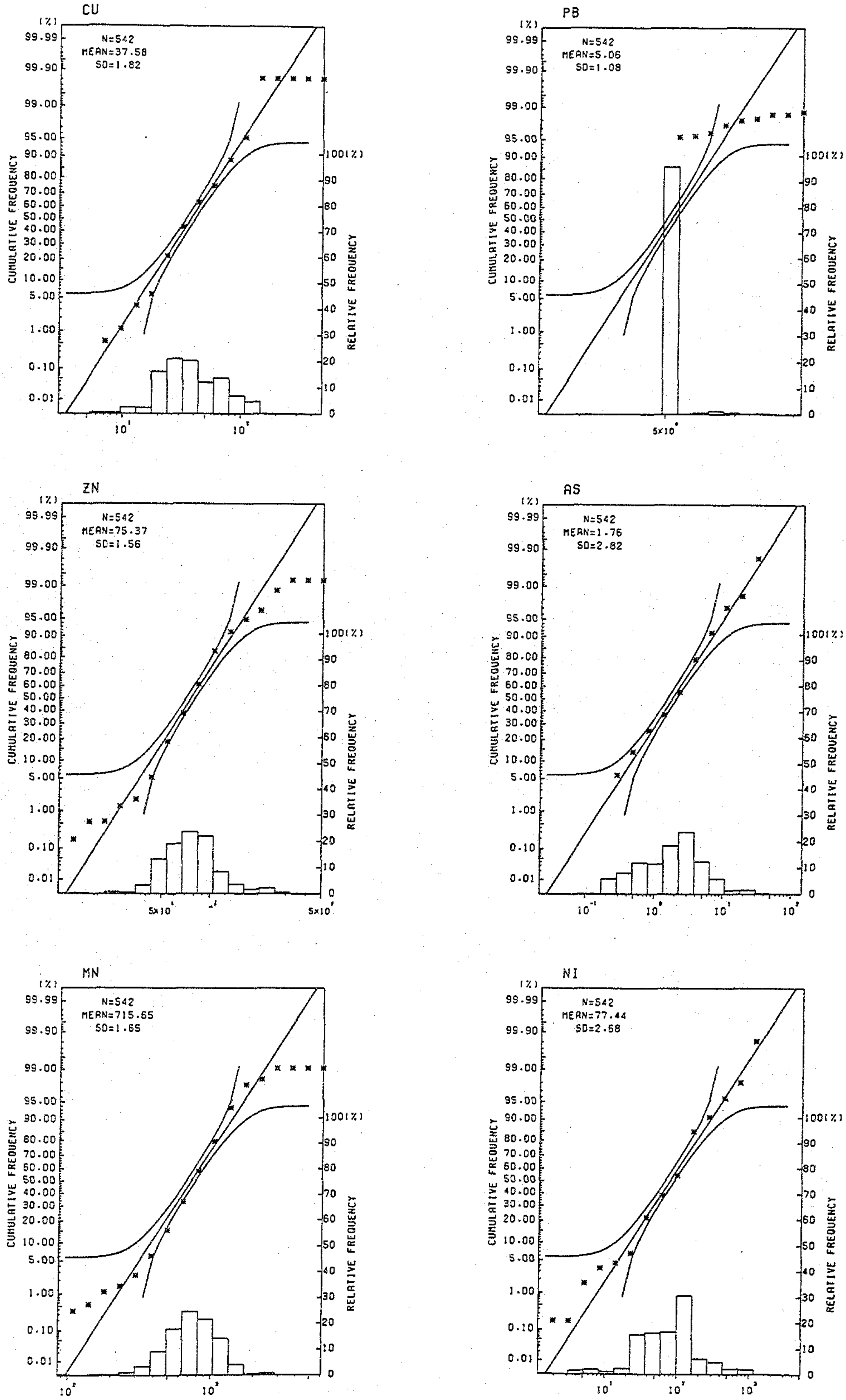
Appendix 1 Histograms and Cumulative Frequency Curves of Cell Average Values

Appendix 2 Flow Charts of Chemical Analysis

Appendix 3 List of Existing Data

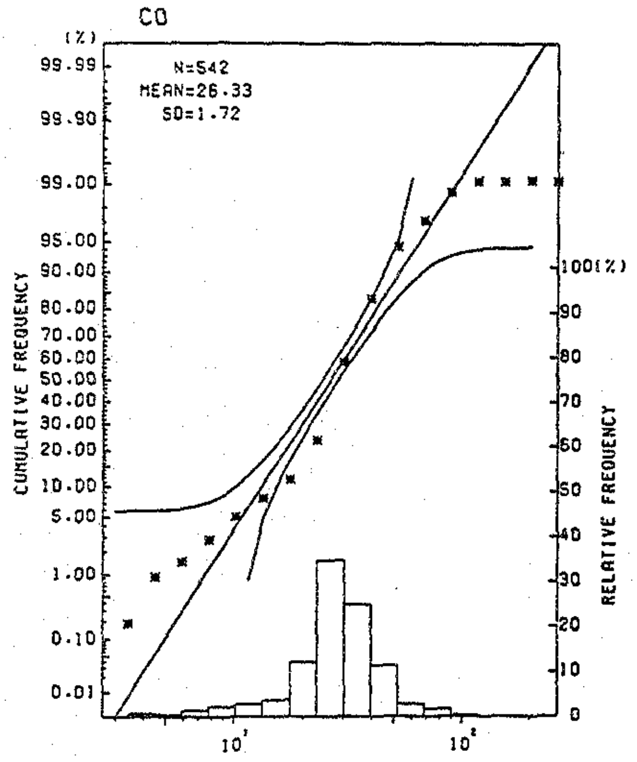
Appendix 1-1 Histogram and Cumulative Frequency Curves of Cell Average Values

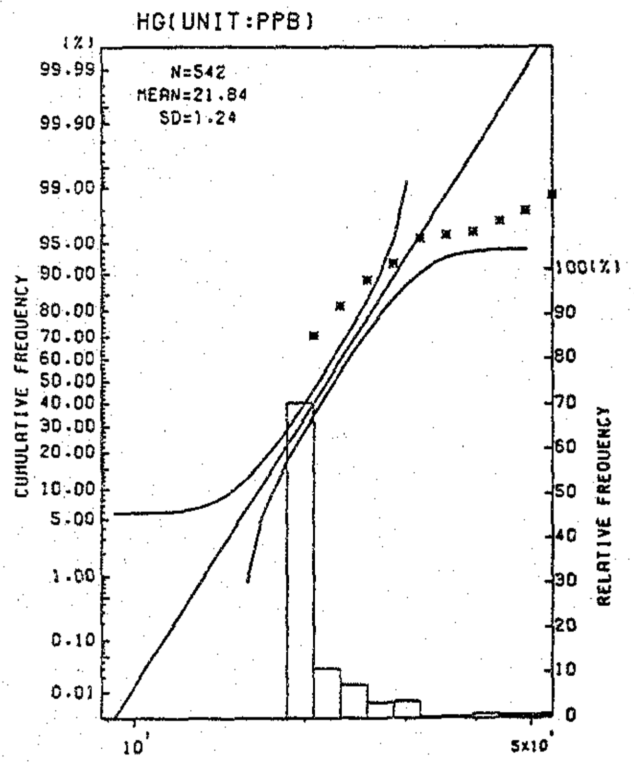
(Samar 1)

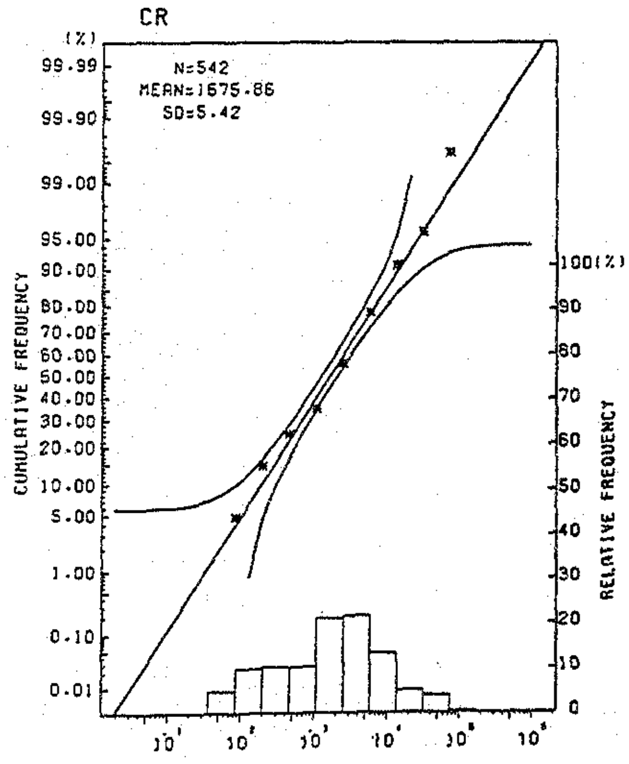


Appendix 1-1 Histogram and Cumulative Frequency Curves of Cell Average Values

(Samar 2)

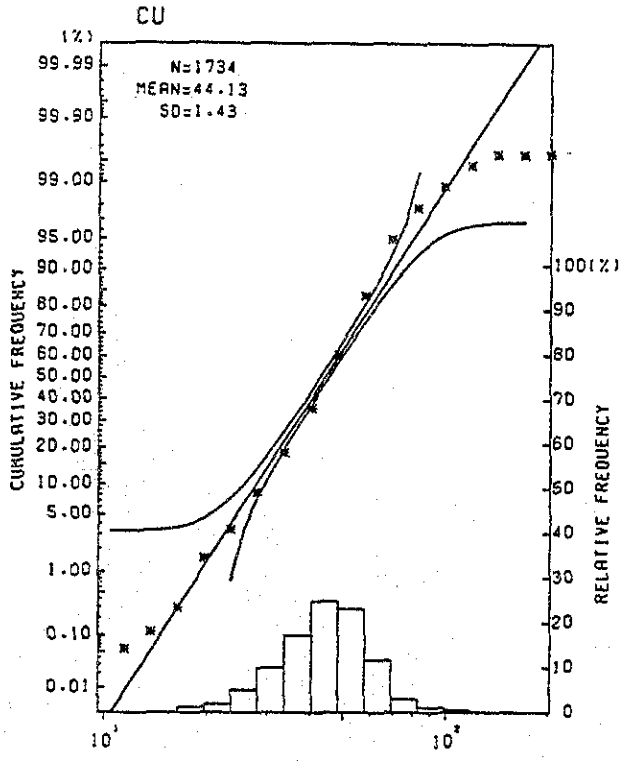


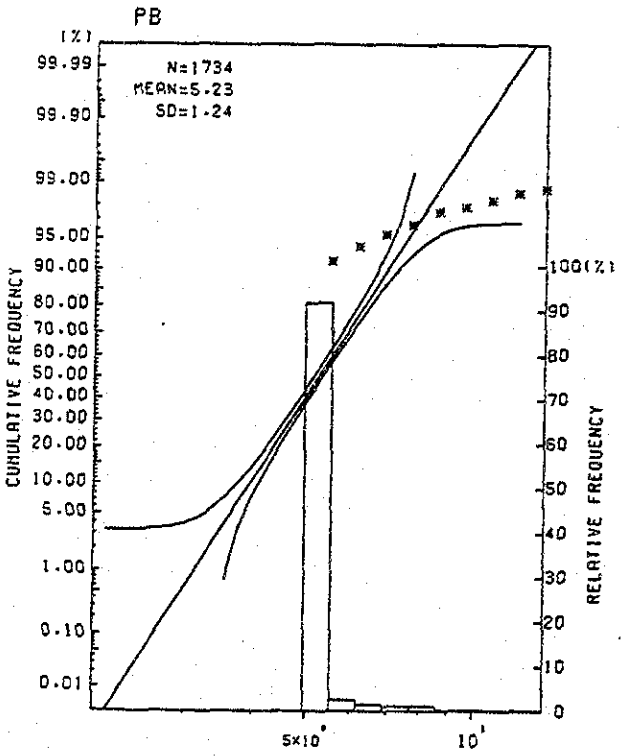


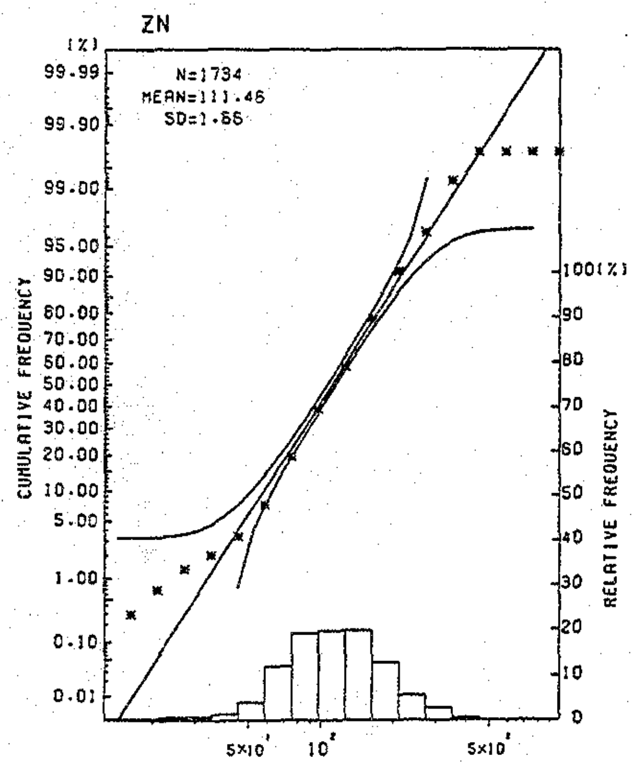


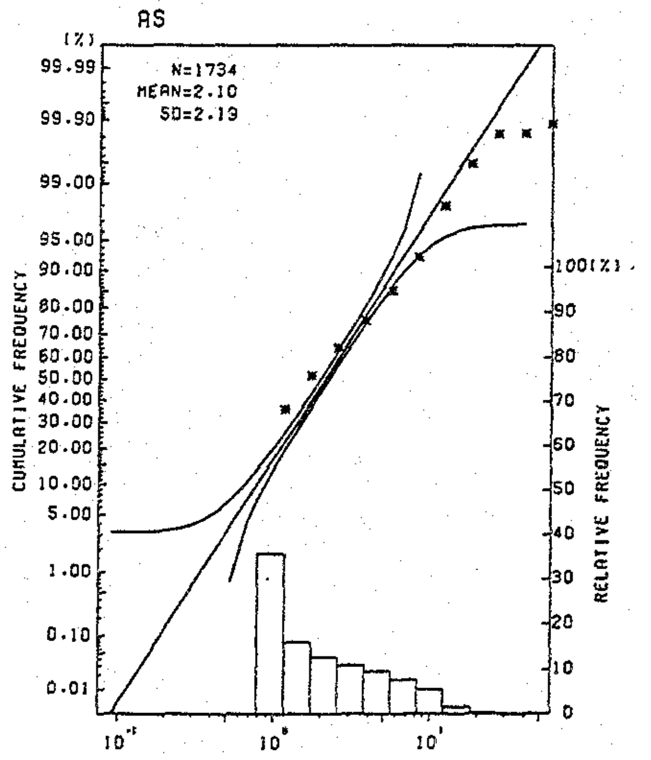
Appendix 1-2 Histogram and Cumulative Frequency Curves of Cell Average Values

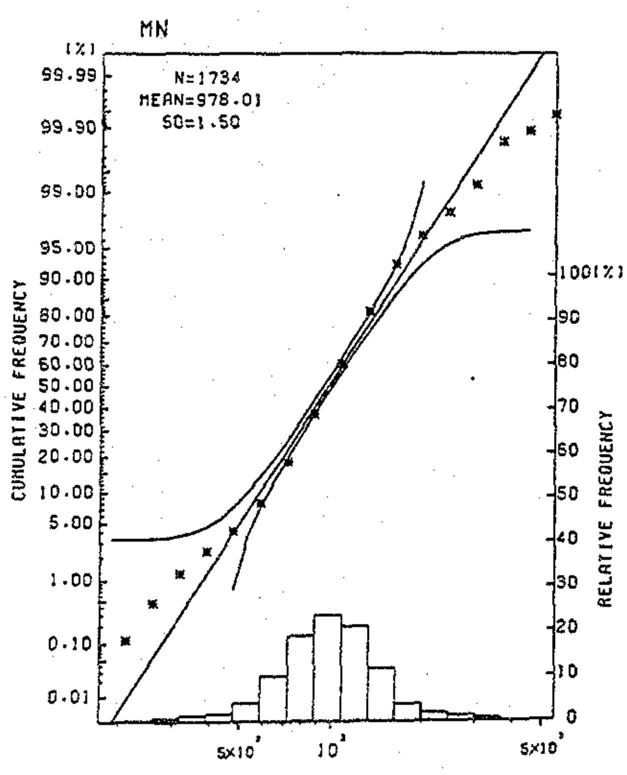
(Leyte 1)

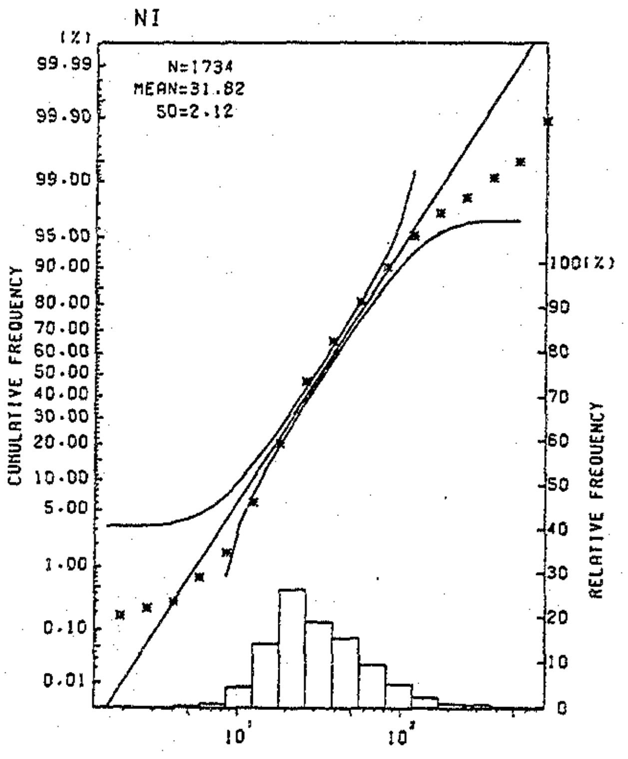






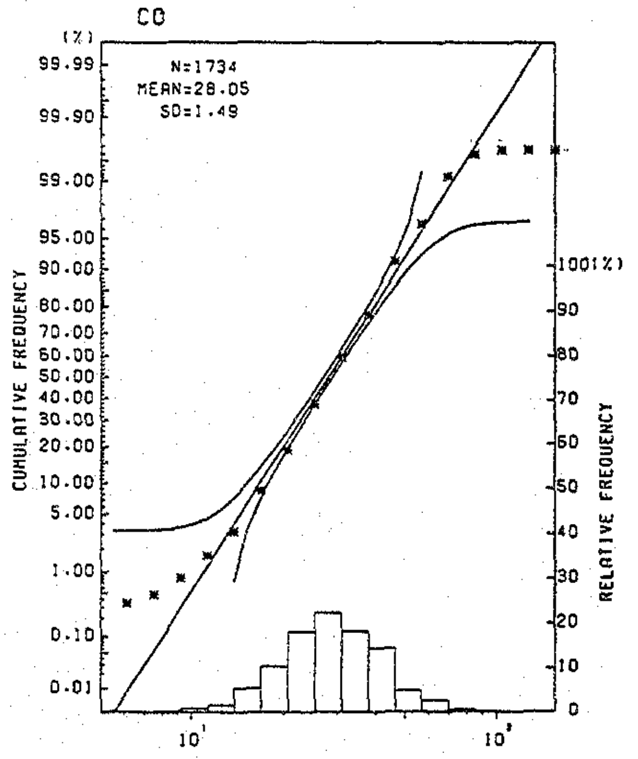


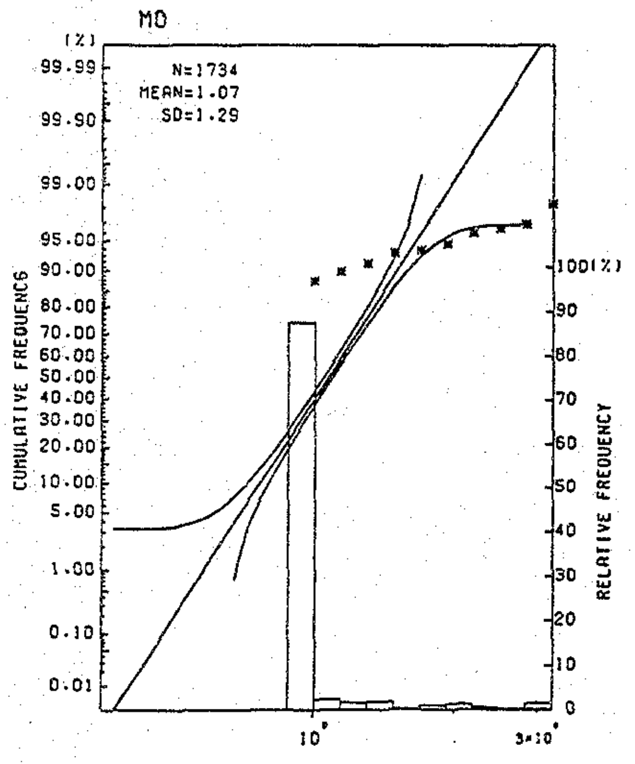


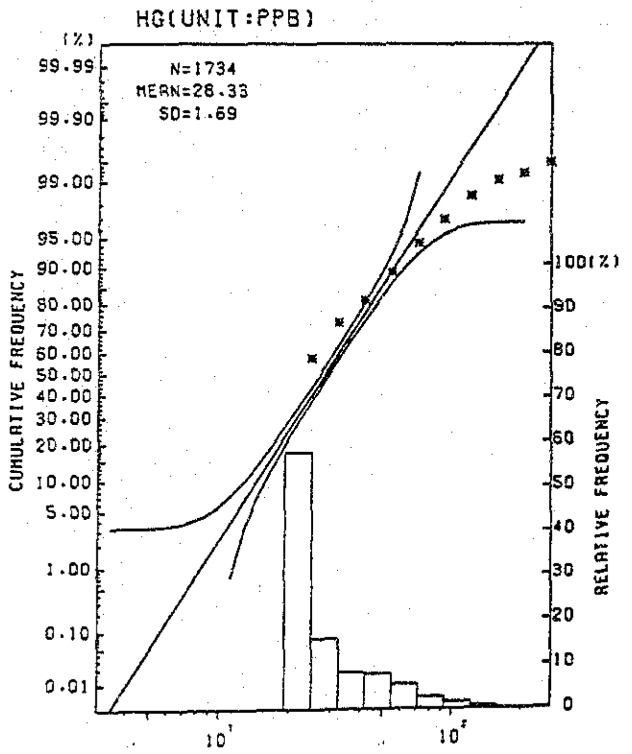


Appendix 1-2 Histogram and Cumulative Frequency Curves of Cell Average Values

(Leyte 2)

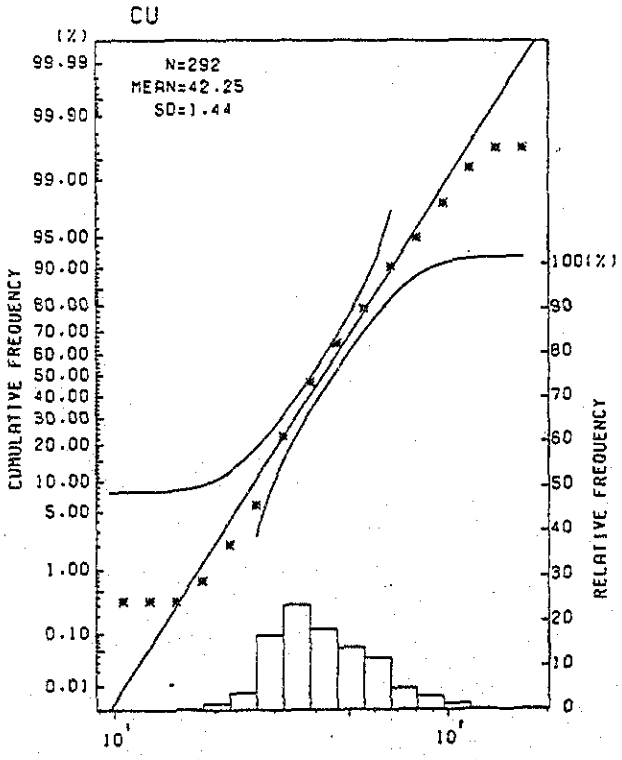


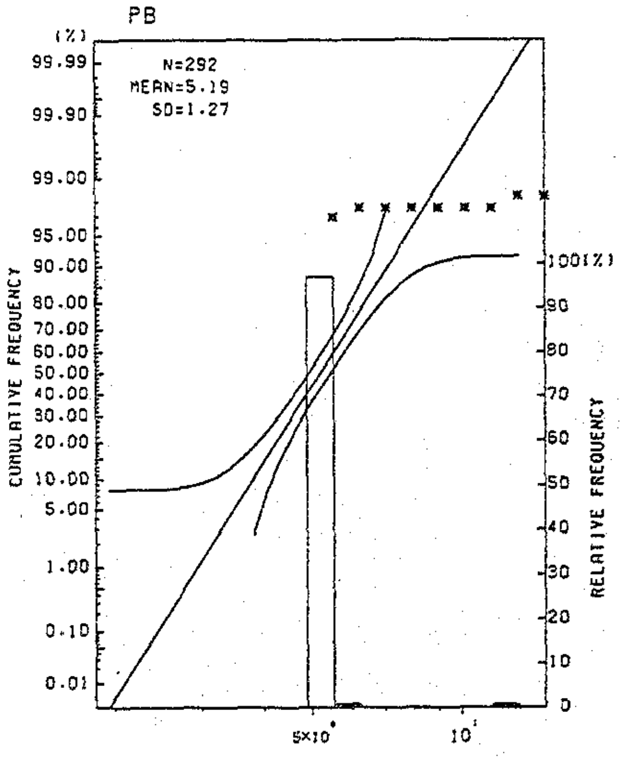


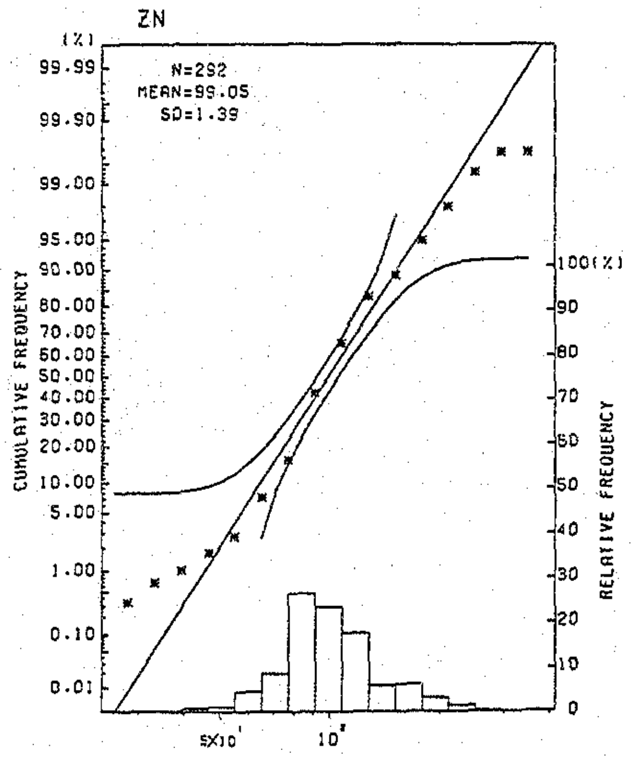


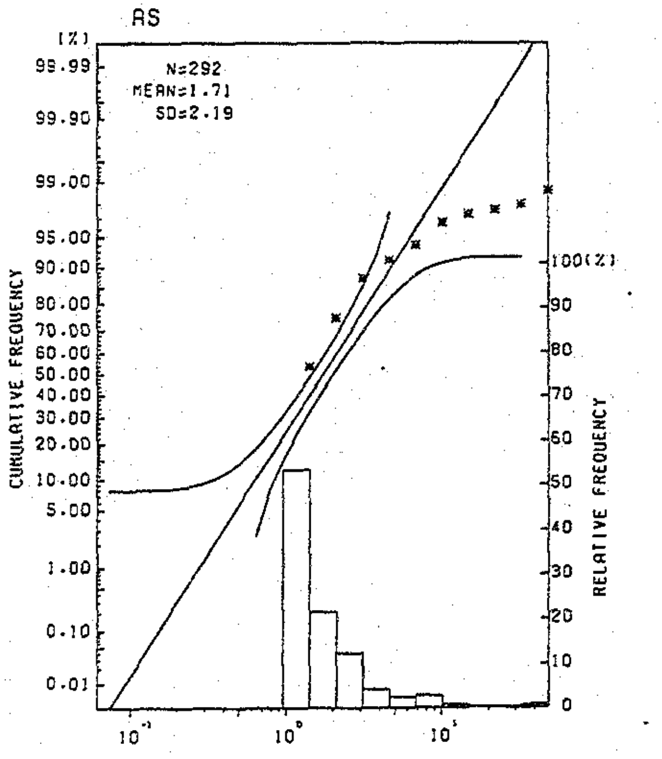
Appendix 1-3 Histogram and Cumulative Frequency Curves of Cell Average Values

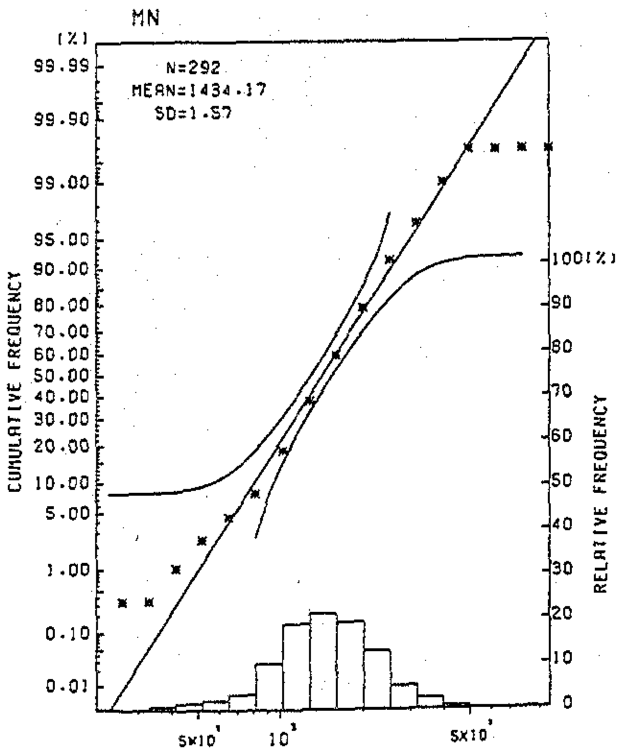
(Dinagat · Siargao 1)

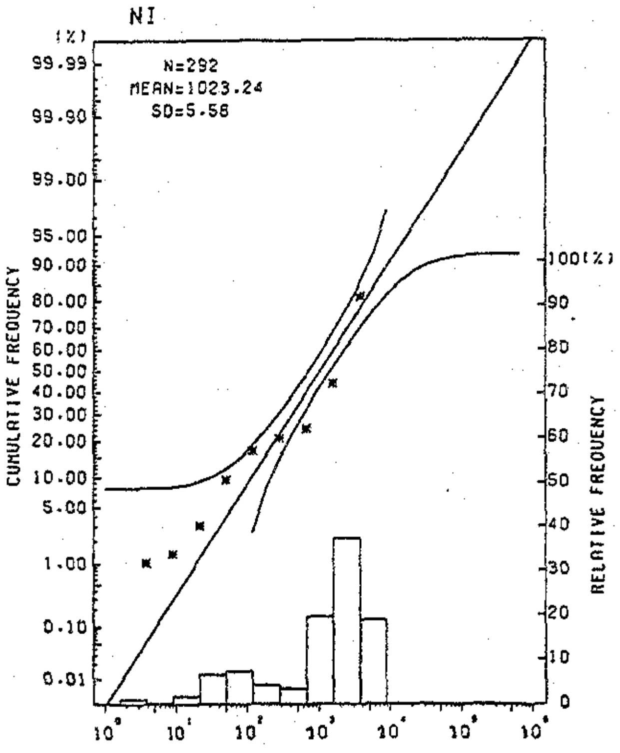






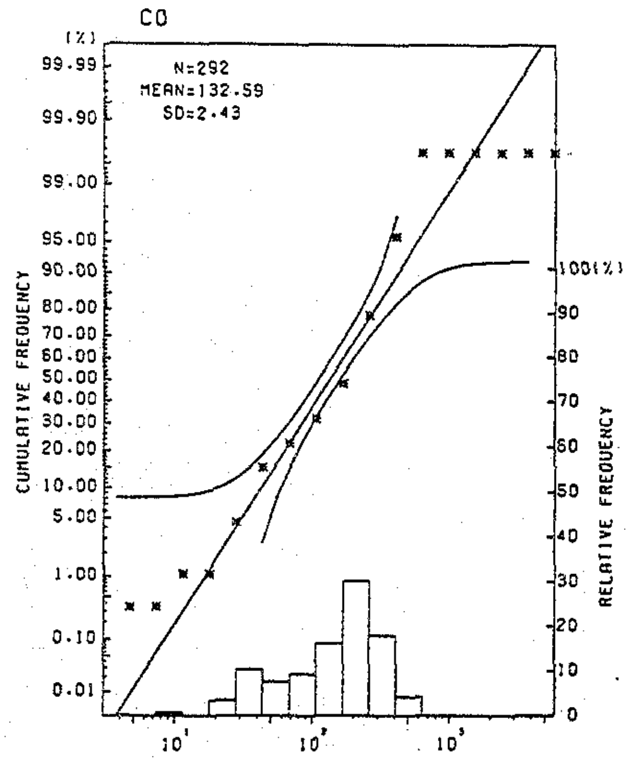


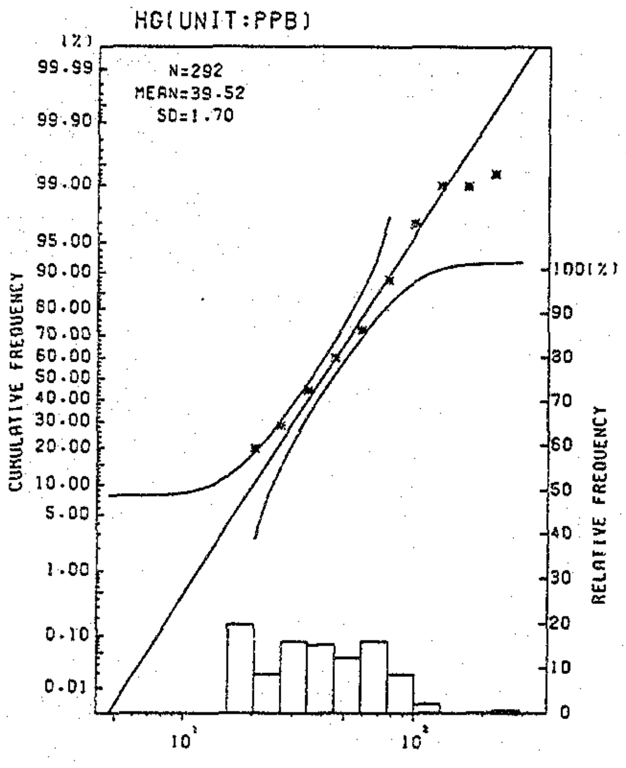


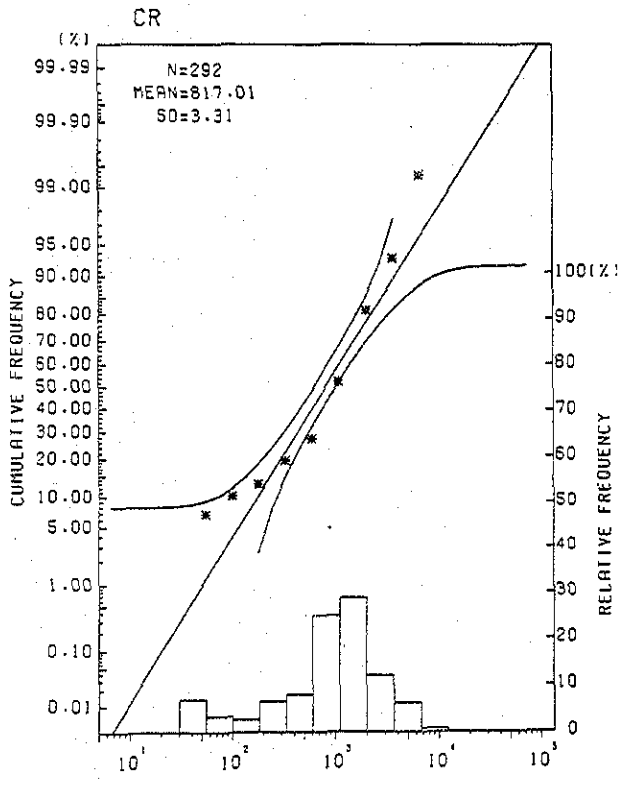


Appendix 1-3 Histogram and Cumulative Frequency Curves of Cell Average Values

(Dinagat · Siargao 2)







Appendix 2 Flow Charts of Chemical Analysis

Appendix 2-1

Analytical flow chart for Cu, Pb, Zn, Co, Ni and Mn

(A) Digestion Procedure with aqua regina

Sample 1 g.
→ Transfer to the test tube (18×150 mm)
Setting test tube stand
← HNO_3 1 ml
← HCl 3 ml

Leave standing One overnight

Boil gently The test tubes are set with aluminum holder on hot plates for 30 min. at 120°C and are occasionally mixed.
← Add approximately 10 ml of distilled water.

Cooling

Setting the volume up to 20 ml. With distilled water.
(Sample solution digested with aqua regina.)

(B) Measurement of contents of Cu, Pb, Zn, Co, Ni and Mn

Sample Solution Digested with aqua regina.

Measurement By Atomic Absorption (AAS).

Element	Flame	Wave Length (Å)
Cu	Air-C_2H_2	3247
Pb	id	2170
Zn	id	2137
Co	id	2407
Ni	id	2320
Mn	id	4033

Appendix 2-2

Analytical flow chart of As, Sb and Hg

(A) Measurement of Sb content

Sample Solution Digested with aqua regina.

Pipet 1 ml.
— Transfer to the plastic vial
— Solution (10% KI + 5% ascorbic acid) 0.5 ml
— 6M-HCl 1 ml.
Hydride generating attachment
0.6% $NaBH_4$ solution

Measurement by Hydration-AAS

Wavelength 2176 Å

(B) Measurement of As content.

Sample Solution Digested with aqua regina.

Pipet 1 ml.
— Transfer to the plastic vial
— Solution (10% KI + 5% ascorbic acid) 0.5 ml
— 6M-HCl 1 ml.
Hydride generating attachment
0.6% $NaBH_4$ solution

Measurement by Hydration-AAS

Wavelength 1974 Å

(C) Measurement of Hg content.

Sample Solution Digested with aqua regina.

Pipet 5 ml.
— Transfer to the 250 ml. Erlenmayer flask.
— $(1+1)H_2SO_4$ 5 ml.
— Distilled water to approximate 100 ml.
— 6% $SnCl_2$ 1 ml.

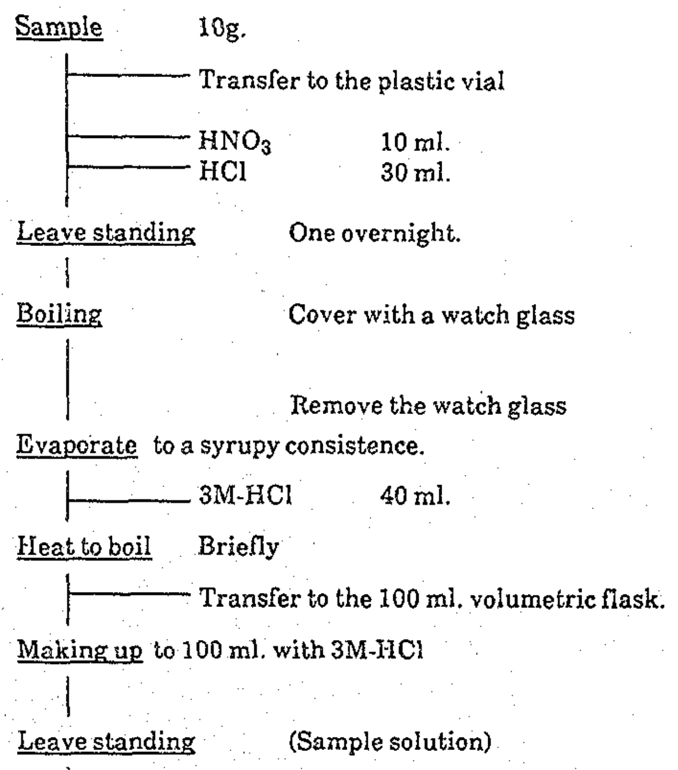
Measurement by Reduction vapor-AAS.

(Mercury analyser)
Wave length: 2537 Å

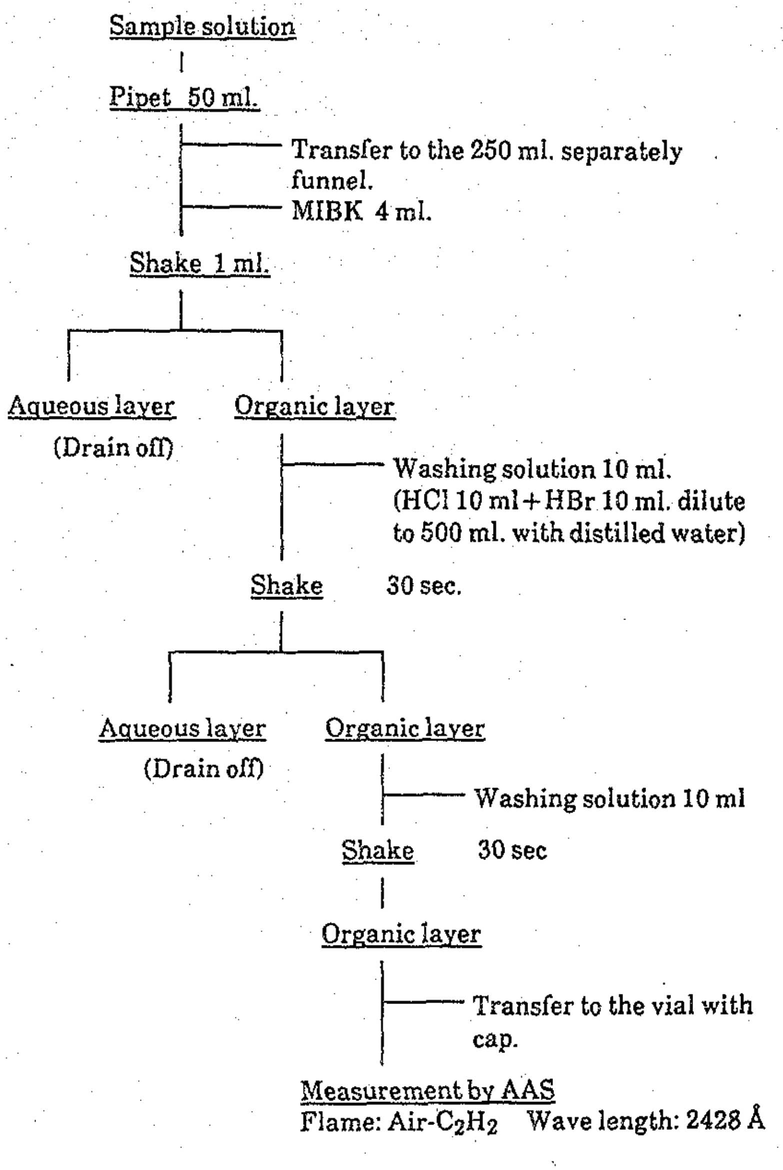
Appendix 2-3

Analytical flow chart of Au, Ag and Ga.

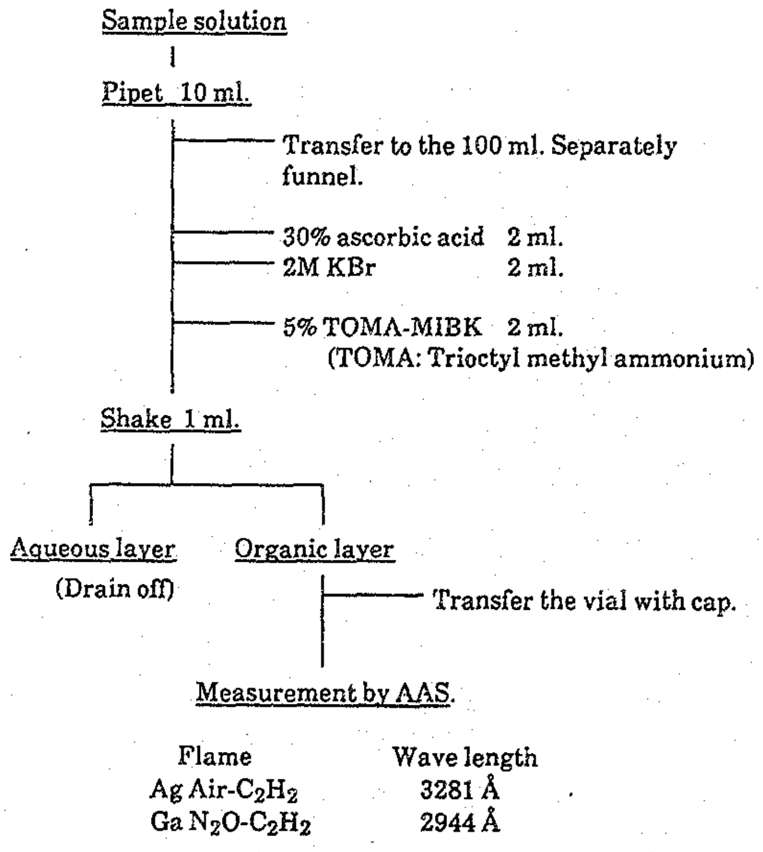
(A) Decomposition of sample.



(B) Measurement of Au content.



(C) Measurement of Ag and Ga content.



Appendix 2-4

Analytical flow chart of Cr and W.

(A) Measurement of Cr content.

Sample 0.05 g
- Transfer to the bolosilicate test tube calibrated for 20 ml.
- KHSO$_4$ 0.5 g.

Fusion Bunsen burner for 5 min. after all sample is dissolved in the melt.

Cooling Place the test tube on a tray and roll it to spread the melt on the test tube walls. (This facilitates solubilization)
- (1+1)HCl 5 ml.
  Place the test tube in a hotwater bath.

Heat to dissolved

Making volume up to 20 ml. with distilled water.

Measure by AAS.
Flame: Air-C_2H_2 Wave length: 3579 Å
(Using a strongly oxidizing flame)

(B) Measurement of W content.

Sample 0.25 g
- Transfer to the bolosilicate test tube
- KHSO$_4$ 1 g.

Fusion Bunsen burner for 5 min. after a quiescent melt has been obtained.

Cooling Roll the test tube while cooling on a tray.
- HCl 5 ml.
  Place the test tube in a hot waterbath.

Heat to dissolve

Pipet 4 ml.
- Transfer to another test tube containing 5 ml. of 10% SnCl solution

Place the test tube in the boiling bath for 10 min.

Heat
- 0.6% Zn-dithiol solution 1 ml.

Heat continue for another 10 min.
occasionally shaking.

Cooling in cold water
- Petroleum spirit 0.5 ml.

Shake 30 sec.

Compare blue color with standard reference solution.

Appendix 3 List of the Existing Data

LEYTE:

REPORT NO.		AUTHOR/S	DATE	TITLE OF REPORTS
* 33 & 59RA		C. Domingo Z. Felizminio	1951,	Sulphur deposits of Biliran Island
* 174		J. Teves	1937,	Geology of Calubian and vicinity, Leyte
* 196		D. Palacio	1956,	Preliminary report on the geology and rock asphalt deposits of balite, Villaba, Leyte
* 209		D. Basco	1954,	Report on the Manila Rock Asphalt property at a sitio of Bo. Balite, Municipality of Villaba, Leyte
* 446		R.F. Sampio	1964,	Report on the investigaiton on the sulfur and iron-sulphide occurrence in Caibiran, Biliran Island , Northern Leyte
* 560		J. Fernandez	1965,	Magnetometer survey of the black sand in the Eastern coast of Leyte
* 641		J. Fernandez		Geophysical reconnaissance of Tongonan geothermal field, Ormoc City, Leyte del Norte
* 719		J. Pilac	1965,	Geology of Northern Leyte
* 951	(1362)	J. Fernandez	1970,	Geological investigation of the nickel project in Antipolo, Jaro, Leyte del Norte
* 1101	(1573)	O. Abarquez	1971,	Mineral canvassing of part of Western Leyte
* 1132	(1625)	C. Samonte	1971,	Geological investigation of the copper prospect in barrio Pulta, Hlongos, Northern Leyte
* 1143	(1668)	A. Paderes	1971,	Report on the geological investigation of Bagacay copper prospect Bagacay, Tacloban City
* 1173	(1636)	Z. Zerda		Memo report on the geological investigation for verification of the magnetite sand in Dulag, Leyte del Norte
* 1328	(1973)	J. Lauron		Geological and survey verification of the magnetite sand deposits in the municipalities of Hiunangan and Silago, Province of Leyte
* 1391		R. Zerda		Report on the mineral ver. of One Hundred Twenty five (125) lode claims of United Copper Mine Co., located at Sogod, Southern Leyte
* 1393		M.R. Apelo		Report on the Mineral ver. of Sixteen (16) placer claims of Great Pacific Mining Corp. in Palo, Leyte del Norte
* 1578	(1975)	J.N. Ronan I. Gappe, Jr.	1975,	Preliminary report on the detailed mapping of a peat deposit in Bo. Liberty, Ormoc City, Leyte del Norte
PG-SA-3		M.V. Garcia M.O. Mercado		Geology & mineral deposits of Samar & Leyte isan J. Bf Gsp. V.35, N.4, Pel. 1981
PNDC-1		1981 student Trainee		Geology of northwest upper Daguitan River, PNoc-Epc July, 1981
MRDP-80-1		R.S. Javelosa		Notes on the Geological & geochemical occurrence of copper golo prospect in Bgy Bantawan, St. Bernard, Southern Leyte
MRDP-80-2		R.S. Javelosa		Exploration studies of copper-Gold prospect in Bgy Ingan, Hinunangan, Southern Leyte
MRDP-80-9		R.G. Robles		Summary report on the diamond drilling expl. on the Cura-Jo, Caiba-an Copper prospect Tacloban City, Leyte in connection with the Samar-Leyte Mineral Resources Rev. Project
MRDP-80-10		R.S. Javelosa		Report on the cope logs of six (6) diamond drill holes on the copper prospect in Curajo-Caiba-An area, Tacloban City, Leyte Prov.
MRO-VII-1		P. Villacastin		A progress report of the geology of parts of the Hilongos & Sogod Quadrangles
MRDP	(1980)	O.M. Pineda	1981,	Electromagnetic Survey of the Reported Copper-Gold mineralization in the Panaon Is. Southern Leyte

Consolidated Report on Cebu, Bohol · Siquijor and Southwest Negros Area

SUMMARY

A total area of 12,840 km^2 in Cebu, Bohol and Southwest Negros was covered by geological and geochemical prospecting from 1985 to 1988 as a part of "The Mineral Exploration-Mineral Deposits and Tectonics of Two Contrasting Geologic Environments in the Republic of the Philippines" project.

The results were statistically processed and evaluated taking into considerations both local and regional geological perspectives, utilizing in the process all the relevant available results from the present geological survey and mineral prospecting in addition to the existing geoscientific data about the area.

The study area (Cebu, Bohol and Southwest Negros) is located in the central part of the Philippine Archipelago and is a part of the Philippine Mobile Belt. The tectonic setting and structural configurations of the study area have been intensely influenced by movements associated with the left-lateral Philippine Fault, magmatism that led to the formation of the Sulu-Zamboanga-Cebu-Masbate Arc and the opening of the Sulu Sea Basin.

The area is divided into four for convenience of geological description and geochemical analyses, namely, Cebu, Bohol, Siquijor and southwest Negros areas.

In the Cebu and Bohol areas, the basement unit consists mainly of Mesozoic crystalline schist. Terriary sedimentary rocks, volcanic and pyroclastic rocks unconformably cover the basement unit. Pleistocene coral limestone, which is the youngest rock unit, is deposited on top of all of these lithological units.

In Siquijor and Southwest Negros areas, the oldest units are Eocene and Oligocene pyroclastic rocks while the younger units consist of Neogene formations.

The main igneous activities in Cebu and Bohol were the Paleocene diorite intrusions and extrusions of Miocene andesites. Miocene diorite intrusive bodies were also observed in the central-eastern part of Cebu. In Southwest Negros, Oligocene diorite and Miocene dacite intrusive bodies were recognized and mapped.

The field surveys conducted led to the recognition of several types of mineralization in the study area. In Cebu, porphyry copper, hydrothermal vein and contact metasomatic types of mineralization were recognized. Porphyry type copper showings, hydrothermal vein type of mineralization and residual type manganese concentrations were found in Bohol and Siquijor. In Southwest Negros, porphyry copper and hydrothermal vein types of mineralization were noted.

The regional analyses and interpretations of the geochemical anomalies were carried out on ten (10) elements (Cu, Pb, Zn, Ag, As, Mn, Ni, Co, Mo, Hg) analysed from approximately 8,000 stream sediment samples (less than 0.175 mm in diameter) collected from the area.

The whole survey area was divided into 2 km × 2 km cells. Four types of statistical analyses were then carried out using the geometric means of each of the elements found in each cell. The four type of statistical analyses utilized were:

1. Univariate analyses of cell average values.
2. Univariate analyses of moving average values which determine the average value of nine cells that correspond to the value of the central cell.
3. Univariate analyses of high-pass filter value which is the positive difference between each cell average and the moving average value.
4. Multivariate analyses (Factor Analyses) for the cell average values.

The results are shown in 1 : 1,000,000 scale maps (Attached Pl. 2-1 to Pl. 2-4).

The geological significance of the statistical results were then evaluated utilizing the data on the distribution of igneous bodies, geological structures and observed alteration patterns associated with the inferred mineralization types.

Finally, the following three localities were selected as promising and warranting further study and prospecting. The localities are prioritized from I to III (Attached Pl. 10).

I. West side of Atlas Mine in central Cebu Island: This zone is characterized by overlapping geochemical anomalies in the Cretaceous to Paleocene Mananga Group and Paleocene Lutopan Diorite. Porphyry copper type mineral showings (e.g. Maypay, Sigpit and Lutopan) are observed in this zone.

   Assumed type of mineralization and the associated commodities; Porphyry copper type mineralization, Cu, Zn and Mo.

II. West side of Liloan in the east coast of Cebu Island: This zone is characterized by overlapping geochemical anomalies in the Jurassic Tumlob Schist, Miocene Malubog Formation and Miocene Talamban Diorite. Vein type and contact metasomatic type of mineral showings (e.g. Consolacion No. 1~3 and Mandawe River) are observed in this zone.

   Assumed types of mineralization and the associated commodities; Vein and contact metasomatic types mineralization, Cu, Pb and Zn.

III. Fifteen kms southeast of the Sipalay municipality in the southwestern coast of Negros island: This zone is characterized by overlapping geochemical anomalies in the Eocene Basak Formation and Oligocene Pagatban Diorite. Vein type mineral showings (e.g. Cabilocan River, Colet and Catuanan) are observed in this zone.

   Assumed types of mineralization and the associated commodities; Vein type mineralization, Cu, Pb and Zn.

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

Consolidated Report on Cebu, Bohol, Siquijor and Southwest Negros Areas

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Appendixes

1. Introduction

1-1 Purpose and Scope

1-1-1 Background and Particulars

Pursuant to the Implementing Arrangement (I/A) entered into between the Government of Japan through the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ) and the Government of the Philippines through the Mines and Geo-Sciences Bureau (MGB) on September 26, 1984, a project, officially titled "The Mineral Exploration-Mineral Deposits and Tectonics of Two Contrasting Geologic Environments" was carried out in the Republic of the Philippines.

This report embodies results of the synthetic evaluation on the areas of Cebu, Bohol-Siquijor and Southwest Negros which are included in the above mentioned project. The field survey took place from April to July, 1985 in Bohol-Siquijor, and from October to December, 1986 in Cebu and from February to March, 1987 in Southwest Negros respectively.

1-1-2 Objectives of the Report

This report embodies the summary of the results of the survey and study of the existing data regarding the mineral resources in the Cebu, Bohol and Southwest Negros which are located in the central part of the Republic of the Philippines. The objectives of this report include the recognition and derivation of the mineral resources distribution in the different survey areas, correlation, processing and analysis all acquired data and the synthesis and evaluation of the area.

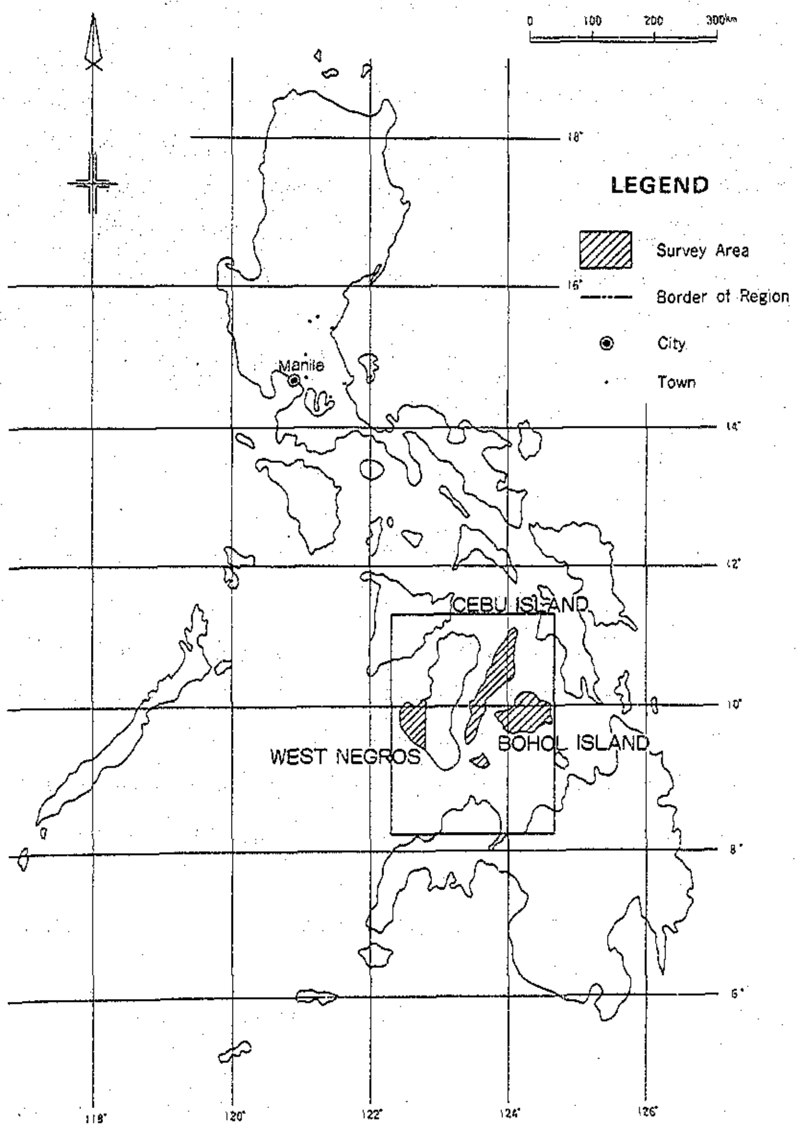


Fig. 1 Location Map of the Survey Area

1-2 Regional Setting

1-2-1 Location

The survey area is located in Visayas in the central part of the Republic of the Philippines and belongs to Region Ⅵ and Ⅶ administratively.

This area is composed of Cebu Island, Bohol Island, Siquijor Island and the southwestern portion of Negros Island. Total survey area extends for 12,840 km^2.

1-2-2 Access

There are regular flights from Manila to Cebu City and to Bacolod in the northern part of Negros Island. The flying time for each route is about one hour. There are regular flights from Cebu City to Tagbilaran City in the southwestern part of the Bohol. Ship services plying from Tagbilaran City, Bohol Island to Larena in the northern part of Siquijor Island are available. Roads along the coast in both islands are paved but inland roads are poorly paved.

1-2-3 Climate

The survey area belongs to the Western Pacific Monsoon Climate Zone. There is a dry season from November to April and a rainy season from May to October in Southwest Negros but the rainfall is more or less even throughout the year in Cebu, Bohol and Siquijor Islands.

Average temperature is 27°C and annual precipitation is 1,400 mm (Tagbilaran, Bohol) to 2,400 mm (Hingaran, Southwest Negros).

1-2-4 Vegetation and others

The inland portions of each island are usually covered by virgin forest, but areas along the coasts and rivers are planted with rice, coconut, banana and vegetable.

1-3 Member of the Survey Team

1-3-1 Planning and Negotiation

Japanese Panel

H. Shinokawa	Ministry of International Trade and Industry (MITI)
M. Aoyama	id.

H. Kainuma	Japan International Cooperation Agency (JICA)
H. Hirano	Metal Mining Agency of Japan (MMAJ)
N. Sato	id.

Philippine Panel

R.D. San Juan	Department of Environment and Natural Resources (DENR.)
P.C. Caleon	Mines and Geo-Sciences Bureau (MGB.)
R.M. Luis	id.
R.L. Almeda	id.
A. Apostol Jr.	id.

1-3-2 Preparation of the Consolidated Report

Japanese Panel

Y. Okubo	Overseas Mineral Resources Development Co., Ltd. (OMRD)
Y. Uehara	id.
Y. Shimazaki	id.

Philippine Panel

R.H. Samaniego	Mines and Geo-Sciences Bureau (MGB.)
M. V. Garcia	id.
B. S. Vargas	id.
R. M. Luis	id.
R. L. Almeda	id.
N. V. Ferrer	id.
A. Apostol Jr.	id.
E. C. Mantaring	id.
N. A. C. Cruz	id.
F. G. Sajona	id.
R. I. Villones	id.
W. G. Diegor	id.
P. B. Rovillos	id.
E. A. Santos	id.
J. Velasquez	id.

1-4 Methodology

The analysis and interpretation of the survey data were conducted as follows.

1-4-1 Survey Area

The survey area is divided into four parts, Cebu, Bohol, Siquijor, and Southwest Negros for convenience of geological description.

1-4-2 Stratigraphy

In this report the stratigraphic classification which had been agreed upon between the Japanese and Philippine panels during the workshop held in Manila in June, 1988 was used. A geological map in the scale of 1 : 1,000,000 has been prepared in conformity with the stratigraphic classification (Attached Pl. -1). Geological descriptions presented here were adopted from the Cebu (E.C. Mantaing & N.A.C. Cruz, 1988), Bohol (F.G. Sajona, R.I. Villones & W.G. Diegor, 1986), Siquijor (P.B. Rovillos & N.A.C. Cruz, 1985) and SW Negros (E.A. Santos & Velasquez, 1988) unpublished reports.

1-4-3 Geochemical Data

In terms of the geochemical data, the zones with anomalous values were identified through the following process. The whole survey area was divided into 2km×2km cells. The univariate and multivariate analyses of the average values of all the geochemical data in each cell were carried out. Univariate analyses of the moving average values of every nine cells and univariate analyses of the high-pass filter values (the differences between the cell average value and the corresponding moving average value) were also carried out.

A total of 8,066 stream sediment samples, including 1,143 UNDP samples, from the whole survey area were analyzed for ten elements: Cu, Pb, Zn, Ag, As, Hg, Ni, Co, Mo, Mn. All data were regarded as one population.

1-4-4 Heavy Mineral Samples

In addition to the stream sediment samples, 421 heavy mineral samples were collected by panning and chemically analyzed for Au, Ag and Ga. The above data were processed by univariate analyses. Twenty of the above samples, ten from Cebu and ten from Southwest Negros were selected at random and the mode of component minerals of these samples were analyzed.

1-4-5 Existing Regional Survey Data

Available data on previous regional geological work of the area were compiled in the lineament map, gravity map, aeromagnetic survey map and mineral showings distribution map at the scale of 1 : 1,000,000 to conform with the geological map (attached Pl. -3, 4, 5, 6. Existing survey data list presented in Appendix).

1-5 Achievements of The Project

1-5-1 Conclusion

Four principal types of mineralization have been recognized in the survey area. (Fig. 2 and Pl. -10)

(1) Vein and porphyry copper type mineralization associated with the dioritic rocks which intruded in Paleocene, Oligocene and Miocene (Atlas Mine, Sipalay Mine, etc.)

(2) Contact metasomatic mineralization which formed at contact zone between Miocene limestone and diorite (Mandawe River, etc.).

(3) Orthomagmatic mineralization associated with ultramafic rocks (Boctol, etc.).

(4) Residual type concentration of manganese (Anda, etc.).

The result of the geochemical analyses were, then evaluated together with the distribution of igneous rocks, geologic structures and alteration associated with mineralization.

These studies resulted in the selection of following three promising area with priorities listed below (Pl. 10).

(I)Western side of Atlas Mine of Cebu.

This zone consists of Cu, Zn, Mn and Mo anomalous cells and occurs in Cretaceous to Paleocene Mananga Group and Paleocene Lutopan Diorite. Botong Sinsin, Sigpit Lutopan and Maypay mineral showings are located in the vicinity. Porphyry copper type mineralization are expected. Assumed commodities are Cu, Zn and Mo.

(II)Western side of Liloan in the east coast of Cebu.

This zone consists of Pb, Zn and As anomalous cells and occurs in Jurassic Tunlob Schist, Miocene Malubog Formation and Talamban Diorite. Consolaction No. 1, No. 2, No. 3 and Mandawe river mineral showings are located in the vicinity. Contact metasomatic type mineralization associated with diorite is expected. Assumed commodities are Cu, Pb and Zn.

(III)Southeastern side of Sipalay Town at the southwest coast of Negros.

This zone consists of Cu, Pb, Zn and Hg anomalous cells and occurs in Eocene Basak Formation and Oligocene Pagatban Diorite. Cabilocan River and Colet and Catuanan mineral showings are located in the vicinity. Vein type mineralization associated with diorite is expected. Assumed commodities are Cu, Pb and Zn.

2. Geology and Mineralization

2-1 Geological Setting (Fig. -2 and Attached Pl.-1)

2-1-1 Regional Geology

The survey area is located in Visayas Region, the central portion of the Philippine Archipelago and belongs to the Central Physiographic Province of the Philippine Mobile Belt. The area is composed of two orogenic arcs, Cebu Ridge and East Panay Ridge and also of the Visayan Sea Basin.

The oldest known geological units are the Jurassic to Cretaceous schist in Cebu and Bohol and the Paleocene to Eocene pyroclastics in Southwest Negros. The Tertiary sedimentary rocks overlie the above lower formations unconformably and are interbedded with limestone. The andesitic tuff breccia was deposited in Pleistocene in Southwest Negros and also coral limestone and marl were formed in Cebu and Bohol.

The diorite intrusive bodies of the area are important regarding mineralization. They are the Paleocene diorite intrusion in central Cebu which gave rise to the mineralization which formed the Atlas Mine and the Oligocene diorite intrusion in Southwest Negros which gave rise to the mineralization which formed the deposits of the Sipalay Mine.

2-1-2 Stratigraphy

The stratigraphic sections agreed upon during the RP-Japanese Workshop in June, 1988 are presented in Figures 3, 4, 5, and 6.

2-1-2-1 Cebu

The Mesozoic formations and the intruded diorite bodies are distributed in the central highland with the altitude of over 200 m above sea level in contrast to the Pliocene and Pleistocene limestone which are distributed mainly in the coastal, northern and southern parts of the island with lower relief.

The Tunlog Schist consists of chlorite orthoschist and micaceous paraschist which were brought about by a moderate regional metamorphism. The chlorite orthoschist bodies are aligned in NE-SW direction in the northern central highland. A rock sample (CG-076R) collected 15 km west-northwest of Old Carmen in the east coast is composed mainly of hornblende and plagioclase with actinolite, magnetite and hematite as accessory minerals.

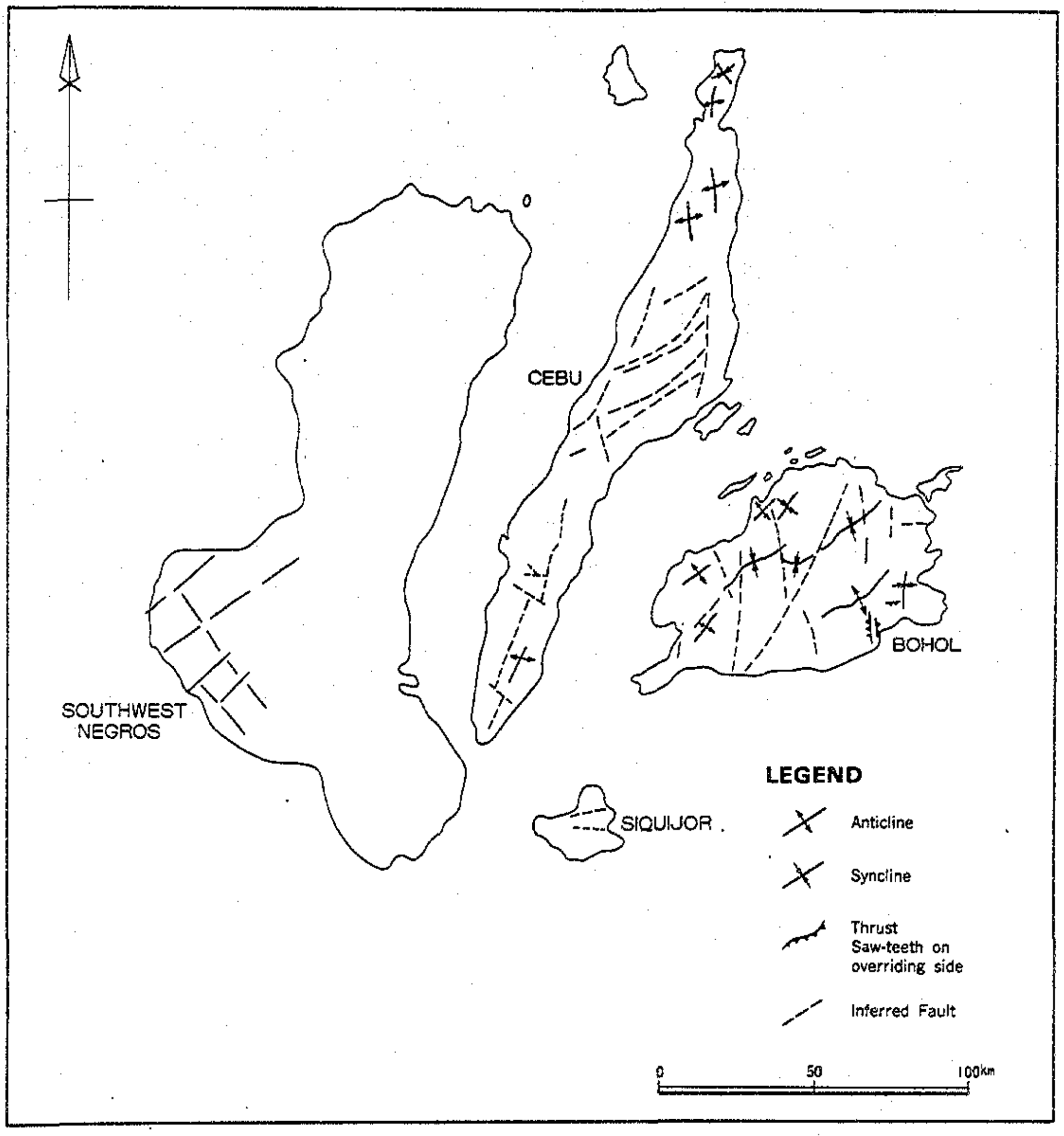


Fig. 2 Major Geologic Structures in the CEBU-BOHOL-SQUIJOR · SOUTH WEST NEGROS

The micaceous paraschist bodies crop out in the upper stream of Guinabasan River and along Lutac-Jaclupan Fault, at 15 km WNW of Old Carmen in the eastern coastal part of the island. These schists are in fault contact with the upper formations.

The Mananga Group was named by Balce (1977) for the sequence of formations exposed at Mananga Valley. The group is composed of, in ascending order, Cansi Volcanics, Tuburan Limestone and Pandan Formation. These units have intertonguing relationship with each other. The group occurs mainly in the central highland in fault or unconformable contact with the younger formations or in fault contact with the older Tunlob Schist (Plate-1). The age of the group is believed to be Late Cretaceous to Paleocene from fossil studies (E.C. Mantaring, et al., 1988).

The Mananga Group consists of three formations as follows:

Cansi Volcanics occur as lenticular masses with NE trending axes in the central highland. the composition of the unit ranges from basalt to pyroxene andesite. These rocks are generally fine-grained with porphyritic texture. Silicification with minor degree of epidotization and chloritization is common and in some parts amygdaloidal texture is seen. Thin layers of cherty sediments are intercalated. The age of the unit is Late Cretaceous based on the fossil studies of the overlying limestone.

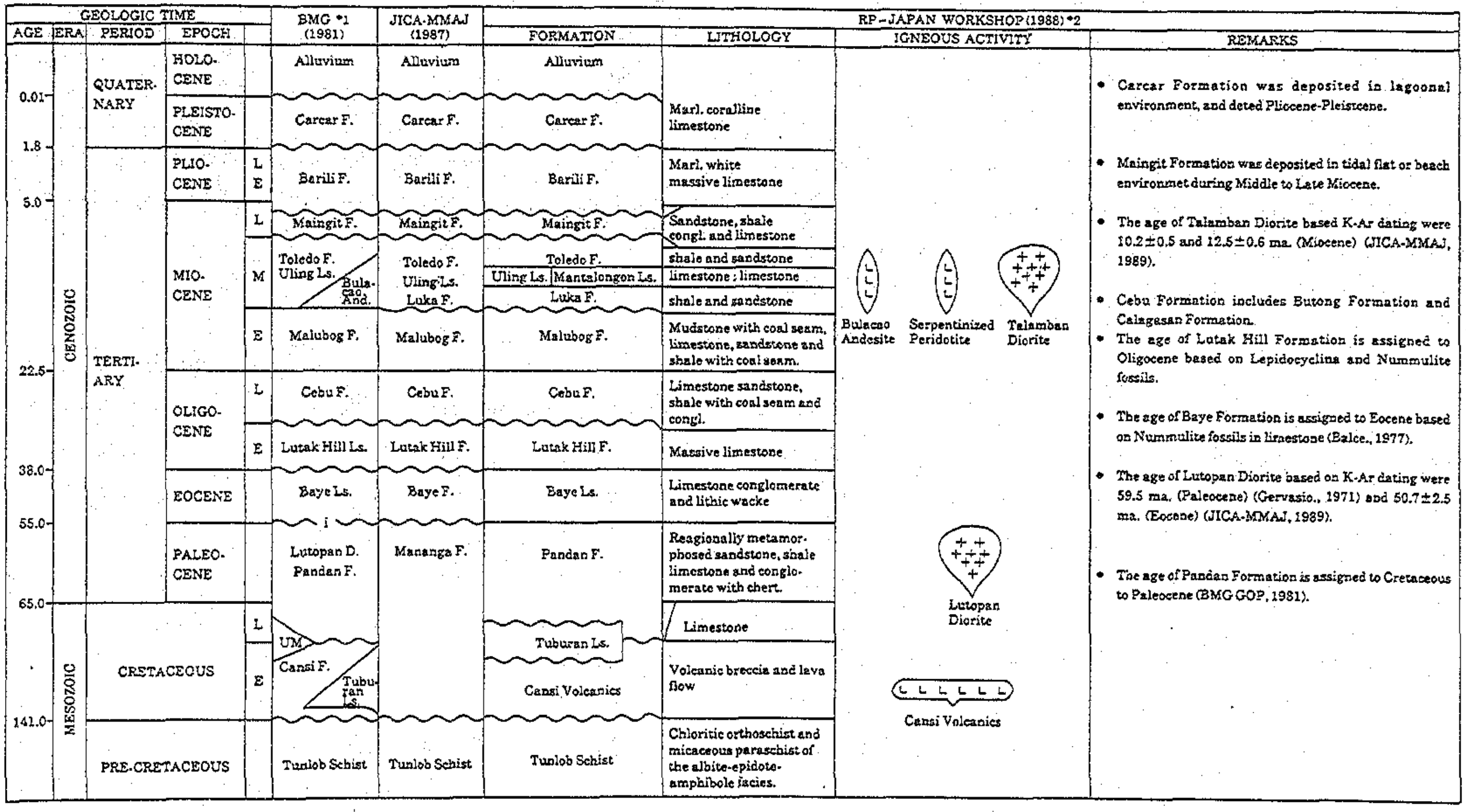
Tuburan Limestone occurs at the eastern ridge of the Tuburan and Asturias on the west coast. It exceeds 20 m in thickness. The unit contains the basal conglomerate through which it is inter-finger contact with the underlying Cansi Volcanics. It is assigned a Cretaceous age based on fossil studies made by Reyes and Ordoñez, 1970.

Pandan Formation occurs in the central highland and is composed of weakly metamorphosed sandstone, mudstone, argillaceous limestone and conglomerate. Volcanic flows and cherty sediments are interbedded as thin layers in the unit (BMG 1981). The thickest section of the unit is found in the northern highland between Tuburan and Catmon, where shale with intercalations of metamorphosed sandstone, thin limestone and conglomerate is recognized. In the vicinity of diorite intrusives, the metamorphored sediments are crystallized into dark hornfels. Intercalated basalt flows were chloritized and epidotized. The age of the unit is from Late Cretaceous to Paleocene based on Globotruncana in intercalated limestone (BMG 1981).

The Baye Formation is the Eocene limestone directly overlying the Mananga Group. It occurs in the central highland and is in conformable contact with the Pandan Formation. This formation is estimated to be 500 m in thickness. The age of the unit is Eocene based on Nummulite fossils in limestone.

The Lutak Hill Formation occurs in the southern slope of Lutak Hill, 6 km northwest of Naga in the east coast. This formation is massive, sandy and light gray. The lithology is limestone and fossiliferous. The age is Oligocene based on Lepidocyclina and Nummulite fossils.

The Cebu Formation occurs in the central highland and is divided into the lowest Guindarhan Conglomerate, lower Cebu Coal Measures and upper Cebu Orbitoid Limestone (Balce and Hashimoto, 1977). The Guindarhan Conglomerate is well compacted and composed of subangular to subrounded clasts of volcanics, quartz and chert. The Cebu Coal Measures is alternating beds of sandstone and shale with occasional lenses of conglomerate and coal. It is brown to dark gray on fresh exposure. The Cebu Orbitoid Limestone is composed of calcareous sandstone and



- Carcar Formation was deposited in lagoonal environment, and deted Pliocene-Pleistcene.
- Maingit Formation was deposited in tidal flat or beach environmet during Middle to Late Miocene.
- The age of Talamban Diorite based K-Ar dating were 10.2±0.5 and 12.5±0.6 ma. (Miocene) (JICA-MMAJ, 1989).
- Cebu Formation includes Butong Formation and Calagasan Formation.
- The age of Lutak Hill Formation is assigned to Oligocene based on Lepidocyclina and Nummulite fossils.
- The age of Baye Formation is assigned to Eocene based on Nummulite fossils in limestone (Balce., 1977).
- The age of Lutopan Diorite based on K-Ar dating were 59.5 ma. (Paleocene) (Gervasio., 1971) and 50.7±2.5 ma. (Eocene) (JICA-MMAJ, 1989).
- The age of Pandan Formation is assigned to Cretaceous to Paleocene (BMG GOP, 1981).

*1 Geology and Mineral Resources of the Philippines VolumeI P.58 (Table-25)

*2 E. C. Mantaring & N. A. C. Cruz "Geology and Mineral Resources of Cebu Island" (ms., 1988)

Fig. 3 Stratigraphic Column of Cebu

carbonaceous marl. The type locality is Uling, northwest of Naga, on the east coast of the island. The thickness of the limestone is estimated to be about 50 m.

The age of the Cebu Formation is from Late Oligocene to Early Miocene. The presence of conglomerate at the base of the formation suggests that submergence of the extensively peneplained area brought about the deposition of sandstone and shale in shallow sea environment and the formation of coal under frequent changes to lagoonal conditions during Late Oligocene.

The Malubog Formation consists of Early Miocene sediments and occurs in the southern and eastern sides of the central highland. The type locality is Malubog, 6 km east-southeast of Toledo, west coast. The unit is divided into the lower Cantabaco Member, middle Binabac Limestone and upper Alpaco Coal Measures. The lower Cantabaco Member consists of alternating beds of sandstone, limestone and quartzite. The middle Binabac Limestone consists of limestone containing abundant corals. The upper Alpaco Coal Measures consists of muddy sandstone with coal beds.

Thickness of the formation varies from 250 m to 2,000 m. The high angle dipping beds due to folding suggest orogenic movement after the deposition. This formation was deposited in Early Miocene and overlies conformably the Cebu Formation.

The Luka Formation occurs at 15 km ENE of Balamban in the west coast. It is composed of alternating Middle Miocene beds of sandstone, conglomerate and mudstone with limestone lenses. This formation is unconformable to the lower Malubog Formation.

The Uling Limestone occurs in the northern and eastern parts of the central highland. The unit is massive coral-red limestone with thickness of 200 to 250 m. It is reefal carbonate containing algae as well as calcisiltite matrix. The age of the unit is Middle Miocene. The unit is conformable with the lower Luka Formation and appears to have been deposited in lagoonal type of environment.

The Toledo Formation occurs in the outer margin of the central highland and has a maximum thickness of 250 m. It is composed of thick sequence of tuffaceous sandstone, calcareous conglomerate and shale with lenses of calcareous sandstone and tuffaceous siltstone. This formation was formed in estuaries and shallow sea environment during Middle Miocene. It is intruded by the Talamban Diorite and the Balacao Andesite is extruded from this formation.

The Maingit Formation occurs in the northern parts and the west coast from Balamban to Pinamungahan. It is distributed in the maginal areas of the island. The formation is divided into lower limestone, middle conglomerate and upper sandstone-shale members. The lower limestone is white, banded and coralline with several kinds of fossils. It is thin and forms lenticular beds with steep dip. The middle conglomerate is polymictic in origin with angular to subrounded pebbles in sandy matrix. The upper sandstone-shale member contains thin beds of limestone and coal seam.

The formation has a steep dip at the basal part and gradually flattens towards the top. The formation is believed to have been deposited in shallow sea environment during Late Miocene. It overlies unconformably the Middle Miocene Toledo Formation and is correlated to the Dingle coralline limestone in the vicinity of Iloilo, Panay Island.

The Barili Formation is generally composed of lower limestone and upper marl and occurs widespread in the central highland and the higher areas of the northern and southern parts of the island. The type locality of this formation is at the eastern part of Barili, in the west coast.

The limestone is compact, massive and occasionally coralline. It partly shows well graded bedding and changes upwards to arenaceous nature. the marl is thick bedded to massive white with thin interbeds of coralline limestone and carbonaceous matter. It is 200 to 300 m thick at the northern highland.

The formation includes finger corals, sponge spicules, shells and ostracodes in a massive carbonaceous sandstone. These facts suggest that it was formed in a lagoonal environment during Late Miocene to Pliocene. The formation overlies unconformably the Maingit Formation.

The Carcar Formation covers all the coastal parts of Cebu Island and is a lagoonal deposit composed of lower limestone and upper marl. The limestone is dominantly coralline and partly dolomitic. The coralline limestone is yellowish brown and porous. A basal part of the limestone is conglomeratic and is rich in corals, marine micro and megafossils. The dolomitic limestone is irregular, dull white to creamy and amorphous. The marl is white to light gray. It is composed of porous, fine crystalline calcite and rich in microfossils.

The formation is horizontal in most places but occasionally the bed dips seaward at a maximum of 20 degrees. The formation appears to have been deposited in Pleistcene and covers uncomformably Barili Formation. It can be correlated to the Hubay Formation of northwestern Leyte and the Maribojoc Limestone of Bohol Island.

Alluvium is composed of silts, sands and gravel and the distribution is occurred in the alluvial flats and coastal parts.

2-1-2-2 Bohol

The Alicia Schist which appears to be Cretaceous, is the lowest formation in Bohol area and the Ubay Volcanics which appear to be Paleocene are exposed in the eastern to northern Bohol. Both units were acreted by the Cretaceous Boctol Serpaetinite and they were intruded by the Paleocene Talibon Diorite.

Formations deposited after Miocene occur extensively in south-eastern to western portions and is overlain by the Pliocene to Pleistocene Maribojoc Limestone.

The Alicia Schist occurs as elongated shape in N-S trend in eastern flank of Bohol Island and is accompanied by the Boctol serpentinite. The unit consists of medium grade green schist and mica schist.

The unit generally trends N10~60 E, and dips northwest or southeast. Fractures parallel to the schitosity are observed at exposures with less deformation.

The Ubay Vocanics occurs at the northeastern part of Bohol Island, and consists of Paleocene dacite, pyroxene andesite and basalt. Various kinds of alteration and various grades of weathering are observed. The relationship to other formations are not clear.

The Calape Limestone Corby, et al. (1951) and Arco (1962) described Late Eocene Cameria bearing limestones which occurs the southeast of Tubigon, northwestern Bohol Island. It is now known that these limestones are not exposed but floated.

The Ilihan shale is described as steeply dipping unit with interbeds of sandy tuffs and calcareous volcanic rubble beds, and occurs at Ilihan Sur. Tubigon. the present study gives an Oligocene age to this unit based on paleontrogical interpretation. (Yolanda, 1988).

The Wahig Limestone is white to light gray and massive to bedded limestone rich in small orbitoids. This unit overlies unconformably the Ubay Volcanics which is exposed widely in the central and northern parts of Bohol and covers the intruded Talibon Diorite, Arco (1962) reported this unit as Upper Oligocene to Miocene. However, more recent dating of samples of this unit placed the age as ranging from Early to Middle Miocene (possible Early Miocene) (E. G. Sajona, et al. 1986).

The Carmen Formation is distributed mainly in the eastern part of Bohol occupying 30 to 40 percent of the total island area. This low dipping thick sedimentary sequence is essentially composed of shale, sandstone, slabby to massive limestone, conglomerate, siltstone, marl and some tuffaceous and siliceous facies. Arco (1962) reported this formation to be Middle to Upper Miocene. However, samples obtained during this survey yielded fossils from Early to Middle Miocene. The conglomerate of this formation occurs around Dimiao, the southern coast and along Tanguhay River.

At the northeastern part of the island, occasional coal lenses in association with tuffaceous sandstone are observed.

The Sierra Bullones Limestones is massive limestone mainly exposed in the southeastern part of Bohol. The upper part of the formation consists of white tuffaces-calcareous siltstone, shale and marl. The limestone is mainly composed of medium to thick coralline beds, biocalcarenite beds and reefal limestone. This formation overlies the Carmen Formation unconformably. Almost 95 percent of the whole Anda Peninsula, in the southeastern part of Bohol is covered by this limestone and it's absence on the western part suggests the tilting and subsequent submergence of the southeastern part, during the Late Miocene.

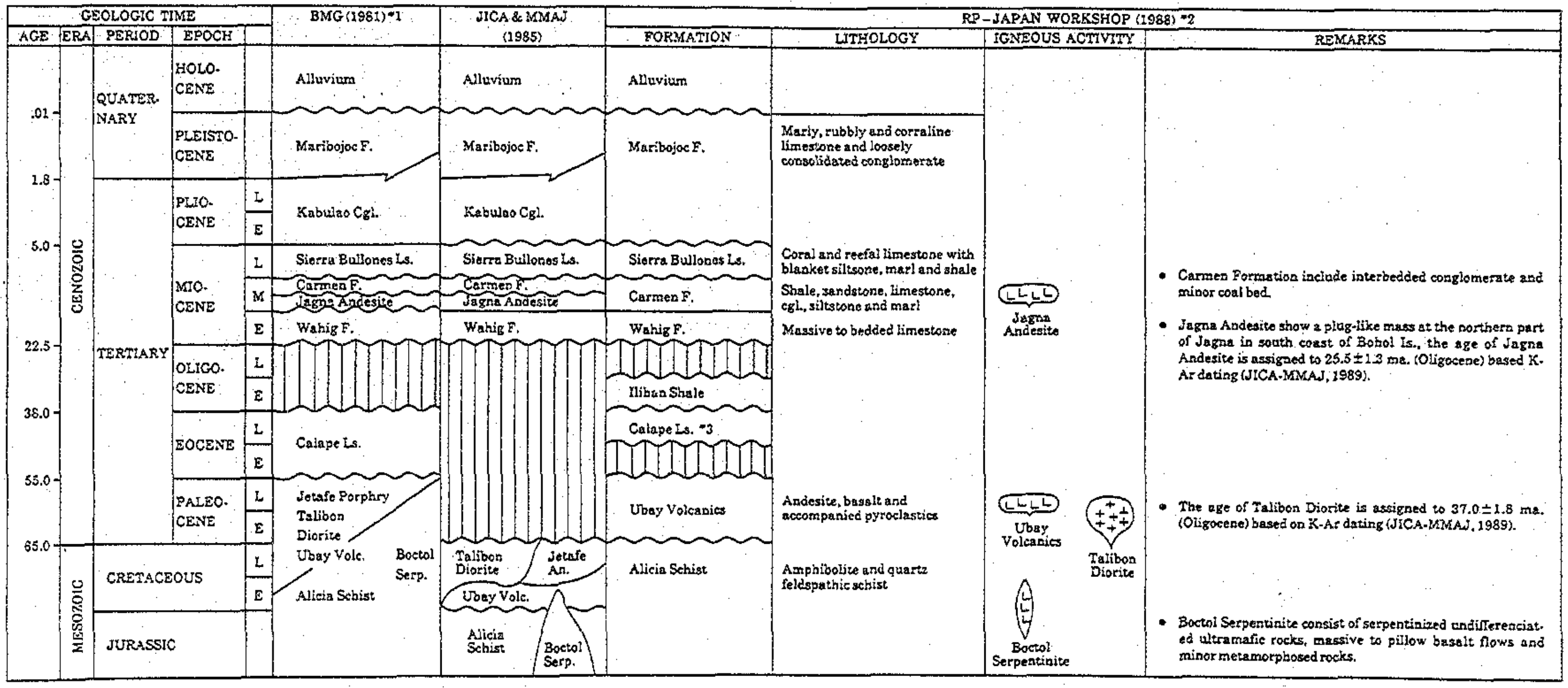
The Mariobojoc Limestone occurs extensively in the western part of Bohol. It is mainly massive or lagoonal limestone and creamy to brownish yellow. It is also coralline, porous and in places marly or agglomeratic. The rocks resembles the Carcar Formation of Cebu. Bedding planes are generally flat though poorly bedded. It is more likely that it was formed either after the deposition of the Sierra Bullones Limestone during Late Miocene, or after the Jagna Andesite activity (F. G. Sajona, et al. 1986).

The Mariobojoc Limestone overlies unconformably the Sierra Bullones Limestone. It was dated Pliocene through fossil studies, but it is inferred that the deposition continued to Pleistocene (E. G. Sajona et al., 1986) and this long deposition period suggests that the environment of this area was stable during this time.

Alluvium is composed of silts, sands and gravel and is confined in alluvial plains and coastal parts.

2-1-2-3 Siqujor

The geology of Siquijor Area is composed of four formations namely, Kanglasog Volcanics, Basac Formation, Siquijor Limestone



- Carmen Formation include interbedded conglomerate and minor coal bed.
- Jagna Andesite show a plug-like mass at the northern part of Jagna in south coast of Bohol Is., the age of Jagna Andesite is assigned to 25.5±1.3 ma. (Oligocene) based K-Ar dating (JICA-MMAJ, 1989).
- The age of Talibon Diorite is assigned to 37.0±1.8 ma. (Oligocene) based on K-Ar dating (JICA-MMAJ, 1989).
- Boctol Serpentinite consist of serpentinized undifferenciated ultramafic rocks, massive to pillow basalt flows and minor metamorphosed rocks.

*1 Geology and Mineral Resources of the Philippines. Volume I p.62 (Table II-28) 1981.
*2 F.G. Sajona, R. I. Villones, Jr. and W. G. Diegoal "The Geology of Bohol Island, central Philippines" (ms., 1986).
*3 "Calape Limestone" is observed as only floating.

Fig. 4 Stratigraphic column of Bohol

and Alluvium (Sorem, et al., 1951).

The lowest Kangalasog Volcanics is composed of volcanic breccias, agglomerates and a small number of volcanic flows and occurs as independent peaks of rugged, sharp crested ranges. It is overlain unconformably by the Basac Formation which consists of the Middle to Upper Miocene sequence of tuffaceous, calcareous and clastic materials. The formation constitutes undulating foothills elongated towards the coast. the youngest formation is the gently dipping Siquijor Limestone dated Upper Pliocene to Pleistocene and occurs as topographically flat-flying coastal plane, sea eroded cliffs and various terraces.

The Kanglasog Volcanics occurs at higher parts of the island and the type locality of the unit is Mt. Kanglasog. The unit is composed of volcanic breccias, agglomerates and a small amount of volcanic flows. the breccias and agglomerates consist of basaltic to andesitic and angular to subangular fragments which are amygdaloidal, vesicular and irregular in size. They are cemented with tuffaceous sandy matrix. In weathered parts of the unit, pale colored fragments are scattered in redish yellow clayey matrix. Steeply dipping tuff is partly observed in the unit. Dark gray to black tuff exhibits ripple marks suggesting marine deposition. However, most of the tuff appear to have been deposited subareally. A small amount of volcanic flow occurs localized and it consist of amygdaloidal basalt filled with zeolite and calcite in the cavities. Secondary manganese minerals which occur in fractures and at boundaries of the flows and quartz-calcite veinlets are also seen. This formation is assigned to Oligocene and covered by the Basac Formation unconformably.

The Basac Formation is composed of two intertonguing members of limestone and shale. The limestone member which lies above the shale member is well exposed at the type locality of Basac. It is hard, cavernous and creamy to buff colored when fresh and gray to almost black on weathered surface. At the basal part of the limestone member, brecciated zones contain pieces of volcanic or pyroclastic rocks, it's diameter are no longer than one centimeter.

Lepoidocyclina (Nephrolepidina) smatrensis is present in the lower portion of the interbedded member and it indicates Middle Miocene (R. B. Rovillos, Jr., et al. 1985).

This formation is covered by the Siquijor Limestone unconformably.

The Siquijor Limestone is considered to be the youngest formation in the island, which has gently dipping beds.

This formation is considered with massive, hard, cavernous and fossiliferous limestone and shows creamy to pinkish color on fresh outcrops and pale gray to black on weathered surface. Clastic limestones, particularly calcarenites, contain large amount of foraminiferas. Calcirudite consisting of limestone clasts in a sandy matrix are noted in various localities.

Alluvium consists of mud, clay, silt, sand and gravel and is confined to the coastal parts and lower stream valleys.

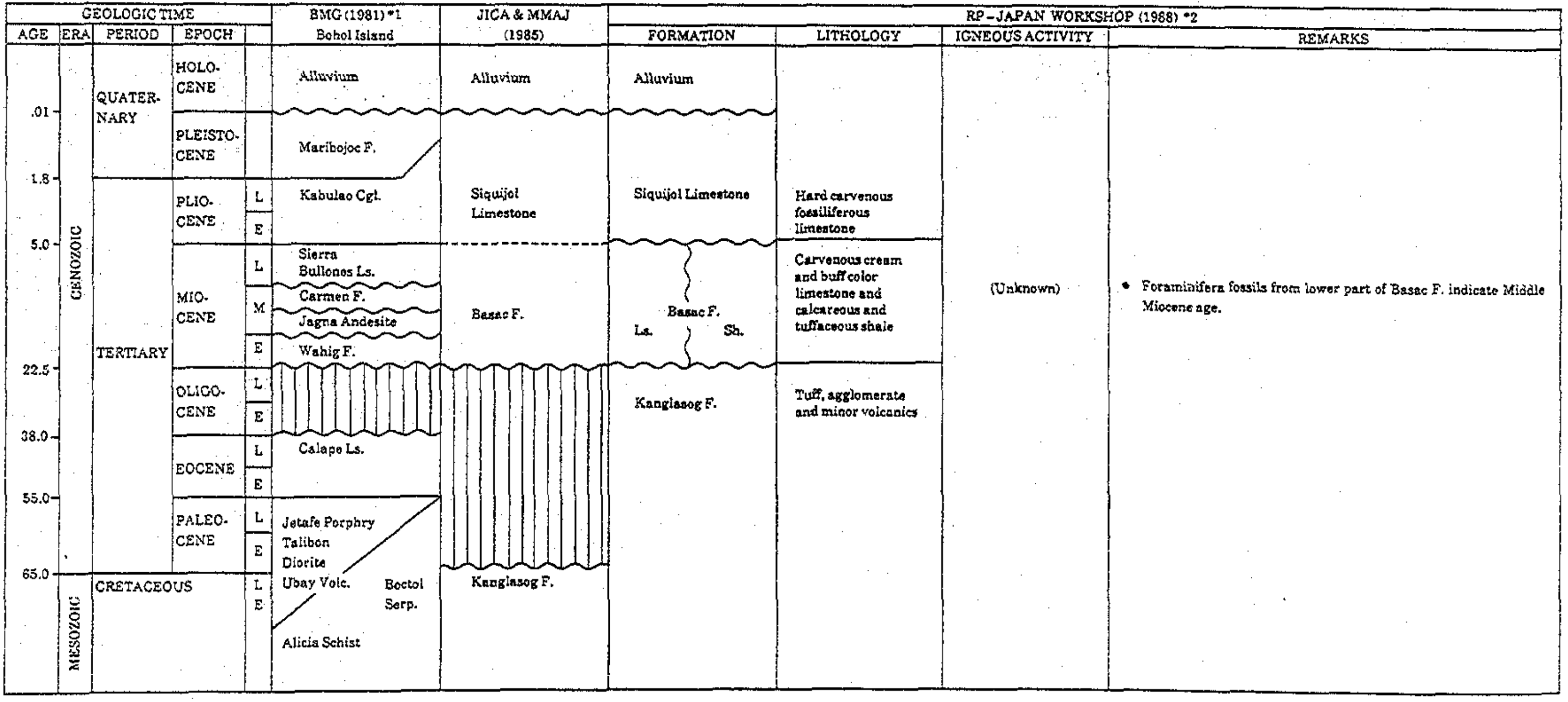
2-1-2-4 Southwest Negros

Volcanic rocks inferred to have originated in Paleogene island-arc volcanoes form the lower formation. The volcanoes are believed to have extended in N-S direction in the southwestern part of Negros. These volcanic rocks are accompanied by porphyry copper mineralization.

The volcanic rocks are overlain unconformably by the Neogene formations.

The Basak Formation is the oldest rock unit in Southwest Negros and is correlative with the Sibara Formation of East Panay and the Mandaon Formation of Masbate.

The formation consists of volcanics and volcanoclastics, they are andesitic rocks with some grading to basaltic composition. the andesite varies from andesite porphyry to porphyritic andesite. These are highly jointed and the color is greenish gray to green by



*1 Geology and Mineral Resources of the Philippines Volume I P.62 (Table II-28)
*2 P.B. Rovillos and N.A.C. Cruz "Geology and Mineral Resources of Siquijol Island" (ms., 1985)

Fig. 5 Stratigraphic column of Siquijor

alteration. At the middle reaches of Hinobaan River, moderately pyritized andesite has steep joints and some brecciated contact with quartz diorite intrusive bodies.

At the upper part of the volcanics, there are thin layers of sediments in the northwestern part of Inayauan. These layers consist of sandstone, siltstone, shale and tuff. The bedding exhibits intense folding showing severe disturbance after deposition. The tuff consists mostly of andesitic and partly basaltic materials. These tuffs occur at ridges and highlands of Hinobaan in the west, Cawayan in the north and Bayawan in the south.

A rock sample from the north of Sipalay mine was identified to be periodotite. This shows the possibility of older ophiolite exposure as a fenster. Further survey regarding this possibility is desirable. As seen above, the Basak Formation occurs at various parts of Southwest Negros as the lower unit.

This formation is covered by Ishio limestone with unconformably and dated Eocene (E. A. Santos, et al. ms. 1988).

The Ishio Limestone is the oldest sedimentary rock in the area and occurs at the banks of Ishio River in the northern part.

Outcrop are creamy to cloudy white and the well-bedded limestone has a strike of N60° W and dip of 25° NE (David, 1982). These outcrops contain abundant fossils of Nummulites which were dated Late Eocene. The Nummulites are one of the oldest fossils known in the area (MaCabe, et al., 1985).

The Tabu Formation occurs mainly in the upper reaches of Guiljungan River and Dacongcogon River in the eastern part of Southwest Negros.

It is composed of alternation of pyroclastics and sedimentary rocks. The sedimentary members are uniformly well-bedded and consist of sandstone, siltstone and shale with conglomerate at the base. The pyroclastics are composed of green basaltic to andesitic volcanic rocks embedded in black tuffaceous matrix. Along Salong and Guijungan River, tuffaceous sandstone and siltstone are observed as interbeds with andesitic tuff and volcanics to a limited extent. The limestone has a general strike of NE-SW with an average dip of 25° NW. Minor folding and faulting which disturbed this formation after the volcanic activity are often observed.

The unit had been dated Early Miocene (E. A. Santos, et al., 1988).

The Dacong-cogon Formation occurs widely in the vicinity of Dacong-cogon in the eastern part of the area. It is well developed along the Cabilokan River, upper reaches of Ilog River, and Tablas River. Topography is characterized by high relief due to extensive weathering.

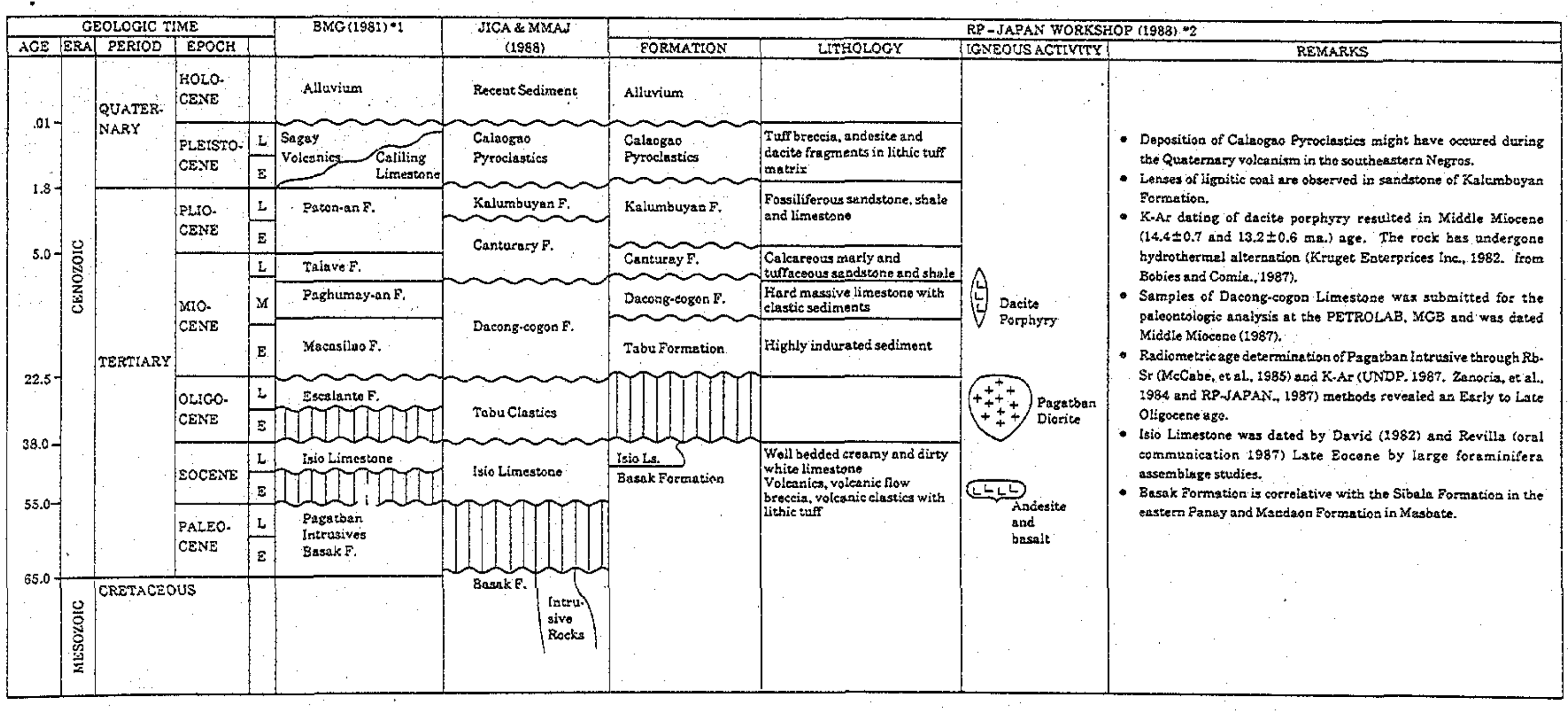
This formation is composed of massive part and well-bedded part. The lower part is generally well-bedded and becomes massive upwards. The rock is hard and, in part, sandy, marly and conglomeratic. The conglomeratic part is confined to the base of the unit but is poorly exposed. The formation overlies the lower Tabu Formation unconformably.

Some horizons are fossiliferous and these samples submitted for paleontologic analysis at the BMG Petrolab was dated Middle Miocene (E. S. Santos, et al., ms. 1988).

The Canturay Formation occurs typically at northwestern Canturay, at the southern part of Sipalay Mine.

It is composed of sandstone, siltstone and shale and is carbonaceous at the base and calcareous towards the top. The formation consists of sandstone, siltstone and shale whose composition varies from sandy to marly and calcareous. The beds are thick, but each bed varies in thickness. Bedding is generally low dipped. The sandstone is medium to coarse-grained, light brown to gray and calcareous. The siltstone-shale sequence is brownish green to light green. It is friable due to clay partings and show well-defined bedding.

The formation is correlated to the Talave Formation in northern Negros and was dated Late Miocene (BMG 1981, Kikel et al., 1956).



- Deposition of Calaogao Pyroclastics might have occured during the Quaternary volcanism in the southeastern Negros.
- Lenses of lignitic coal are observed in sandstone of Kalumbuyan Formation.
- K-Ar dating of dacite porphyry resulted in Middle Miocene (14.4±0.7 and 13.2±0.6 ma.) age. The rock has undergone hydrothermal alternation (Kruget Enterprices Inc., 1982. from Bobies and Comia., 1987).
- Samples of Dacong-cogon Limestone was submitted for the paleontologic analysis at the PETROLAB, MGB and was dated Middle Miocene (1987).
- Radiometric age determination of Pagatban Intrusive through Rb-Sr (McCabe, et al., 1985) and K-Ar (UNDP. 1987. Zanoria, et al., 1984 and RP-JAPAN., 1987) methods revealed an Early to Late Oligocene age.
- Isio Limestone was dated by David (1982) and Revilla (oral communication 1987) Late Eocene by large foraminifera assemblage studies.
- Basak Formation is correlative with the Sibala Formation in the eastern Panay and Mandaon Formation in Masbate.

*1 Geology and Mineral Resources of the Philippines BMG. Volume I P.62 (II-27) 1981

*2 E.A. Santos and J. Velasquez "Geology of Southwest Negros and its Tectonic Implication" (ms., 1988)

Fig. 6 Stratigraphic column of Southwest Negros

The Kalumbuyan Formation is a sequence of sedimentary rocks exposed at the lower reaches of Pagatban and Bayawan Rivers.

It is composed of thick bedded sandstone, siltstone and fossiliferous limestone. Bedding planes are low dipped to almost horizontal. The sandstone is fine to medium-grained, gray to dark gray and contains lenses of lignite. The siltstone and shale are white, argillaceous to calcareous. The limestone is massive and is poorly bedded. The formation overlie unconformably the Lower Canturay Formation.

It dated Pliocene (E. A. Santos, et al., ms. 1988).

The Calaogao Pyroclastics occurs the upper reaches of Tinabanan River to the coastal plain near Calaogao in southeastern part of Negros Island.

It is mainly composed of andesite and dacite fragments whose size ranges from pebble to cobble set in a light gray, fine and coarse grained lithic tuff matrix. It shows apparent gradation with respect to volcanic fragments. Bedding and flow structure dipping 10° to 15° north. The pyroclastics might have been deposited as a result of the Quaternary, volcanism. These rocks were considered by Burton (1983) as a facies of the Tabu Formation but this has been confirmed to be of a younger age from field occurrences and the results of photogeologic interpretation. This formation is overlain the Kalumbuyan Formation unconformably.

BMG (1984) considered the unit to be Pleistocene.

Alluvium is composed of unconsolidated detritus of gravel, sand, silt and mud deposited in flood plains along rivers and in alluvial flats near shore.

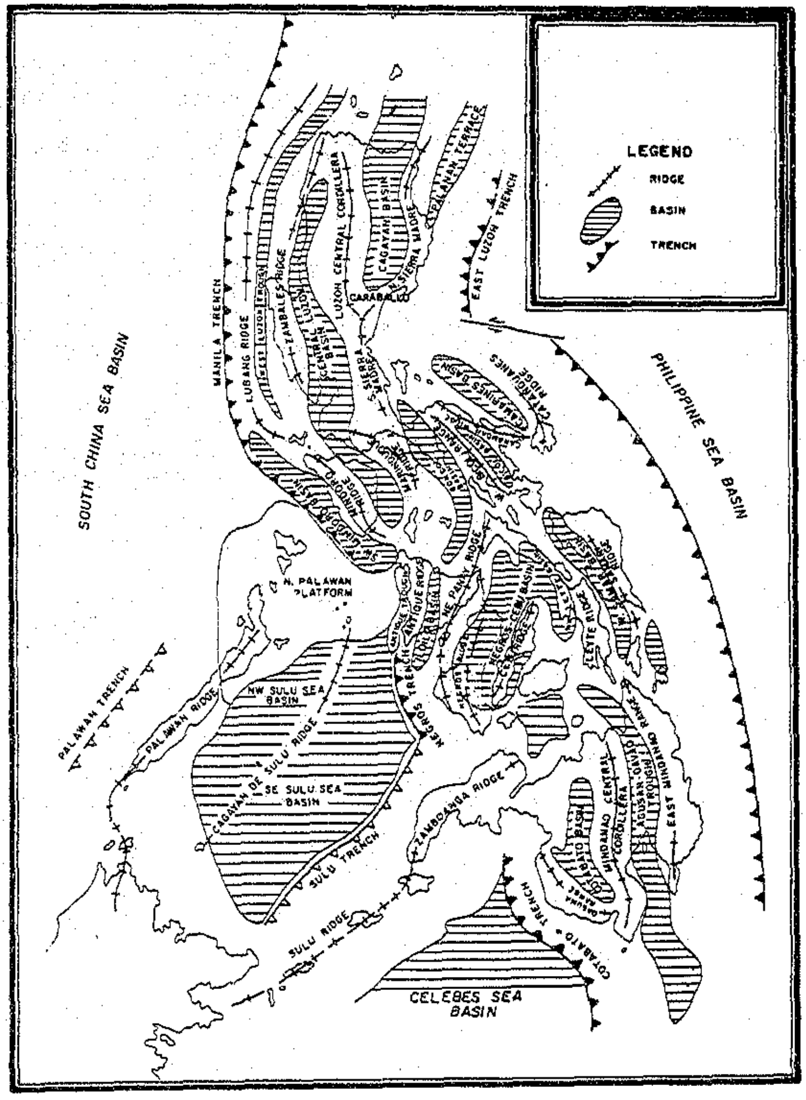


Fig. 7 Major Physiographic Elements in Philippines (After G. R. Balce, et al. 1981)

2-1-3 Geological Structure

The geological structure of the survey area displays a different pattern in each tectonic block. NE-SW trending folds and faults are prevalent in Cebu and Bohol, whereas NW-SE trending faults are developed in Southwest Negros.

These prevailing trends in Cebu and Bohol are nearly parallel to the Sulu-Zamboanga-Masbate Arc advocated by Mitcell et al. (1986) (Fig. 8) while the trend of the structures of Southwest Negros is nearly perpendicular to the spreading direction of the Sulu Sea in Southwest Newgros. In addition, numerous small-scale fractures obliquely cutting the above trends are also recognized (Figs. 2 and 7).

2-1-3-1 Cebu (Fig. 2)

Northeast-southwesterly trending fault and fold systems, stated above are dominant in Cebu and the vertical displacement of the faults appears to be considerable due to repeated movement.

Cebu is divided into three major structural units, namely, the northern, the centralhighland and the southern part.

The centralhighland is bordered on the north by the line connecting Catman on the east coast and Tuburan on the west coast. It is bordered on the south by the line connecting Naga on the east coast and Pinaungan on the west coast.

In the northern part, Miocene Maingit Formation and Pliocene Barili Formation occur along the N-S trending folding axis, and Pleistocene Carcar Formation occurs surrounding the above Formations.

The central highland has been uplifted in horst structure by many NNE-SSW trending faults during Late Cretaceoun to Miocene age and show contrasting structure to the northern and southern parts which consist of low hills and flood plains. Jurassic Tunlob Schist occurs in the north and is in contact with the Cretaceous-Paleocene Mananga Group through N-S and NNE-SSW faults (Tunlob, Calangahan Faults, etc.). Mananga Group occupies a broad portion of this central highland. Oligocene Cebu Formation overlie this group unconformably at the higher part of the central ridge. Pagatban Diorite, the northeasterly elongated intrusive body and many small stocks also occur near the central ridge. Neogene formations are distributed surrounding the Mananga Group and the Pleistocene Carcar Formation occurs on the outer side of these Neogene formations toward the coastline.

At the southern portion of the central highland, the very important porphyry copper deposits of the Atlas Mine are located. The deposits of this mine occur between the North Barot Fault and Cantabaco Fault which are parallel and has ENE trend in this lifted zone (3,600 m width).

Three ore bodies of Carmen, Lutopan and Biga-Barot and also Maypay, Sigpit Lutopan mineral showings are known in this vicinity.

In the southern part, Cretaceous-Paleocene Mananga Group occurs with small scale outcrops along the NNE-SSW trending Bato-Banlot Fault which passes through the center of the mountain range. These basal formations are covered by Oligocene Cebu and

Miocene Malubog Formations. Pleistocene Carcar Formation occurs around the above area and the flood plain.

2-1-3-2 Bohol and Siquijor (Fig. -2)

Major structures delineated in Bohol generally trend NE-SE. Several folded areas are recognized by field data and photo-geological interpretation.

The NW trending Colonia-Mahayag Syncline swerves northwest at its central part and continues to the Buenavista Syncline.

In southeastern part of Bohol, there is the Sierra Bollones Anticline while the northwest, the Tubigon and Inbang Anticlines occur parallel to the above synclines. In addition the Candijay-Balihan Anticline and Catigbian-Sagbayan Syncline were identified by field work.

Small scale foldings and faultings including minor strike-slip faults were also recognized. A lineament map which was constructed from satellite image interpretation is presented in the Attached Plate-6. At the southeastern part.

At the southeastern part, the metamorphic rocks are overlain by ultramafic rocks which show imbricated structure, accompanied with remarkable brecciated contact zone. The ultramafic rocks believed to override on the metamorphic rocks (Sajona, et al., ms. 1986.)

2-1-3-3 Southwest Negros

A series of NW to NNW striking faults are developed in Southwest Negros and numerous complementary faults which are generally related to N-SW trending geologic structures are observed as well.

The order NW to NWW fault system is believed to have been formed during the intrusion of the Pagatian Batholith. Porphyry copper mineralization is closely controlled by the general trend and intensity of the faulting. Recurrent faulting and intrusion of the batholith produced fractures and joints both on the Basask Formation and batholith itself and these served as conduits and channel ways for hydrothermal fluids which brought about the alteration of the surrounding rocks and porphyry copper deposits. The fault pattern was delineated as lineaments through satellite image interpretation.

2-1-4 Igneous Activities

Igneous intrusive activities in the survey area are as follows. Diorite intrusion occurred in Cebu during Paleocene and Niocene, in Bohol during Paleocene and in Southwest Negros during Oligocene. Andesite dyke intrusion occurred in Cebu and Bohol during Miocene and dacitic porphyry occurred in Southwest Negros during Miocene. In addition, the formation of serpentinite and periodotite dykes were emplace of in Cebu during Miocene.

2-1-4-1 Cebu

Lutopan Diorite occurs as NE-SW elongated masses and are exposed along ridges of the central highland. The lithology is hornblende diorite and hornblende quartz diorite. The pale gray medium to coarse-grained granular diorite occurs most extensively in the area and consists of 60~70% anhedral to subhedral plagioclase (Oligoclase), 12~30% quartz, 5% hornblende and biotite and the accessory minerals are magnetite, apatite and zircon. The stocks of this diorite, at the east side of the central western part, are porphyritic and consists of 40~50% andesine, 30% quartz, 5~20% chlorite, 5% biotite and some accessory minerals such as magnetite, apatite and zircon.

In hydrothermally altered zones, the major components are sericite, quartz, kaoline and epidote. Contact zones with the Cansi Volcanics are marked by strong shear and intense epidotization.

The diorite intruded into the Mananga Group between the northern Barot Fault and southern Cantabaco Fault consists of 50 to 70% andesine, 10~20% hornblende and biotite. It is porphiritic and intrudes in Cretaceous-Paleocene Pandan Formation as stocks with about one kilometer in diameter. Atlas Mine ore bodies occur in these stocks. Alteration of this stock is silicification, sericitization, pyritization and argilization.

The age of the diorite based on K-Ar dating is 59.5 ma. (Paleocene) (F. Gerbasio, 1971) and 50.7±2.5 ma. (Paleocene) (JICA-MMAJ., 1989).

Talamban Diorite occurs as small stocks in the western part of central eastern Talamban with fault contact to Jurassic Tunlob Schist. It is coarse-grained quartz monzonite and contains euhedral to subhedral plagioclase, euhedral quartz, potash feldspar and hornblende under microscope.

The K-Ar dating indicates 10.2 to 12.5±0.5-0.6 ma. (Miocene) (JICA-MMAJ., 1989).

Bulacao Andesite occurs in the central highland of Cebu and consists of massive volcanic flow and pyroclastics.

It is generally porphyritic, brecciated and vesicular and consists of phenocrysts of plagioclase and hornblende in a glassy matrix. It is also cut by quartz veinlets at the outcrops. Alteration of the andesite is confined in parts around the Talamban Diorite and this consists of pyritization, silicification and epidotization with minor argillization.

The andesite may have been emplaced as an extrusive or intrusive bodies along older structural zones in central Cebu during Middle Miocene.

Serpentinized peridotite occurs along major fault zones in central Cebu. Typical outcrops are observed along Toledo-Tabunoc road near Camp 7.

A sample collected at the outcrop is composed of clinopyroxene and olivine with smaller amount of anhedral plagioclase and hornblende. The largest body of the rock extends over 3.5 km along the above road. In the central highland, the rock occurs along the Tunlob Calangahan, Cueva and Maypay Fault zone. The unit intruded during Miocene (E. C. Mantaling, et al. ms. 1988).

2-1-4-2 Bohol and Siquijor

Intrusive bodies in the area are Paleocene Talibon Diorite and Miocene Jagna Andesite, the former is exposed in the northern to central part and the latter occurs in the southeastern part of Bohol.

Talibon Diorite intruded the Paleocene Ubay Volcanics and the largest mass of the diorite is exposed at the north of Bohol and small stocks of the diorite are also present trending N-S, from northern Talibon to central Dagohoy.

The minerals of the diorite are generally subhedral, light colored and medium to coarse-grained. Numerous sulphide bearing quartz veiniets occur in the intrusive body. The ore minerals are pyrite, sphalerite, galena, magnetite and chalcopyrite with limited gold.

The diorite is one of the main host rocks of mineralization in the areas. Many mineral showings, Kauswagan, Campacot and others occur in the intrusive bodies.

The Talibon Diorite and the Ubay Volcanics are considered closely related igneous rocks, K-Ar dating of this diorite shows 87.0±1.8 ma. (Early Oligocene) (JICA-MMAJ., 1989).

Jagna Andesite occurs as andesite breccia 2 km north of Janga, at the southern coast of Bohol.

It is a gray massive rock containing phenocrysts of plagioclase in glassy matrix. Floats and boulders of andesites, presumably from Jagna Andesite, are widely observed to the north of Jagna. The exposure of the rocks is limited. It was emplaced in Miocene and is relatively fresh compared to the Paleogene Ubay Volcanics. It is thought that the deposition of the Wahig Limestone was followed by the Jagna Andesite activity in Early-Middle Miocene (F. G. Sajona, et al., ms. 1986). K-Ar dating result is 25.5±1.3 ma. (Late Oligocene) (JICA-MMAJ., 1989).

2-1-4-3 Southwest Negros

Igneous intrusives exposed in the area are composed of the Oligocene Pagatban Diorite and Miocene dacitic porphyry. The former occurs as NNE-SSW trending fork-shaped batholith along the southwestern coast and the latter occurs as stocks and dykes within the former.

Pagatban Diorite is Part of the batholith which occupies a large part of the lower part of the island intruding into metasediments and metavolcanics of the Basak Formation in Sipalay, Hinobaan and Basay areas. This intrusion formed a NW-SE trending anticlinal structure. Rivers flowing over this diorite body cut dendritic or trellis type of drainage patterns.

This body consists of variety of rocks, from diorite to diorite porphyry and at the upper reaches of Pagatban River, it has appearance of gabbro. Fresh samples of the rock are medium to coarse-grained, white to gray. They have subhedral granular to occasionally porphyritic texture. Hornblende phenocrysts in diorite and quartz diorite reach 2 cm in length. Crystal grains porphyry generally become coarse as it becomes gabbroic. Some exposures are pyritized, silicified and argillized in association with chalcopyrite, malachite and azurite mineralization. Alluvial gold mineralization is known on the whole stretch of Hinobaan River but source veins cannot be observed.

Radiometric dating of the diorite by Rb-Sr (McCabe, et al., 1985) and K-Ar method (UNDP, 1987, Zanoria, et al., 1984 and RP-Japan, 1987) revealed Early to Late Oligocene ago. This unit is correlated to the Paleogene plutons (Sara Diorite) of eastern Panay and thus both units appear to have been derived from the same magmatic arc (UNDP, 1987), Zanoria, et al., (1984) noted that this magmatic arc continues southward to link with the intrusives in northwestern Mindanao of similar age. It is regarded as a magmatic arc correlated to an easterly dipping trench whose northern part is now partly buried under the Iloilo Basin and continues southward to the present Negros Trench.

Dacite porphyry occurs as NE-SW and N-S trending stocks and dykes which intruded into the Basak Formation and Pagatban Intrusives from Sipalay to Hinobaan.

It is gray and consists generally of large phenocrysts of plagioclase, subhedral quartz and platy biotite all set in fine-grained groundmass. A medium to coarse-grained quartz is usually zones and often contains inclusions. Both plagioclase and quartz phenocrysts reach lengths of 2~3 cm. The units mapped in Sipalay indicates post-intrusive mineralization but has no sign of gold mineralization.

2-2 Mineralization

Metal mineralization in the survey area is represented by potphyry copper type deposits such as the well known Atlas mine in Cebu and Sipalay mine in Negros. In addition, mineral showings associated with the Talibon Diorite in Bohol, gold and silver veins in Cebu and alluvial gold in Southwest Negros are also identified. In Siquijol, only small scale sedimentary manganse showings are observed.

2-2-1 Cebu Area

Three kinds of mineralization found in the area are as follows:

A) Porphyry copper type mineralization derived from the Lutopan diorite in the central part.
(Examples) Biga, Carmen and Lutopan pits

B) Hydrothermal veins associated with the Cretaceous Cansi Volcanics.
(Examples) Sta. Lita, Buanoy and Maypay

C) Contact metasomatic type mineralization derived from Miocene intrusives.
(Examples) Mandawe River

The mineral showings of the above-defined category were investigated and they are shown in Table-1.

Biga, Carmen and Lutopan porphyry copper deposits are summarized as Atlas mine in the next section.

The Atlas mine is located 35 km west of Cebu city and can be reached by car. The mine area occurs in diorite stocks which bordered by faults at north and south side. These faults associated with the mineralization are the North Barot Fault to the north and Contabaco Fault to the south. Geology of the mine area comprises the Cretaceous Cansi Volcanics and the Lutopan Diorite which intruded into the Paleocene Pandan Formation.

The Lutopan Diorite consists mainly of diorite porphyry and occurs as three parallel intrusive bodies trending northeasterly from Lutopan to Carmen, Biga to Barot and Kanapnapan to Luay respectively.

Mineralization is related to the diorite and occurs as aggregation of dissemination and network in diorite and adjacent altered volcanics. Ore reserves with the center on diorite bodies in Lutopan, Carmen and Bega areas amount to more than a thousand million tons which rank as the largest copper mine in the Philippines.

Lutopan deposit in the western part has a high grade portion 0.8% Cu in biotite diorite body and a low grade portion of 0.3% Cu in adjacent altered volcanics and it extends for 1,280 m with a width of 320 m. Carmen Deposit occurs associated with the diorite body which continues northeastward of the Lutopan Deposit. It extends for 1,300 m in length with 400 m in width. Biga-Barot deposit in the eastern part is associated with the eastern diorite body. High grade parts occur in breccia pipe and brecciated zones. It extends for 1,500 m in length with 500 m in width and is currently being mined by open cut method.

Ore minerals are mainly pyrite, molybdenite, chalcopyrite and magnetite with minor amount of bornite, hematite, anhydrite, quartz, calcite and gypsum. The following is the ore reserves recently published by the mine. Proven ore; 759,228,000 MT. 0.44% Cu, 0.26 g/MT Au (Annual Report of Atlas Development Coop., 1986)

2-2-2 Bohol-Siquijor

The four types of mineralization observed in the area are as follows:

A) Porphyry copper type mineralization derived from the Talibon Diorite in the northern part.
   (Examples) Bonakan, Campacot
B) Hydrothermal veins in the Paleocene Ubay Volcanics.
   (Examples) Salamanca
C) Orthomagmatic nickel and chrome mineralization derived from ultrabasic rocks in the southwestern part.
   (Examples) Boctol, Bangwalog
D) Residual manganese deposition in cavitiy of limestone and on the surface of shale.
   (Examples) Anda, Nangka and Pisong

The mineral showings of the above-defined category were investigated and they are shown in Table-2. Among these showings, Kauswagan deposit is presently operated on a small scale for gold.

2-2-3 Southwestern Negros

Two types of mineralization observed in the area are as follows:

A) Porphyry copper type mineralization formed along belts intruded by the Pagatban Diorite in the western part.
   (Examples) Calatong River I, II, Capayasan etc.
B) Hydrothermal veins in the Pagatban Diorite in the western part.
   (Examples) Paling Gamay

The mineral showings of the above defined category were investigated and shown in Table-3. The deposits at San Jose in the northwestern part of the area are summarized as the Sipalay mine in next section.

<u>The Sipalay Mine</u> is located in San Jose Village, Sipalay district (lat 9° N. long 127° 27' E.) in the southwestern part of Negros Island. It is operated by Maricalum Mining Co. and the daily production is 30,000 DMT of crude ore containing 0.54% Cu.

The geology surrounding the mine comprises the Paleogene pyroclastics called Basak Formation and the Oligocene Pagatban Diorite intruding into the Basak Formation. It is overlain by

Table-1 Major Investigated Mineral Showings in Cebu

*1 MINERAL SHOWING NAME	LOCATION	COMMODITY AND MINERALIZATION	AGE	TECTONIC PROVINCE	DESCRIPTION	
					OCCURRENCE	CHEMICAL ASSAY OF SAMPLE
38 Mandawe River	123° 55' E 10° 25' N	Pb, Zn Contact metasomatic	Miocene(?)	Volcano-plutonic Arc	Massive pyrite in epidote skarn	Au 0.38 g/t, Ag 3.7 g/t, Cu 0.01%
40 Botong Sinsin	123° 47' E 10° 21' N	Au Hydrothermal vein	Paleogene	Volcano-plutonic Arc	Au disseminated in sericitized zone of andesite	Au 0.22 g/t, Ag 11.2 g/t, Cu 1.26%, Pb 0.01%, Zn 0.04%
95 Sta. Rita	123° 51' E 10° 37' N	Cu Hydrothermal vein	Paleogene	Volcano-plutonic Arc	Vein in Mananga Group	Au 0.03 g/t, Ag 72 g/t, Cu 21.4%, Pb < 0.01%, Zn < 0.01%
96 Buanoy	123° 43' E 10° 27' N	Au Hydrothermal vein	Paleogene	Volcano-plutonic Arc	Gold vein in Mananga Group	
97 Maypay	123° 42' E 10° 24' N	Au Dissemination	Paleogene	Volcano-plutonic Arc	Country rock is altered andesite	Au 0.38 g/t, Ag 3.7 g/t, Cu 0.01%, Pb < 0.01%, Zn < 0.01%
98 Sigpit Lutopan	123° 42' E 10° 21' N	Au Hydrothermal vein	Paleogene	Volcano-plutonic Arc	Vein in Mananga Group (pyrite, chalcopyrite, spharelite)	Au 9.85 g/t, Ag 2.6 g/t, Cu 0.06%, Zn 0.11%, Pb 0.69%
99 · 100 · 101 Consolacion No. 1, 2, 3	123° 56' E 10° 25' N	Au, Cu, Zn Hydrothermal vein	Miocene	Volcano-plutonic Arc	Pyrite veinlets and dissemination in alternated zone of Bulacao Andesite	

*1 These numbers correspond to the numbers in Attached Pl. - 8.